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GUIDELINES

RSSDI CONSENSUS GUIDELINES 2025 - NUTRITION MANAGEMENT OF DIABETES MELLITUS IN CHILDREN, ADOLESCENTS, AND YOUNG ADULTS IN INDIA *(Supported by ICMR - National Institute of Nutrition)*

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RSSDI CONSENSUS GUIDELINES 2025 - NUTRITION MANAGEMENT OF DIABETES MELLITUS IN CHILDREN, ADOLESCENTS, AND YOUNG ADULTS IN INDIA (Supported by ICMR - National Institute of Nutrition)

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LETTER OF SUPPORT

India has nearly 247 million adults living with diabetes and prediabetes, as per the ICMR-INDIAB 17 report. As national organizations, it is our collective responsibility to ensure they receive the best possible care. Nutrition plays a pivotal role in diabetes management, and there is a pressing need for India-specific dietary guidelines that consider regional dietary patterns and challenges.

Recognizing this need, RSSDI has taken the initiative to develop evidence-based **Diabetes-Specific Nutrition Guidelines** tailored to India's diverse population. These guidelines were formulated with inputs from leading diabetologists, endocrinologists, nutrition experts, as well as senior scientists from ICMR-National Institute of Nutrition. They have undergone rigorous scrutiny at three levels to ensure scientific accuracy and eliminate bias.

We believe that these guidelines will contribute significantly to improving diabetes management, enhancing patients' quality of life, and reducing the risk of complications. Furthermore, by promoting adherence to structured dietary recommendations, these guidelines have the potential to lower medicat on costs, thereby reducing the overall economic burden of diabetes care.

(Bharati Kulkarni)
Director

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Dear RSSDI colleagues,

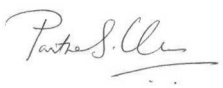
At Breakthrough T1D, we are dedicated to helping improve everyday life for those living with Type 1 Diabetes- as we strive to find a cure for T1D. In parallel, we collaborate with national decision-makers to address issues affecting the T1D community, focusing on current and future needs. For children, adolescents, and young adults who are growing and developing physically, emotionally, socially, and psychologically, access to a balanced diet free from unnecessary taboos is especially crucial.

As things stand, according to available data, India may have the highest number of people with T1D in the world.

In the background of this? The initiative by RSSDI to develop T1D-specific Nutrition Guidelines (created by paediatric endocrinologists, diabetologists, endocrinologists, and nutrition experts across India), aimed at children, adolescents, and young adults—considering India's diversity and different socio-economic levels—is extremely welcome. We believe it will drive meaningful change and improve the lives of young people with this condition. In addition? The influence of this work is likely to extend beyond the intended audience, informing practices across Asia and beyond; benefiting adults with T1D; and promoting healthy nutrition among those without diabetes as well.

Breakthrough T1D is therefore pleased to support this innovative initiative, which holds great potential to enhance the quality of life and outcomes for people with T1D, with considerable ripple effects. We wish you the very best in cascading this work to many who will benefit from this.

Regards



Dr. Partha Kar

Breakthrough T1D Clinical Lead (India)

PREFACE

Diabetes Mellitus in children and adolescents, whether type 1 (T1D) or type 2 (T2D), presents unique nutritional challenges that require a multidisciplinary, evidence-based approach to optimize glycemic control, support normal growth, and prevent long-term complications. In young people, diabetes is more likely to be T1D. In India, the complexity of managing diabetes is further heightened by diverse dietary habits, cultural food practices, and varying levels of access to healthcare resources.

The RSSDI CONSENSUS GUIDELINES 2025 Nutrition Management of Diabetes Mellitus in Children, Adolescents, and Young Adults in India, supported by the Indian Council for Medical Research - National Institute of Nutrition (ICMR-NIN), represents a collective effort to provide standardized, practical, and culturally relevant nutritional guidance. This comprehensive document is a result of rigorous research, expert consensus, and the dedicated contributions of the RSSDI 2025 Consensus Group, Editorial Committee, Reviewer Committee, and contributing Authors, who have meticulously reviewed current scientific evidence and best practices.

This comprehensive document covers essential aspects of nutritional management, including nutrition care, education, and meal planning, enabling individuals and caregivers to make informed dietary choices. It provides evidence-based macronutrient and micronutrient recommendations to support optimal metabolic health while emphasizing the importance of synchronizing food with insulin therapy for improved glycemic control. The Guidelines also focus on glycemic index and glycemic load considerations, ensuring better management of mixed meals and carbohydrate intake. Furthermore, they address key areas such as the role of nutrition in handling physical activity, sick-days, and psychological aspects associated with T1D. Recognizing the real-world challenges, the document also includes guidance on managing T1D during special occasions like festivals and travel, offers strategies for nutritional care in limited-resource settings, and explores the integration of technology with medical nutrition therapy to enhance diabetes management.

Developed by a diverse group from across the country of leading diabetologists, pediatric endocrinologists, endocrinologists, dietitians, nutrition scientists, sports physicians, and diabetes educators, these guidelines are designed to serve as a valuable resource for anyone providing care for diabetes in the young - clinicians, dietitians, diabetes educators, caregivers, and policy-makers. Implementing these recommendations can enhance the quality of nutritional care, ultimately improving health outcomes, and quality of life.

We extend our sincere gratitude to all the contributors and organizations involved in the development of these Guidelines and hope this resource empowers healthcare providers and families across India.

Dr. Vijay Viswanathan
(President, National RSSDI)

Dr. Sanjay Agarwal
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FROM THE EDITORS

Managing diabetes, whether type 1 (T1D) or type 2 (T2D), in children, adolescents, and young adults is extremely challenging, with medical, social, and financial burdens thrown into the lives of the affected person and the entire family. In these life stages, which see rapid physical growth, pubertal maturation, emotional development including formation of self-image and lifelong attitudes to health and self-care, preparation for career, marriage, and reproduction, good nutrition is crucial. Dietary habits are significantly impacted by cultural, local, regional, and socioeconomic factors, which must be factored into individualized meal plans and interventions.

Good nutrition is important for good diabetes care as well as normal growth and overall well-being. It is one of the pillars for managing T1D, along with physical activity, basal-bolus insulin replacement, and self-monitoring of blood glucose, supported by diabetes education. However, the term "Diet" carries so many negative connotations of needless restrictions that the term "Medical Nutrition Therapy" or "MNT" was coined. Sound scientific evidence is available regarding the nutrition needs of young individuals, but many practices and concepts of dietary management lack robust studies. What seems clear is that children, adolescents, and young adults with diabetes do not need special recommendations of a "one-size-fits-all diabetic diet" – they should focus on healthy eating principles and routines shared by the entire family. Individualized advice based on the existing eating habits, with balancing of nutrients and portion control, matching insulin to meals, and physical activity would enable well-being and good glycemic control. This, in turn, would promote good general health and reduce discrimination for the affected people with diabetes (PwD).

In India, characterized by vast diversity in eating habits, traditional practices have evolved over centuries to utilize local produce in ways suitable for local and individual needs. The ancient concept of Ayurveda, "you are what you eat," uses food to nourish and heal. Unfortunately, while industrialization has reduced food insecurity and food costs across the world, it has also caused a shift from traditional diets to inexpensive but unhealthy processed and ultra-processed foods (UPF). In India, the impact of colonization followed by industrialization has resulted in diets high in carbohydrates, fat, and salt, with rising consumption of addictive refined carbohydrates, sugar, and saturated fat. Protein intake is often low for cultural or financial reasons. The challenge is to wean families away from these UPFs to balanced, culturally appropriate, yet cost-effective nutrition with adequate macro- and micronutrients. It is worth keeping in mind that food insecurity may be present not just in poor families but anyone with erratic timings as well. Thus, MNT and insulin dosing must provide flexible strategies to account for variable food availability, whether quality, quantity, or timing, and variable activity levels. MNT is also important to manage prediabetes, T2D, neonatal, and monogenic diabetes in children/ adolescents.

All this requires knowledgeable healthcare personnel (ideally a multidisciplinary care team) who can put in the considerable effort needed to impart diabetes education. They must provide education about meal planning, snack timing, and healthy eating practices as well as other aspects of diabetes care to the PwD, caregivers and other family members, and staff/ friends/ colleagues in school/ college/ workplace.

These Guidelines aim to provide this key information to healthcare personnel and, indeed, educate intelligent caregivers about the intricacies of nutritional management in a simple, practical format. The attempt is to enable a family-centered, culturally sensitive, cost-effective approach during childhood, adolescence, and the transition period to adulthood to optimize clinical and metabolic outcomes. Indeed, the Guidelines are equally useful for anyone advising good nutrition to young persons, with or without diabetes. Good nutrition, sensibly provided, is an essential component of a supportive, empowering, and destigmatizing environment necessary for good diabetes care and good quality of life.

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Chapter 1: Introduction – "No Such Thing as a Diabetic Diet"

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Diet had been the cornerstone in treating Type 1 Diabetes Mellitus (T1D) for three thousand years before the discovery of insulin in 1921.[1] A severely restrictive diet had been the only recourse to diabetes management for centuries before insulin became available and accessible. The term "diabetic diet" still carries the same negative connotation of restrictive eating advice, and its continued usage can have a significant negative psychological impact on People with Diabetes (PwD) and their caregivers. Similarly, labeling certain universally liked and commonly consumed healthy foods as "diabetic" (e.g., rice, banana, potato) and advising to avoid them strictly can be devastating to the person diagnosed with diabetes. The importance of using the correct language, especially in stressful and life-changing situations, cannot be overstated. Where a *'diabetic diet'* implies restrictions and harsh advice on '*what not to eat,'* replacing it with the term '*Medical Nutrition Therapy (MNT)',* shifts our focus to guiding and empowering PwD to make correct dietary choices by imparting knowledge and awareness of '*what to eat.'* [2,3]

MNT is one of the four fundamental principles of T1D management.[1] The International Society for Pediatric and Adolescent Diabetes (ISPAD) and the American Diabetes Association (ADA) recommend individualized MNT to achieve glycemic goals and overall well-being and timely growth, development, and puberty in children and young PwD. This should preferably be planned and taught by a trained and qualified dietitian with a thorough and up-to-date knowledge of T1D care.[1,4] However, because access to a dietitian familiar with T1D is limited in many places, all Healthcare Professionals (HCPs) or clinicians providing care for PwD must become familiar with the basics and nuances of nutrition, including the latest recommendations.

The main focus of MNT is on educating individuals and their families on the basic concepts, like the macronutrients (carbohydrates including fiber, proteins, and fats), how each contributes to good health, and how they affect the Blood Glucose (BG) levels, especially carbohydrates. It involves teaching which foods are carbohydrate-rich and which are good sources of protein and fat. Concepts like Glycemic Index (GI) and Glycemic Load (GL), the importance of fiber and micronutrients in daily diet, and different cooking methods to improve food quality are also discussed. The family must be equipped to adjust insulin doses according to what will be eaten, to ensure good glycemic control and good physical and mental health. MNT also addresses managing T1D in the presence of comorbidities like celiac disease, food allergies/ intolerance (lactose intolerance), obesity, dyslipidemia, hypothyroidism, and renal dysfunction; making smart choices in special situations such as when eating out or during festivities; and choosing the correct packaged food when needed, by reading and understanding the food labels. As carbohydrates are the main macronutrient causing postprandial glucose excursions, dietary advice has evolved from the concept of very-low-carbohydrate diets of the early 20th century to a more moderate approach, with a greater focus on adequate insulin coverage of the meals, balanced diets with high fiber content, greater dietary freedom, and general well-being.[5]

Studies have suggested a general lack of knowledge or misunderstanding of dietary management in diabetes. PwD and their families who have received advice from a dietitian as part of their treatment plan have better compliance. In a systematic review, MNT with carbohydrate counting and matching pre-meal insulin doses with carbohydrates improved glycemic control in individuals with T1D and Type 2 Diabetes Mellitus (T2D) on insulin therapy. This improvement was sustained beyond one year with continued MNT support by a registered dietitian.[6] MNT can also bring greater flexibility to food timings and variety, thus decreasing discontent and helping to cope with challenges surrounding the lack of freedom of dietary choice. Flexible, low-GI dietary regimens have improved Quality of Life (QoL), life satisfaction scores, and glycemic control.[7,8] Thus, available evidence makes it imperative that families know how to do carbohydrate counting and match pre-meal insulin doses with meal carbohydrates to achieve optimal post-meal BG levels and consequently improve QoL.

The chronic low-grade inflammation associated with T1D and intensive insulin therapy exposes PwD to a higher risk of obesity, which increases the risk of metabolic conditions like dyslipidemia, hypertension, and insulin resistance, and thus overall cardiovascular risk.[9,10] MNT must focus on glycemic control, carbohydrate counting, and preventing acute and chronic complications.[11] If dietary education can inculcate a sense of self-responsibility for one's health and impart knowledge, it results in higher adherence to recommendations.[12] Encouraging a routine eating pattern and avoiding grazing from early on, regardless of age, improves glycemic outcomes and the nutritional quality of the overall diet.[13] The portion size effect (eating more when served larger portions) and portion distortion (normalizing exaggerated portions) are known causes of obesity, and their prevalence is rapidly rising in individuals with T1D.[14] The primary goal of MNT is to encourage lifelong healthy dietary habits like having balanced meals, eating meals on time, avoiding grazing/ snacking, choosing correct portion sizes according to age, etc.

Adolescence is a crucial phase of development that increases the risk of unhealthy lifestyle choices. The constant daily stress of dietary planning, monitoring carbohydrate intake and food portions, and being different from peers can be quite overwhelming for the teenager, causing significant diabetes distress.[15] Eating disorders like anorexia nervosa and bulimia nervosa are seen in young people with T1D, along with the less common frank psychiatric problems like anxiety and depression.[16] The treating team, including dietitians, must be aware of this and factor it into care. Less severe disordered eating symptoms like occasional self-induced vomiting, dieting for weight loss, and binge eating are common. Eating disorders increase the risk of serious T1D-related complications like ketoacidosis and hypoglycemia, as well as poor bone and muscle mass accrual, with potentially long-lasting adverse consequences. They can also increase the risk of microvascular complications like retinopathy. A multidisciplinary team approach (involving the treating physician, dietitian, psychologist/ counselor, and, when necessary, psychiatrist) is needed, along with family-based interventions to change the family dynamics around food and improve self-esteem and body acceptance in the young person.[16] With the increasing acceptance of telemedicine, the primary HCPs may wish to discuss with and refer to experts not locally available.

India's sociocultural and food environment changes have dramatically increased the consumption of ultra-processed and high-nutrient-density foods in recent years. The increasingly available and accessible ultra-processed modern food choices are rapidly replacing the traditional

Indian diet.[17] On the other hand, in low- and middle-income countries like India, with the costs of diabetes mostly out-of-pocket, the additional costs of healthy food can contribute to higher food insecurity, and caregivers may struggle to follow T1D dietary recommendations. Handing out diet charts with calorie and nutrient recommendations without understanding the socio-cultural and economic background is neither adequate nor tenable. HCPs and dietitians should explore each family's economic and dietary situation and assess food insecurity, to individualize their advice and, where needed, help to identify cheaper yet nutritious options.[18]

Cheaper internet access made sure of near-universal access to social media sites, where the small amount of right information is often drowned by the deluge of wrong messages encouraging fad diets, extreme diets, and quick fixes, offering cures by self-proclaimed experts and influencers with no dietetic or medical knowledge or training. Desperate families, willing to try any means to make their child better, might follow such faulty advice, resulting in serious complications. HCPs and dietitians should be aware of these practices, enquire about them, and be empathetic while addressing them head-on without being judgemental or harsh.

Indian food and cuisine are as diverse and complex as her geography and people. Understanding the cultural and social background of the families and adapting dietary advice to their existing patterns improves acceptance. The HCP's role is to improve the entire family's knowledge and attitude towards food, cooking habits, and behaviors rather than targeting the child alone.[19] There is "No such thing as a diabetic diet"; there are only healthy dietary habits and choices, allowing personal and cultural preferences and synchronizing meals with appropriate insulin dosing. Cooking, taught as an essential life skill to all children - boys and girls - from an early age, can increase the consumption of home-cooked meals, improving the entire family's health.

Comprehensive and structured dietary education of individuals with T1D and families does not have to be limited to institution-based care. Even small standalone clinics can and should be able to deliver appropriate education and care with the help of technology, telemedicine, peers living with T1D, and T1D Support Groups. Structured courses such as Ispae Diabetes Education And Learning (IDEAL) which are virtual and comprehensive, are game-changers, as they increase the pool of HCPs familiar with T1D care and help to improve the quality of care.[20] In this scenario, recognizing the pressing need for India-specific dietary guidelines for T1D, the Research Society for the Study of Diabetes in India (RSSDI) has gathered a qualified team with experience in the field to formulate these MNT guidelines to provide advice on dietary approaches for individuals with T1D and how to tailor the diet for those with associated comorbidities like overweight and obesity, celiac disease, dyslipidemia, hypothyroidism, chronic kidney disease, etc. Centuries-old myths surrounding the relationship between diabetes and diet can make the work of HCPs and dietitians challenging. These guidelines try to dispel them with scientific evidence and knowledge. We hope this document will become an invaluable tool for all the HCPs, dietitians, and Pediatric Diabetes Educators (PDEs) advising individuals with T1D and their families in their daily practice.

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Chapter 2: Nutrition Care, Education, And Meal Planning

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2.1. BACKGROUND

Type 1 Diabetes Mellitus (T1D) is the second most common chronic disease in children and adolescents in India. India ranks first globally in both the prevalence and incidence of T1D among children and adolescents, with an estimated 229,400 individuals currently living with the condition and approximately 24,000 new cases reported annually in the 0–19 age.[1] Treatment with insulin is the mainstay in managing individuals with T1D, along with regular blood glucose monitoring (BGM) and diabetes education, including nutrition education (and meal planning).[2] This is needed to manage Blood Glucose (BG) levels and to help optimize other metabolic parameters such as Blood Pressure (BP) and lipid levels. Dr. EP Joslin stated 91 years ago, *"I look upon the diabetic as charioteer, and his chariot as drawn by three steeds named Diet, Insulin, and Exercise."* For People with Diabetes (PwD), nutrition education, i.e., creating healthy meal plans and knowing how various foods affect BG, is essential to their daily routine. Healthcare Professionals (HCPs) looking after PwD must be proficient. Individualized meal planning must account for food choices, family eating patterns, physical activity routines, and cultural influences.[2–4]

2.2. RATIONALE

Indian cuisine is widely variable and strongly impacted by geography, religion, customs, and seasons. In addition, economic, social, occupational, and ecological issues all have an impact. Henry *et al.*[5] showed that Indians had higher glycemic responses to the same foods than Caucasians. The ingredients and cooking techniques used in various cuisines can differ greatly from one another. The main aims of nutrition advice for children and adults with T1D are normal growth and development, maintaining BG targets with minimal glycemic variability, meeting BP and cholesterol targets, and maximizing quality of life while minimizing social impact.[6] India-specific nutrition guidelines for individuals with T1D appear to be lacking, though there are a variety of general dietary guidelines and recommendations. Which dietary guidelines or approaches are most effective for the Indian population across different age groups and circumstances is not readily obvious; most Indian healthcare providers combine several standards and adapt them to suit the needs of the individual.[7] For the benefit of individuals with T1D, more region-specific data and guidelines are necessary.

2.3. CHALLENGES

The care of individuals with T1D involves several unique challenges, which must be considered and resolved when providing nutrition education and planning meals:

• **Inadequate support from peers, family, and the workplace:** Joseph *et al.*[8] found that many individuals with T1D experience exclusion rather than positive support, with academic and work-related obligations the main obstacles to following dietary recommendations. In addition, in joint families, everyone may not accept alterations to the current way of life, with diabetes care providing flash points in family conflicts. The healthcare team should convince families that following the same nutrition and exercise principles benefits each member.

• **Individuals with T1D and caregiver education:** Parent/ caregiver education on Medical Nutrition Therapy (MNT) is important to ensure adherence to MNT.[9] However, individuals with T1D and their families were found to not fully comprehend dietary recommendations even if they visited the hospital regularly; moreover, understanding did not necessarily result in constructive behavior changes.[7,8] Effective teaching methods must be imbibed by the healthcare team to improve understanding and adherence.

• **Dietary Practices:** Most Guidelines suggest a dietary composition of 45-55% [low Glycemic Index (GI) and Glycemic Load (GL)] carbohydrates from sources like cereals, mixed grains, and whole pulses, including soybeans; 15-20% proteins derived from low-fat dairy, eggs, fish, and lean meats and plant-based sources (pulses and lentils); and 25-30% fats, with less than 10% from saturated fats (7% in those with raised blood lipid levels) and the remainder primarily from Monounsaturated Fatty Acids (MUFA) and Polyunsaturated Fatty Acids (PUFA) [MUFA: 10% energy + any calories left from carbohydrate portion; PUFA- 10 % of energy].[2,10]

Parents and individuals sometimes impose specific dietary fads, including 'low-carbohydrate' or 'fruit-only' diets, to control diabetes, often after being misled by friends, family, quacks, or the media. Discouraging fad diets and modifying existing dietary habits works better than creating a new diet plan.

• **Economic barriers:** Families from low socioeconomic status may not be able to afford adequate protein in their diet; sometimes, they may resort to unhealthy but inexpensive and easily available unhealthy foods like biscuits or fried snacks due to lack of money and time to cook at home. Families living in remote areas may find it difficult and expensive to travel to centers with expertise for proper diabetes care and education; they may have to make do with whatever care they can get locally. Those who survive on daily wages may be unable to afford lost wages due to hospital visits and travel.[11,12] One study from north India found the average annual direct cost of managing diabetes was 18.6% of the family's annual income, with those from lower incomes devoting as much as 32.6%.[13] According to Rohilla *et al.*[14], there is a high financial burden of T1D care [annual spending on glucose monitoring (Rs 21,576), insulin administration (Rs 28,965), doctor consultation (single visit Rs 2889), and laboratory investigations (Rs 5069)]. Finding imaginative ways to obtain funding support, ways to improve the quality of nutrients within budgetary constraints, and access through telemedicine may be necessary for such families, as discussed in Chapter 15.

While designing the meal plan, consideration should be given to the following factors: current dietary patterns, cultural and religious factors affecting compliance with MNT, area of residence, accessibility to medical care, family composition, affordability, literacy level, comprehension ability, school/ college/ workplace schedule, academic pressures, peer pressures, comorbid conditions, and insulin type, regimen, and dosage. Given India's diversity, advice has to be tailored accordingly. It is also necessary to provide teaching materials in regionally

appropriate local languages.[15] Such resources are being slowly developed; diabetes team members should be aware of what is available, for instance, patient support groups, local or regional juvenile diabetes associations, and national organizations. There are many organizations active in India, such as the Indian Society of Pediatric and Adolescent Endocrinology (ISPAE) (https://ispae.org.in/best/#:~:text=ISPAE%20has%20designed%20a%20structured,Diabetes%20mellitus%20and%20their%20caregivers.), Udaan (https://www.udaankids.org/), and the Type 1 Diabetes Foundation of India (https://www.t1dfindia.org/).

2.4. NUTRITION EDUCATION

MNT is a life-enhancing process, not limited to calorie restriction/ distribution and portion control. It involves designing and advising meal plans and approaches that need only the necessary alterations in established eating patterns and habits to achieve short- and long-term goals. The PwD and the family's preferred foods and eating patterns must match the intake required to maintain metabolic well-being and normal growth and development.[2] MNT has to be synergized with insulin therapy and adapted to meet the changing needs of PwD over the years.[16] This must be evaluated at every clinic visit and modified as needed. If a dietitian or diabetes educator is not part of the care team, the clinician should seek help from experienced professionals, with referral as required and practical, in person or online.

2.4.1. Initial Nutrition Workup and Assessment

During the initial presentation, this preliminary evaluation includes a detailed dietary history of typical daily food intake, preferences, dislikes, daily routine, and way of life.[17] The individual's nutritional needs are assessed, and the individual's and family's capacity and willingness to adhere to dietary recommendations are determined.[18] The initial nutrition assessment also includes the possibility of lifestyle unpredictability, family support, resource constraints, food customs, religious taboos, and the existence of metabolic and non-metabolic disorders that may require avoiding particular foods.[19] (Table 2.1)

Table 2.1: Key assessment features

Key assessment features include:
- Medical history, current height, weight, growth velocity, BP, and pubertal status
- Current medical prescription
- Diabetes distress; available support systems
- Religious and cultural influences
- Health beliefs and attitudes
- Physical limitations
- School timings, routines, tuition timings, co-curricular activities (sports/ picnic, etc.)
- Social determinants of health, e.g., financial status
- Barriers to adherence.
- Composition of family: key family members (may not be parents only)

2.4.2. Diagnosis of Nutrition Needs

The clinical profile of individuals with T1D is evaluated to identify potential risk factors (for example, obesity, comorbid conditions, celiac disease), the environmental and behavioral profile, diet diversity, and nutrient density of the food consumed. At this stage, the dietitian/ educator/ clinician will comprehensively understand the diet's quality/ nutrient composition/ quantity and timing and the coexisting metabolic and non-metabolic circumstances to plan calculations and modifications.[19] (Table 2.2)

Table 2.2: Questions to understand the nutritional pattern

- **Sample case study** (The following are a set of questions to help us understand the nutritional pattern of a given child/ adolescent/ adult)
- **Dietary Patterns**

→ What is the typical daily eating pattern, including meal times and portion sizes? (Weekdays/ Weekend)
→ How many meals and snacks does the child consume per day?
→ Does the child have any dietary restrictions?
→ How often does he/ she consume meals prepared at home versus eating out?

- **Macronutrient Intake**

→ What is the distribution of macronutrients (carbohydrates, protein, and fat) in the child's diet?

- **Food Choices**

→ What types of carbohydrates are consumed more frequently, e.g.? (refined/ whole grains)
→ What is the frequency of consuming fruits every week?
→ What is the frequency of consuming High Fat Sugar Salt (HFSS) food and Sugar-Sweetened Beverages (SSB)?
→ What are the food items the child likes and dislikes?

- **Insulin, exercise:**

→ How does the child manage insulin dose and meal/ snack consumption in relation to exercise?

2.4.3. Initiating Medical Nutrition Therapy

This stage entails creating tailor-made, personalized meal plans, counseling, educating, and coordinating nutrition-related care, starting as soon as the diagnosis of T1D is made. The individual's nutrition goals must be the basis for developing the meal plans; there is no "one size fits all" approach.[20]

2.4.3.1. Components of Nutrition Education & Meal Planning

Teaching the PwD and family, basic concepts

- **'Why maintaining a nutritious, well-balanced diet is crucial'**

[Includes details and persuasion - spelling out reasons to change]
→ There is no such diet as a "Diabetic Diet"; it is a healthy, balanced diet recommended for everyone, so the entire family should have the same food.[2,9,10]
→ The advantages of eating well-balanced meals for managing diabetes and general health.[2,9,10]
→ The advantages of regulating food portions for managing diabetes and other aspects of health.[2,9,10]
→ The adverse effects of inadequately managed diabetes/ metabolic state.[2,9,10]

- **'What to do and how to manage'**

[Includes action-oriented sessions and skill building slowly over initial weeks, with reinforcement later]
→ Understanding the proximate principles of diet with real samples of foods already consumed or culturally appropriate.[2,9,10] The HCP should have or can create food models and have a picture album to assist in estimating the food intake.
→ Addressing basic aspects such as predictable meal timings, balancing nutrients in each meal, and differentiating between healthy and unhealthy food items.
→ Understanding glycemic index (GI) and glycemic load (GL) of various food items.

→ Teaching carbohydrate counting (CC): initially level 1 (basic).
→ Matching carbohydrate intake to insulin dose and action profile.
→ Exercise and nutritional management.
→ Meal planning for school, sick days, festive occasions, picnics, treks, and other contingencies.
→ Addressing dietary beliefs and food fads.[2,9,10]

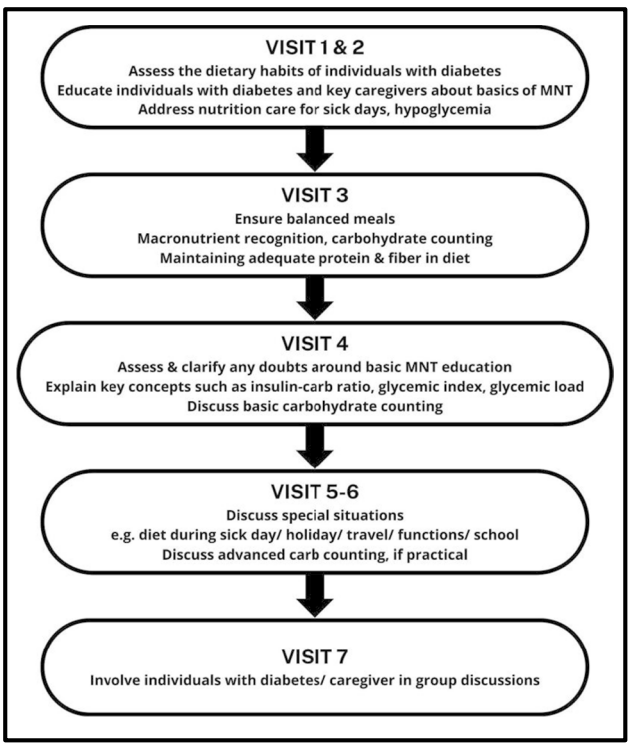
• 'Who should take part in Nutrition Education sessions'

→ Education of the PwD and all key caregivers is needed to ensure adherence to prescribed MNT.[7] The young person should be involved in the education process from the beginning, to improve compliance and enable good diabetes management in the future when on his/ her own.
→ Those who reside in joint family households may sometimes not receive a supportive family atmosphere. Grandparents, uncles, aunts, and siblings may be unwilling to change their own lifestyle and may even provide/ enable unhealthy snacks or other forms of indiscipline.
→ For this reason, it is important to involve key family members in the nutrition education sessions and convince them that lifestyle changes and discipline would benefit them, not just the PwD. This will likely improve the chances of getting support and appropriate care within the family.[21,22]

• 'How to Deliver Nutrition Education'

Methods employed during training should be person-oriented, interactive, non-preachy, motivating, and practical.[23] Intensive nutritional counseling is usually needed at the time of diagnosis, which may require 2-4 sessions; thereafter, a review after a month and then at every clinic visit is desirable.[2,4,9] So, typically, every PwD should get four or more sessions per year, with timely follow-ups. Additional sessions would be advisable if there are problems adapting to dietary guidance or if glycemic control remains poor.
→ Sessions should be interesting and well understandable, preferably in the language the family is comfortable with. Appropriate reading materials, handouts, and books in the preferred language should be provided as soft or hard copies.[24]
→ Visualization: Pictorial presentations or visual aids generate better understanding. For example, the content of a nutritious meal can be easily understood if the Thali Model is used to explain it. (Figure 17.1) Similarly, audiovisual aids, videos, mobile applications[25], photographs, or food models showing portion sizes of food items can be used.[26] (Figure 17.2 A & 17.2 B)
→ Education should be delivered in acceptable portions rather than trying to cover all aspects in a single session. It should also include finding solutions to any particular issues. Subsequent sessions should refocus on the most important issues or obstacles and then move on to new topics. Additionally, reviewing the previous session's discussion is essential to ensure that both the caregiver and the child have fully understood the information. During this recap, it's important to address any concerns the caregiver may have and the challenges experienced by both the child and the caregiver before introducing new topics. Identifying any resistance to the advice provided is also valuable in this process.
→ Mode of delivery: Sessions can be conducted in person or virtually, one-on-one or in a group. Group discussions become more interactive but require the group to be carefully chosen.[27] Utilizing telehealth, virtual consultations, interactive videos, booklets, and quizzes could facilitate better access to nutrition education by experienced dietitians/ diabetes educators.[28,29] Educational sessions are more effective with various entertaining and creative activities. This not only includes parents and children together, but it also facilitates the creative and enjoyable transfer of knowledge. Reinforcement can be provided with online general awareness sessions.
→ Peer support groups have demonstrated encouraging outcomes in imparting education and improving diabetes management, and this makes them a viable and affordable strategy for nutrition education and guidance while also encouraging self-care and BG management.[30]
→ It is also essential to educate individuals with T1D and their families to bust prevailing myths around fad diets, including low-carbohydrate or keto diets, forbidding certain foods, 'Instagram diets,' or blindly following social media influencers and self-proclaimed experts.[31] WhatsApp can be used to share healthy carbohydrate-counted recipes, and individuals are encouraged to share pictures of their plates.
→ Nutrition education/ review should be done at every visit to the clinic, which would be frequent in the first month after diagnosis and then at least every three months.[9,10,19] Initially, it is important to focus on core issues of high significance, such as hypoglycemia prevention and treatment, correct insulin technique, insulin storage, and the basics of MNT. Subsequently, more detailed issues such as managing nutrition in school, during holidays, travel, and exams should be dealt with.
→ At every clinic visit, diet compliance and difficulties faced by individuals with T1D and caregivers should be enquired about, and MNT issues should be resolved. Any individual failing to maintain glycemic targets or experiencing wide BG fluctuations should undergo a detailed nutrition analysis and re-education.
Education about nutrition is an ongoing process. The emotional well-being of the individuals with T1D and their families must be considered while designing a strategy, as it can impact their retention. While nutrition education should be initiated at the time of diagnosis, in many cases, it may be better to go into details after a few days, when the family has somewhat recovered from the shock of diagnosis and can absorb more information. The customized food plan must include locally available foods that the family can easily access and afford. (Refer to Chapter 15)
This flowchart (Figure 2.1) outlines the sequential steps of visits and the activities involved in each visit to manage dietary education in individuals with T1D.

Figure 2.1: Sequential steps of visits and the activities involved.



2.4.4. Follow-Up: Monitoring and Evaluation

2.4.4.1. Follow-up Visits

Following diagnosis, a sequence of follow-up consultations are planned; the first review session should occur within one month, with subsequent interactions at least every two months during the first year, followed by an evaluation at least every three months.[2] For the best care, ongoing assistance and evaluation by a dietitian familiar with T1D is needed. The frequency of review will depend on some factors, including modifications to the insulin regimen, mode of insulin delivery, dyslipidemia, the requirement for age-appropriate education, and weight changes.[19] Co-morbidities like celiac disease, discussed in Chapter 14, necessitate additional knowledge and more frequent reviews. Likewise, transition times like puberty, the shift from pediatric to adult care, beginning a new exercise regimen, starting hostel life or a new job, etc., could necessitate more regular visits to the dietitian.[19]

2.4.4.2. Monitoring and Evaluation

Reviewing progress is crucial to determine the appropriateness and efficacy of the prescribed MNT through dietary and lifestyle assessments. They can reveal significant dietary and behavioral changes crucial for long-term dietary adherence.[19] Follow-up sessions with the diabetes educator/ dietitian are needed to resolve queries/ problems and continue nutrition counseling and motivation (face-to-face or telephonic meetings). (Table 2.3)

Table 2.3: Checklist for follow-up sessions

A checklist during follow-up sessions can be useful to ensure important aspects are not missed:

- Anthropometry: monitoring height, weight, BP, and growth chart plotting at every visit. Calculating body mass index (BMI) and, if possible, monitoring the body fat percentage may be helpful.
- Dietary recall of the past three days during school days and holidays.
- Understanding the basics of MNT management and revision of CC.
- Adherence to MNT, any affordability or logistic issues.
- Understanding meal-related insulin dose adjustment.
- Inquiry about specific challenges faced and personal likes and dislikes.
- Clarifying myths around diet.
- Enabling the child and caregiver to understand the carbohydrate content of newer foods in the market space and new recipes that the family may try at home by reading food labels.
- Identifying disordered eating behavior and addressing the issue; determining if there is a need to involve a counselor.

2.4.4.3. Other Components

Countering hypoglycemia

Management of hypoglycemia is covered in detail in Chapter 13. A single episode of nocturnal hypoglycemia or severe hypoglycemia can prove to be a major hurdle in reaching glycemic targets. Meal planning from the beginning, with adequately spaced meals and proportionate distribution of each meal and snack, can help prevent hypoglycemia.[31] Individuals should always carry two to three 5g packets of sugar and a carbohydrate snack to prevent hypoglycemia. A bedtime snack to avert nocturnal hypoglycemia may be needed by those on Regular insulin, those who are physically very active in the evenings, or if the bedtime BG is low.[32,33]

Nutrition management of exercise:

Exercise is discussed in detail in Chapter 10. Reducing insulin doses appropriately and planning exercise-related meals/snacks, with 0.3-0.5 g/kg of additional carbohydrates for every 45-60 minutes of moderate to intense physical activity, can reduce the risk of hypoglycemia during and after exercise.[34] A higher amount of carbohydrates, even up to 1-1.5 g/kg per hour, may be needed if the PwD has had recent hypoglycemia, as hypoglycemia unawareness may be present.[5] For prolonged exercise, slow-releasing carbohydrates, and for shorter-duration exercise, faster-releasing carbohydrates can be chosen.[5] Proteins and fats should be incorporated in snacks (e.g., a spoonful or *ladoo* of nuts and seeds) and dinner to prevent late-night hypoglycemia.

Continuous Glucose Monitoring (CGM)

CGM is very helpful in tailoring MNT and managing diabetes well, and it should ideally be used by each person with T1D from the time of diagnosis.[35]

2.4.4.4. Role of Schools in Nutrition Education

Teamwork is necessary to manage diabetes in school: teachers, school nurses, and other staff should be given a diabetes management plan and be involved in diabetes care by the family and medical team. In school, the child must test BG and take insulin before having the school meal/ tiffin. Testing BG periodically at other times, and taking corrective action for hypoglycemia or ketosis may be needed. All this should be done under a teacher's supervision.[36] It may be easier for the parents to estimate the carbohydrate content of the tiffin, and give the child a sliding scale (to include the correction dose) for insulin dose for that particular meal, requesting school authorities to allow the child to take the dose under the teacher's supervision in the classroom itself, rather than going to the medical room every day.[36] Instilling healthy eating habits in the child and family and encouraging them to discuss these habits and healthy options with peers can lessen the influence of peers to consume unhealthy meals.[37] At the same time, the child should be aware at least of approximate CC so that if he/ she is planning to share food with friends, the insulin dose can be adjusted as needed. This normalizes life for the child and reduces the chances of sneaking in extra food not covered by insulin.

2.5. SPECIAL SITUATIONS

Apart from school, there will be several occasions like festivals, celebrations, or fasting, when the food will be different. Details of how to handle feasting and fasting are discussed in Chapter 9. Being able to eat unhealthy and rich food occasionally is important for ensuring mental well-being and compliance, and being able to adjust insulin doses and physical activity accordingly ensures that glycemic control is maintained. It is also important to find out if there are periods of food insecurity, intense physical labor (e.g., during farming), or both, and educate the family on how to cope with such situations. For example, the PwD should not be left unaccompanied during such situations, and physical labor may have to be forbidden for the individual if adequate food is not available.

Encouraging the child with diabetes, the other children (boys and girls), and all adults (men and women) in the family to be involved in age-appropriate ways with buying provisions (including fruits and vegetables), planning menus, and cooking on a regular basis is needed to maximize home cooking and making sure that the entire responsibility for MNT does not fall on one person. Such participative involvement makes home cooking feasible and enjoyable rather than a burden,

reduces conflict, and ensures lifelong healthy eating. The family should be explained that learning this essential life skill would promote well-being and reduce future financial and medical problems (hypertension, dyslipidemia, obesity, acne, hirsutism, reproductive outcomes, arthritis, etc).

2.6. SUMMARY & RECOMMENDATIONS

• Meal planning and nutritional education is an important pillar in managing T1D.
• There is no "one size which fits all". Individualized meal planning is the key.
• Nutrition education should build a positive outlook towards nutrition management.
• Nutrition advice is not limited to individuals with T1D; the entire family should practice healthy eating.
• Personal preferences, family traditions, and beliefs must be taken into account.
• The meal plan should consider exercise, travel, sick days, festive and other occasions, comorbid conditions, and the presence of complications, if any.
• The dietitian's assessment and advice should begin at the time of diagnosis, intensively for the first month, thereafter at least four times a year, and more often if glycemic control is poor or during times of transition.
• Nutrition education encompasses key learning concepts such as healthy eating, CC followed by protein and fat counting, glycemic index, glycemic load, portion control, and following a balanced meal plan.
• Meal planning should aim at preventing hypoglycemia and hyperglycemia, as well as obesity, hypertension, and dyslipidemia.

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CHAPTER 3: Normal Growth and Development; Recommendations for Nutrition Requirements.

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3.1. INTRODUCTION

Medical Nutrition Therapy (MNT) is essential to managing Type 1 Diabetes Mellitus (T1D). The dietary recommendations for children with diabetes are based on healthy eating guidelines suitable for all children and adults to improve diabetes outcomes, allow normal growth and development, and reduce cardiovascular risk and other chronic complications.[1] The dietary habits and cuisines in a family, across countries and regions, are determined by ethnicity, culture, and socioeconomic status differences. Nutritional advice for a child must be adapted to cultural, ethnic, and family traditions, available resources, growth phase, and the psychosocial needs of the individual and the family. It should also account for co-existing conditions such as lactose or gluten intolerance and food allergies, if any. The focus is to ensure normal growth, development, and mental health, and maintain a healthy weight, Blood Pressure (BP), and Body Mass Index (BMI).[1]

3.2. ENERGY NEEDS AT VARIOUS AGES

3.2.1. Energy Requirements of Infants, Children, Adolescents, Young Adults

Energy requirements of infants, children, and adolescents are estimated as the amount of dietary energy needed for a desirable level of physical activity and to support optimal growth and development consistent with long-term health. The energy requirement for children and young adults with T1D is similar to the age and sex-matched healthy population (Table 3.1). Therefore, when planning the diet for an individual with T1D, the Indian Council of Medical Research - National Institute of Nutrition (ICMR-NIN) recommendations can be used.[2] The Estimated Average Requirement (EAR) is to be considered for the individual. It should be kept in mind that soon after diagnosis of T1D and after recovery from any episode of Diabetes Ketoacidosis (DKA), the caloric requirement is higher than usual to restore the preceding catabolic weight loss. This phase lasts till the pre-illness weight has been regained. Once the weight has normalized, appropriate advice should be given for the child/ adolescent to avoid obesity. The need for increased calorie intake should be individualized based on the nutritional status.

Table 3.1: Macronutrient and micronutrient composition as a percentage of total daily energy intake

MACRONUTRIENTS	PERCENTAGE OF TOTAL DAILY ENERGY INTAKE
Carbohydrates	45-55% (Sucrose should contribute <10%)
Fats	25-30% (Saturated Fats <10%)
Proteins	15-20% (50% from good quality proteins)
Micronutrients	Vitamin and mineral requirements are similar to that of healthy children.
Fiber (g/day)	5 g + age of the child
Salt	Similar to that of healthy children. 1-3 years: 1000 mg/day (2.5 g salt/ day); 4-8 years: 1200 mg/day (3 g salt/day); 9 years and older: 1500 mg/day (3.8 g salt/ day) Pickles, papad & processed foods: high salt content, to be avoided

3.2.2. Energy Balance

The growth rate is a good indicator of overall dietary adequacy during infancy, childhood, and adolescence. Meal planning for children with T1D should consider all the factors affecting energy balance like growth rate, level of physical activity[3], physiological states like puberty[4,5], pathological conditions with altered energy requirements (conditions that are likely to interfere with nutrient availability, affect substrate utilization) like trauma, infections, systemic illnesses, and comorbidities like celiac disease, autoimmune liver disease, etc.[6] Energy deficit leads to undernutrition and growth failure; delayed motor, cognitive, and behavioral development; diminished immunocompetence; and increased morbidity and risk for mortality.[7] On the other hand, excess energy intake with a sedentary lifestyle can result in overweight/ obesity and its comorbidities, including hyperlipidemia, hypertension, hyperandrogenism, metabolic dysfunction associated with steatotic liver disease, orthopedic problems, etc. Energy imbalance in children with T1D will also have an adverse impact on glycemic control and compound the short-term and long-term risk of microvascular and macrovascular complications, respectively.[3]

3.3. MACRO AND MICRONUTRIENT NEEDS AT VARIOUS AGES

3.3.1. Macronutrients - Classes & Distribution Ranges

Macronutrients are defined as nutrients required in large quantities to provide energy and maintain body structure. The three main food components that do so are carbohydrates, protein, and fat. The accepted range of macronutrient intake needed to provide adequate quantities of essential nutrients with a reduced risk of chronic diseases is called the Acceptable Macronutrient Distribution Range (AMDR) and is expressed as a percentage of energy derived from carbohydrates, protein, and fats. Guidelines by The International Society for Pediatric and Adolescent Diabetes (ISPAD)[1] & ICMR-NIN[8] recommend that carbohydrates provide 45-55%, fats provide 25-30%, and proteins 15-20% of total daily energy intake for optimizing Blood Glucose (BG) control and promoting normal growth in children. Sucrose and saturated fatty acid intake should each be restricted to less than 10% of total energy intake. Each nutrient has a set of Dietary Reference Intake (DRI), which includes an EAR and Recommended Dietary Allowance (RDA) or an equivalent Adequate Intake (AI) when the EAR and RDA of a nutrient cannot be defined. EAR, AI, and Tolerable Upper Limit (TUL) should guide food intake to prevent excess and deficiency.[2] The definition of each of these terms is listed in Table 3.2.

Table 3.2: Definition of important terms

TERMS	DEFINITION
Average Nutrient Intake (ANI) OR Estimated Average Requirement (EAR)	The average daily nutrient intake level is measured to meet the requirement of half of healthy individuals in a particular life stage and gender. This is used to evaluate groups or populations.
Recommended Dietary Allowance (RDA) OR Recommended Nutrient Intake	Daily dietary nutrient intake level is sufficient to meet the nutrient requirement of nearly all (97-98%) healthy individuals in a particular life stage and gender group. It is calculated as ANI plus 2 Standard Deviations of the distribution of requirements. This is specifically used to evaluate individual diets, and not for dietary assessment of groups.
Adequate Intake (AI) or safe intake	Defined as the recommended average daily intake based on experimentally determined or observed estimates of nutrient intake by a group of apparently healthy individuals that are assumed to be adequate; used when there is a lack of scientific evidence to set RDA or determine EAR.
Upper Nutrient Level OR Tolerable Upper Level (TUL)	Defined as the highest daily nutrient intake level not to cause any risk of adverse health effects to almost all individuals in the general population; intake above this level increases the probability of adverse health effects.

India is a diverse country, and cuisines vary in each region. Hence, a customized meal approach that considers personal and cultural preferences must be discussed with the family. Other variables that need to be considered in the dietary recommendation are seasonal variations, the child's activity levels, daily routine and school timings and the school timetable, socioeconomic status, and family structure.[9–12] Consideration of the school timetable is critical because there are days when Physical Education (PE) and Physical Training (PT) classes may be held, and some other days during the week could be sedentary. Meals and amounts need to consider travel time for returning home from school. Hypoglycemia or marked hyperglycemia occurring when the child is not at home can be stressful and demoralizing, and must be avoided.

Dietary Carbohydrates

Carbohydrates are the main energy sources, with each gram providing four calories.[13] Grains, pulses, vegetables, fruits, sugar in any form, milk, and milk products are the major sources of carbohydrates in a child's diet. Carbohydrate intake is the primary determinant of short-term impact on Post-prandial Blood Glucose (PPBG) levels. Carbohydrates can be grouped into glycemic carbohydrates or simple sugars (monosaccharides, disaccharides) and non-glycemic carbohydrates or complex carbohydrates (oligosaccharides and polysaccharides like starch, maltodextrin).[14] Glycemic carbohydrates are quickly digested and lead to sharp spikes in BG. In contrast, complex carbohydrates like starch in whole grain cereals, legumes, and vegetables result in slow digestion and a gradual rise in BG. Consuming carbohydrates in natural forms is preferred to refined forms as the former is associated with slow and lower spikes in BG.[15] Insulin regimens and doses must be matched to the meal's carbohydrate content to control PPBG. Sucrose (glucose + fructose) and sucrose-containing foods must contribute to less than 10% (for a person of healthy body weight) and ideally less than 5% of the energy intake[16] and be adequately covered with insulin. Sugary foods and beverages cause Post-prandial (PP) hyperglycemia and weight gain, so their consumption should be minimized.

Besides carbohydrate content in the meal, several other factors influence the glycemic response to food, like the Glycemic Index (GI), the Glycemic Load (GL), food processing techniques, and the content of other food components like fiber, fat, and protein.

The GI measures the rise in BG above the fasting level in the 2 hours after ingestion of 50 g of the carbohydrate under study, compared with the response to glucose which is considered to have a standard GI value of 100. The type of carbohydrates, cooking technique, processing, storage, and stage of ripeness influence GI. Foods are classified as having low, medium, and high GI if the GI is <55, 55-69, and ≥70, respectively.[17] Moderate to Low GI foods produce slower and lower PPBG. Moderate to Low GI foods include foods like *chapatis* and bread made from whole wheat, millets and gram flour; soybeans, kidney beans, peas, and lentils; yogurt; fruits such as apples, peaches, pears, etc. Foods with high GI include foods made from refined flour (*maida*) like white bread and savories, semolina, white rice, puffed rice, maize especially cornflakes, *ragi*, potatoes, tapioca, fruits like pineapple, papaya, mango, and sugars like honey and *gur*. The higher the GI of a food, the faster the BG will rise. Substituting high GI foods with low GI foods helps to reduce PPBG spikes.[18]

GL is the net effect of a carbohydrate intake on BG, which takes into consideration both the quantity (portion size) and food quality. GL is calculated by multiplying the GI with the carbohydrate content and dividing by 100. GL of <10 is considered low, while >20 is high.[19] (refer to Chapter 7).

Carbohydrate counting (CC)

CC is a meal planning approach that focuses on estimating carbohydrate content in a meal, since it is the main determinant of the PP glycemic response and deciding the dose of the bolus insulin to be taken. It aims to improve glycemic control while allowing flexibility in food choices and meal routines, thereby improving diabetes-specific health-related quality of life.[20] The international consensus is to introduce CC at the time of diabetes diagnosis and teach how to titrate insulin dose (based on the meal's carbohydrate content) for optimizing BG. CC methods include estimating the exact grams of carbohydrates in a meal by measuring ingredients, or by using a carbohydrate exchange list.[15] Reading nutrition labels on packaged foods (serving size and total carbohydrates in each serving size) must also be taught to both caregivers and the child when he/she is old enough to estimate the carbohydrate content consumed.[21,22] (refer to Chapters 5 & 8)

Low Carbohydrate Diet

Low carbohydrate diets are those that provide <26% energy from carbohydrates. They sound fascinating, as they may improve glycemic control and lower HbA1c in the short term, but they tend to be nutritionally inadequate and can lead to growth failure. Scientific evidence in their support is scarce.[23] Instead, such diets may lead to ketonemia or ketosis, dyslipidemia, and disordered eating behaviors.[24] They may

also increase the risk of hypoglycemia or impair the ability of glucagon to treat severe hypoglycemia.[25] Therefore, carbohydrate content should not be restricted below 40%.

Dietary fiber

Dietary fiber refers to the indigestible carbohydrates in food. It is present in legumes, lentils, beans, whole grain cereals (unpolished rice, wheat), vegetables, and whole fruits with skin, which are usually adequate in the traditional Indian diet.[18] Whole fruit intake is encouraged; fruit juice is discouraged as it lacks fiber and provides no nutritional advantage. Soluble fiber improves total and Low-density Lipoprotein (LDL) cholesterol levels by binding to bile salts, slows carbohydrate absorption by delaying gastric emptying, thus giving a flatter BG curve, and may reduce insulin requirement. Dietary fiber is also crucial as a prebiotic, potentially improving gut microflora.[26] Fiber provides satiety, does not contribute to calories, and prevents constipation.[27] The recommended daily dietary fiber in grams is calculated by adding 5 to the child's age (15 g/1000 calories & 30 g/2000 calories).[28]

Dietary Proteins

Proteins are the building blocks that form the structural and functional components of the cell, which promote growth, but only when sufficient total energy is available. Amino acids are the building blocks of protein. They help in the growth, synthesis, and repair of body tissues. There are 24 amino acids, of which 9 are essential for all age groups. For infants under 6 months of life, breast milk is the optimal source of protein that sustains growth and good health. The EAR of protein intake for infants (<6 months), children (6 months - 10 years), and adolescents is given in Table 3.3. Protein requirements also vary with physiological states, activity, and stress; they are generally higher during infections and illnesses or stress. Foods like pulses, legumes, nuts, milk and other dairy products, eggs, meat and fish are protein sources.[29]

Dietary proteins differ in their ability to provide nitrogen and amino acids to support growth due to variations in amino acid composition and digestibility. Animal sources (eggs, milk, meat, fish) and soy protein are of high biological value as they provide all the essential amino acids in the required amounts.[30] Vegetable proteins (legumes, beans, nuts, seeds, and cereals) work best in combination as they have lower biological value, being deficient in one or the other essential amino acids (methionine in pulses, and lysine in cereals). Protein complementation (combining two plant sources, for example, legumes and grains, nuts, and grains; or plant and dairy, for example, legumes/ grains/ nuts with dairy) is recommended to provide all 9 essential amino acids the body requires.[31] Protein intake in children with T1D should be similar to that of their age- and sex-matched normal healthy peers. Half the protein intake should come from good-quality protein lean sources that are low in saturated fat, like legumes, low-fat dairy products, fish, and lean meats. Vegetable proteins like legumes, beans, and soy contain more fiber and complex carbohydrates, and less saturated fat. Every major meal or large snack should include a protein source to reduce PPBG excursions and achieve satiety.[18] This can be achieved by adding whole pulses/ sprouts/ *sattu* (roasted chickpea flour)/ soybean/ curd/ cottage cheese (*paneer*)/ egg/ chicken/ fish in varied proportions. High protein drinks and food supplements are neither needed nor recommended for children with diabetes. In patients with diabetic nephropathy, the recommendation of protein (quantity and quality) must be individualized and based on the individual's current dietary intake; in most instances, existing protein intake is already low enough not to require further reduction.

Table 3.3: Summary of Estimated Average Requirement (EAR) of Nutrients for Indians[2]

Category/Age Group	Physical activi-tylevel	Body Wt (Kg)	Energy (**) (Kcal/ d)	(kcal Kg/d)	(g/d)	Protein (g/kg/d)	Calcium (mg/d)	Magnesium (mg/d)	Iron (mg/d)	zinc (mg/d)	Iodine (ug/d)	Thiamine (mg/d)	Riboflavin (mg/d)	Niacin (mg/d)	Vit B6 (ug/d)	Folate (ug/d)	Vit B12 (ug/d)	Vit C (mg/d)	Vit A (ug/d)	Vit D (IU/d)
Adult Men >18y	Sedentary	65	2110	32	43	0.66	800	370	11	14.1	95	1.2	1.6	12	1.6	250	2	65	460	400
	Moderate		2710	42								1.5	2.1	15	2.1					
	Heavy		3470	53								1.9	2.7	19	2.6					
Adult women >18y	Sedentary	55	1660	30	36	0.66	800	310	15	11.0	95	1.1	1.6	9	1.6	180	2	55	390	400
	Moderate		2130	39								1.4	2.0	12	1.6					
	Heavy		2720	49								1.8	2.6	15	2.1					
Pregnant#	-					0.66 (2nd trimester, additional 7.6g/day)	800	370	21	12	160	1.6	2.3	11	1.9	480	2.2	65	406	400
		55	AddL Calories required 350		44															
		+																		
		10				0.66 (3rd trimester, additional 17.6g/day)														
		GWG			54															
Lactation#0-6m	_	55	Addl. Calories required 600		50.0	0.66 (additional 10.6g/day)							2.5		1.82					
7-12m			520		47.0	0.66 (additional 13.6g/day)	1000	335	16	11.8	200	1.7	2.4	13	1.76	280	2.8	95	720	400
Infants 0-6m*	__	5.8	530	90	7.0	1.16	_	_	_	_	_	_	_	_	_	_	_	_	_	_
6-12m		8.5	680	80	9.0	1.04			2	2.1					0.5	71	1		170	
Children																				
1-3y	_	12.9	1110	83	10.0	0.79	400	73	6	2.8	65	0.6	0.8	6	0.8	97	1	24	180	400
4-6y		18.3	1360	74	13.0	0.70	450	104	8	3.7	65	0.8	1.1	8	1.0	111	2	27	240	
7-9y		25.3	1700	67	19.0	0 75	500	144	10	4.9	65	1.0	1.3	10	1.3	142	2	36	290	
Boys 10-12y	_	34.9	2220	64	27	0.75	650	199	12	7	70	1.3	1.7	12	1.7	180	2	45	360	400
Girls 10-12y	_	36.4	2060	57	27	0.73	650	207	16	7.1	70	1.2	1.6	12	1.6	186	2	44	370	400
Boys 13-15y	_	50.5	2860	57	36	0.72	800	287	15	11.9	100	1.6	2.2	16	2.2	238	2	60	430	400
Girls 13-15y	_	49.6	2440	49	35	0.7	800	282	17	10.7	100	1.3	1.9	13	1.8	204	2	55	420	400
Boys 16-18y	_	64.4	3320	52	45	0.7	850	367	18	14.7	100	1.9	2.5	19	2.5	286	2	70	480	400
Girls 16-18y	_	55.7	2500	45	37	0.67	850	317	18	11.8	100	1.4	1.9	14	1.9	223	2	57	400	400

*Adequate intake (AI); ** There is no RDA for energy; the EAR for energy is equivalent to the Estimated Energy Requirement (EER).

Apart from the daily requirement of Energy per kg body weight, pregnant women should take an additional energy allowance of 350Kcals/day, while lactating women require an additional energy allowance of 600 Kcals and 520 Kcals, respectively.

Protein requirement (EAR): additional 7.6g and 17.6g during the 2nd and 3rd trimesters for pregnant women and 13.6g & 10.6g for lactating women, respectively. An additional requirement for protein is for 10kg gestational weight gain (GWG). Protein recommendation is for quality protein

Dietary Fats

Fats are concentrated energy sources that help digestion, absorption, and transport of fat-soluble vitamins. Intake of fats in children with diabetes should be limited to 25-30% of total energy intake.[1,8] Fats are categorized as saturated and mono- or poly-unsaturated fats. Saturated Fatty Acids (SFA) are stable, and some are solid at room temperature. Coconut oil, palm oil, fats from dairy (cheese, butter, ghee), and animal foods like meat provide SFA. They increase LDL cholesterol, and should provide <10% of the total energy.

Long-chain Polyunsaturated Fatty Acids (PUFAs) such as omega-6 (including linoleic acid) and omega-3 (including alpha-linolenic acid) are essential fatty acids, as they are not synthesized in the body.[32] Omega-3 PUFA may be low in traditional Indian diets; dietary sources include soybean, canola, and mustard oils, pulses like black chickpeas (*kala chana*), kidney beans (*rajma*), cowpeas (*lobia*), flaxseeds, walnuts, and deep-sea fish like tuna, sardine, mackerel, and salmon.[33] Vegetable oils like sunflower oil, safflower oil, cottonseed oil, corn oil, soyabean oil, groundnut oil, and sesame oil are rich in omega-6.[34] The ratio of omega-6 to omega-3 fatty acids should be 5:1 to 10:1 to prevent free radical injury, angiotoxicity, and atherogenic risk.[35] Monounsaturated Fatty Acids (MUFA) are the healthiest, as they reduce the LDL cholesterol, and their consumption (10% + any calories left from carbohydrate portion) is preferred over PUFA. Sesame oil, rice bran oil, mustard oil, olive oil, peanuts and peanut oil, almonds, and avocados are good sources of MUFA. SFA, MUFA, and PUFA are recommended in the ratio of 1:1.5:1.

An appropriate SFA, MUFA, and PUFA blend can be achieved by consuming different fats and including foods rich in omega-3 PUFA, such as legumes, green leafy vegetables, fenugreek, and flaxseeds. Blended cooking oils or using different oils for different recipes combines the benefits of component oils and provides a balance of fatty acids and antioxidants, enhancing the oxidative & thermal stability of oils.[36] An appropriate combination of the edible oils (Groundnut or Sesame or Rice bran + Mustard; Groundnut or Sesame or Rice bran + Soyabean; Safflower or Sunflower + Palmolein + Mustard; Groundnut or Sesame or Rice bran + Canola) provide a favorable lipid ratio, decreases inflammation and thus reduce atherogenic risk.[36] ICMR-NIN India has recommended the rotation of oils or the use of commercially available blended oils to acquire the right balance of fatty acids in the diet.[2]

Hydrogenation of oils leads to the production of trans fatty acids, whose intake is associated with an increased risk of coronary heart disease.[37,38] Hydrogenated oils are found in several processed foods, commercially prepared fried foods (like samosas, french fries, and chips), bakery products, vanaspati (e.g., *Dalda*), and margarine (e.g., *Nutralite*). They should be eliminated from the diet as they raise LDL cholesterol and lower High-density Lipoprotein (HDL) cholesterol, making them more dangerous than saturated fats.[37] Understanding the nutrition labels when consuming processed foods is important, particularly for monitoring the amount of trans fatty acids. Regulatory bodies like the Food Safety and Standards Authority of India (FSSAI) have set guidelines and limits to control the amount of trans fats in food products. This upper limit is designed to minimize the health risks associated with trans fats while allowing some flexibility for food manufacturers. This information helps consumers make informed choices about their dietary intake and adhere to recommended limits for maintaining better health.

3.3.2. Micronutrients in Health

Micronutrients are the essential nutrients required in minimal amounts for good health and adequate growth and development. Even though they are required in minuscule quantities, their absence makes an individual vulnerable to deficiency states. Micronutrient deficiencies are called "hidden hunger" as they may not give rise to classical signs and symptoms until the deficiency becomes severe.[39] Vitamins are essential for maintaining numerous body functions and are classified as water-soluble (vitamin C and the B-complex) or fat-soluble (A, D, E, and K). Minerals are required for the integrity of skin, hair, bones, nails, blood, and soft tissues. They help in nerve cell transmission, acid/ base and fluid balance, enzyme and hormone activity, and blood-clotting functions. The important macro-minerals are sodium, potassium, calcium, phosphorus, magnesium, and sulfur, while zinc, copper, selenium, molybdenum, fluorine, cobalt, chromium, and iodine are micro-minerals.[40,41] Children with diabetes have the same vitamin and mineral requirements as other healthy children.[2] Individualized meal planning should have optimal food choices to meet the recommended dietary allowance for all micronutrients. Children on a balanced, adequately diverse diet, with normal growth and development, do not require routine supplementation of vitamins and minerals. Therefore, routine supplementation of antioxidants, such as vitamins E and C and beta-carotene, is not recommended - because of lack of evidence of efficacy and concerns related to long-term safety. Fresh fruits and vegetables are naturally rich sources of antioxidants (tocopherols, carotenoids, vitamin C, and flavonoids) (Table 3.4). They are strongly recommended for children with diabetes as they protect against oxidative stress and inflammation and provide cardiovascular protection.

Table 3.4: List of fruits and vegetables rich in antioxidants

Carotenoids • Beta-carotene (a type of carotenoid that converts to vitamin A): ❖ Fruits: Mangoes, apricots, melons, watermelons, papaya ❖ Vegetables: Carrots, sweet potatoes, butternut squash, pumpkin, red peppers • **Lutein and Zeaxanthin** ❖ Fruits: Kiwi, grapes ❖ Vegetables: Spinach, corn, Kale
Vitamin C • Fruits: Lemons, guavas, papaya, oranges, strawberries, kiwi, guavas, papayas • Vegetables: Tomatoes, gooseberry, bell peppers (especially red and yellow), broccoli, Brussels sprouts
Tocopherols (Vitamin E) • Fruits: Kiwi, avocados • Vegetables: Spinach, broccoli
Flavonoids • Fruits: ❖ Berries: Jamun, mulberry, strawberries, raspberries, blackberries ❖ Citrus Fruits: Oranges, grapefruits, lemons ❖ Others: Apples, grapes, cherries • Vegetables: ❖ Cruciferous Vegetables: Cabbage, cauliflower ❖ Others: Onions, red cabbage, brinjal

3.3.3. Salt Intake Recommendations

Salt intake recommendations in children with T1D are similar to those of age-matched healthy children (Table 3.1). In an attempt to consume a "non-sweet" diet, children may have meals and snacks with high salt content that can predispose them to hypertension.[32] Packaged foods like baked products (bread, biscuits, pizza), canned and packaged foods, savories like namkeens, sauces, papads, pickles, other preserved foods,

and Chinese/ Korean food have high amounts of salt. Therefore, all such food items with high salt should be restricted.

3.4. WHAT IS A HEALTHY EATING PATTERN?

Children and adolescents, whether they have T1D or not, are encouraged to adopt healthy eating patterns that support normal growth and development. Foods and beverages should be selected from diverse food groups (Figure 3.1) in correct proportions to achieve or maintain healthy body weight, ensure adequate nutrient intake, optimize BG, and prevent microvascular and macrovascular complications.[1,2] Parents and other family members have to be role models for the children to develop healthy eating patterns. Children should be involved in making decisions about food and make correct choices from an early age.[42] They should be taught how to cook early: to start with, they should be involved in making salads, *raitas*, and other easy-to-assemble foods. The traditionally practiced Indian concept of the '*Thali*' is now commonly known as the 'plate method' or the 'Joslin plate model.' Foods from all food groups, including whole grains, vegetables, pulses, dairy products, and non-vegetarian items, are incorporated for optimal food diversity, while the choice of meals is determined by the regional/ ethnic background, cost, and availability of food items, and the taste preferences of the child and family. Snacks are an important diet component in a young child; healthy options should be suggested to the family (Table 3.5). When planning snacks, it's essential to consider the carbohydrate content and how it fits into the child's overall meal plan. Liberal water intake should be encouraged, and juices and sugary beverages should be avoided at home or school. Under- and over-nutrition should be avoided at all ages.

Figure 3.1. Basic food groups and their sources

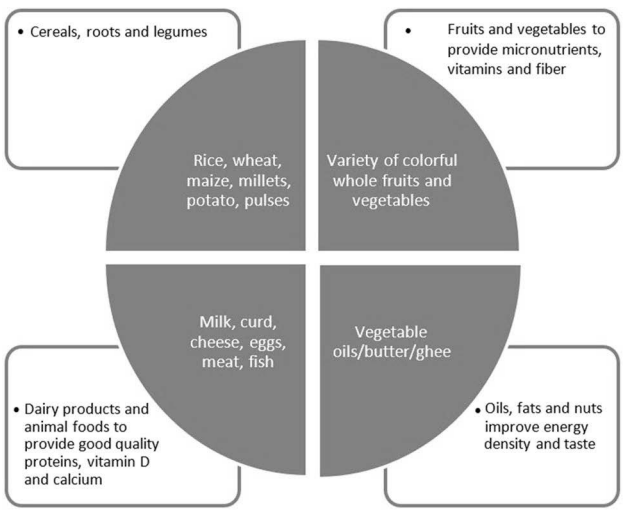

Table 3.5 Option of healthy snacks for children

- Fresh Fruits: Apples, pears, berries, and oranges are good options. Pair them with a small amount of nuts or seeds for added protein and fiber.
- Vegetable Sticks: Carrot, cucumber, and bell pepper sticks can be paired with a small portion of hummus or curd for dipping.
- Yogurt: Unsweetened homemade yogurt can be topped with fresh fruit or a sprinkle of nuts. It provides protein and probiotics without added sugars.
- Boiled Eggs: Boiled eggs are a great source of protein and can be seasoned lightly with salt and pepper.
- Nuts and Seeds: Peanuts, melon/ watermelon/ pumpkin/ sunflower seeds, almonds, walnuts, sunflower seeds, and chia seeds offer healthy fats and protein. Just be mindful of portion sizes.
- Homemade Energy Balls: These can be a nutritious and satisfying snack made with oats, nuts, seeds, and a bit of natural sweetener like honey or dates.
- Chia Seed Pudding: Made with chia seeds, milk (or a dairy-free alternative), and a small amount of fruit, this provides fiber and omega-3 fatty acids.
- Popped Corn: Air-popped corn or roasted corn (*bhutta*) is a whole-grain snack that's low in calories and can be seasoned with herbs and spices for flavor.
- Paneer Cubes: Paneer (Indian cottage cheese) is high in protein and calcium. It can be eaten plain or with a sprinkle of spices.

3.5. CHALLENGES AND NEEDS OF CHILDREN IN DIFFERENT AGE GROUPS

Food preferences and dietary patterns continue to evolve from toddlers, preschoolers, and school-age children to adolescents and young adults. Nutrition education and planning for a balanced diet, healthy eating patterns and behavior, should consider different age groups' specific nutrition and developmental needs. Pre-school children are more likely to have erratic food intake and activity; older children have more consistent routines but may be picky eaters or uncooperative at times. Adolescents are difficult to handle as they have mood swings, physiological insulin resistance, and BG swings. Also, rebellion and peer pressure can influence their food choices and timings of food intake in the face of increased need for macro- and micro-nutrients due to the growth spurt, increased appetite, and increased need for insulin; they are at risk for developing eating disorders.[43] Key nutrition-related challenges at different ages are ensuring dietary adequacy and diversity, dealing with fluctuations in appetite, achieving adequate intake of iron and other micronutrients, preventing consumption of sugary beverages and unhealthy food (biscuits, chips, *namkeens*, etc.)[44] and developing healthy eating behaviors and routines.[45] Parents are to be taught to adjust insulin bolus doses according to the carbohydrate content of the meal consumed, BG logs, and expected physical activity. Parents may need assistance in developing the skills to deal with situations where the child does not cooperate or the adolescent is sneaking food or insulin surreptitiously. During adolescence, independent education should be geared towards choosing appropriate healthy foods, reading food labels, and titrating insulin doses based on meal choices, activity, and lifestyle.[46]

The diabetes care team should discuss with the child/ adolescent and family and together prepare an individualized Diabetes Management Plan (DMP) for school staff regarding food eaten and insulin taken in school, based on the composition and size of the meal in school, whether taken from home or provided by the school.[47] Education and reinforcement are needed to promote the importance of healthy, family-based meals, proper portion sizes,

and regular, adequate, appropriate physical activity. Avoiding excessive snacking should be emphasized at all times, particularly during rapid growth phases, to prevent inappropriate weight gain and reduce the risk of cardiovascular disease or any other complication.

3.6. PHYSICAL ACTIVITY RECOMMENDATIONS

Exercise should be part of a healthy lifestyle for all, regardless of age, gender, or fitness level. All children should engage in at least 60 minutes of physical activity/ exercise daily, including at least 20 minutes of vigorous activity. Muscle and bone strengthening exercises should be done at least three days a week. These recommendations apply to children with T1D as well.[48] Exercise provides physical, metabolic, cardiovascular, and psychological benefits beyond glycemic control. The meal planning and insulin dose adjustments needed to avoid hyperglycemia and hypoglycemia during or after exercise are dealt with in Chapter 10. BG responses depend on whether exercise is aerobic/ anaerobic/ mixed, its duration and intensity, and the initial BG level. BG monitoring before, during, and after exercise; adequate calorie cover and hydration are needed, particularly for school events such as sports days, camps, etc.[49]

3.7. GROWTH MONITORING AND ONGOING CARE, DETECTING ABNORMALITIES

Growth is a key indicator of health in children. Children with well-controlled T1D should experience normal growth and development. Height, weight, and BP should be measured every 3-6 months and plotted along with BMI on appropriate growth charts. The Mid-parental Height (MPH) is calculated by carefully measuring both parents' height, taking the average, and adding 6.5 cm for boys or subtracting 6.5 cm for girls. The MPH gives the genetic potential of the individual child, with the final adult height likely to be within the range of MPH ± 7 cm. It is plotted on the right axis of the growth chart and gives an idea of the likely trajectory the child would follow. World Health Organization (WHO) growth reference standards[50] can be used for children up to 5 years of age, and the Indian Academy of Pediatrics (IAP) growth reference data[51,52] can be used beyond 5 years. Combined WHO (1-5 years) and IAP 2015 (5-18 years) growth charts are available on the IAP website, and an anthropometric calculator application is available for Android phones based on combined WHO-IAP charts. BMI in children aged 5-18 years should be interpreted using IAP 2015 reference charts. A BMI >23 adult equivalent is defined as overweight, and >27 adult equivalent is classified as obesity.[53] (see also Chapter 10)

Serial height measurements with plotting and calculating growth velocity are more valuable than single measurements. After the rapid growth of the first 2 years, a child should gain 5-6 cm and 2 kg/year till the onset of puberty, which should not be before the age of 8 years in girls (first sign breast budding) and 9 years in boys (first sign increase in testicular volume).[54] A child showing up-crossing or down-crossing of centiles should be carefully evaluated. Pubertal assessment and progression should be evaluated in the peripubertal age group. Measuring the waist circumference and the waist-hip ratio can be useful for monitoring obesity, which is becoming an increasing problem and should be prevented.[55] Children with poor growth velocity, short stature, weight loss, signs of malabsorption, and frequent unexplained hypoglycemia or hyperglycemia need thorough evaluation and screening for comorbidities like hypothyroidism, celiac disease, and macro/microvascular complications.

A team-based approach is optimal for effectively managing children with T1D, but it may not be available everywhere. The team should include a pediatric endocrinologist or pediatrician familiar with T1D care, a nurse educator, a dietitian, a mental health professional, and a social worker to ensure adequate care and capacity building. A qualified dietitian, experienced in childhood diabetes, should provide nutrition education to the child and the family.[56] With the increasing use of telemedicine, online help can be sought from experts.[57] The initial assessment of the child's nutritional needs and the family's usual dietary practices is necessary. Regular review during follow-up visits is especially needed for children with poor growth, excessive weight gain or loss, delayed puberty or pubertal arrest, high glycemic variability, and high HbA1c. Poor adherence to dietary recommendations can result in undernutrition or obesity, which can be identified through serial growth monitoring.

3.8. MAINTENANCE OF HEALTHY WEIGHT AND NUTRITIONAL STATUS

Children with newly diagnosed T1D, especially if presenting with DKA, may have a lower BMI than age and gender-matched healthy children due to the catabolic state induced by the preceding insulin deficiency. Normal body weight is usually restored within 6-8 weeks of starting insulin therapy, with a greater tendency for obesity than age- and gender-matched healthy peers.[58–60] This weight gain may be due to the lipogenic effect of insulin dose, poor physical activity (perception the child is "sick", and/or fear of hypoglycemia), and/or dietary imbalance. During puberty, intensification of insulin therapy may result in leptin resistance and greater adiposity, particularly in girls.[61] Adiposity has unfavorable health implications of increased cardiovascular risk factors like hypertension, dyslipidemia, and poor bone mass. Carbohydrate counting and a continuous glucose monitoring system can improve glycemic control. Besides nutrition, providing family-based guidance on modifiable lifestyle factors, including regular adequate physical activity, limiting screen time, and healthy sleep behaviors, is essential for maintaining good health and optimizing growth in children with T1D.

3.9. SUMMARY & RECOMMENDATIONS

- Children and young adults with T1D generally require energy, nutrient intake, and physical activity requirements similar to their healthy peers. Increased caloric intake may be necessary immediately after diagnosis or recovery from DKA to restore weight loss, followed by a focus on balanced intake to prevent obesity.
- Effective meal planning should account for factors like growth rate, physical activity, puberty, and any concurrent health conditions. Energy imbalances can lead to growth issues, weight complications, and poor glycemic control, impacting long-term health outcomes.
- Carbohydrates, the primary energy source, should prioritize whole foods like grains, fruits, and vegetables for sustained blood glucose control. Sugar intake should be restricted to less than 10%, preferably less than 5%, of daily intake, with careful attention to portion sizes and the GI of foods to minimize post-meal BG spikes.
- Dietary fiber from sources such as legumes, vegetables, fruits, and whole grains is recommended to improve digestion, maintain BG stability, and support overall health. A simple guideline is "age + 5 g" daily for children, providing benefits like satiety and reducing insulin needs.
- Adequate protein from lean sources, including both animal and plant-based options, supports growth and helps prevent BG excursions when included in each meal. Combining plant proteins, like grains with legumes, ensures all essential amino acids are consumed.
- Fat intake should be 25-30% of total calories, emphasizing unsaturated fats and limiting saturated fats to below 10%. An appropriate mix of fats (SFA, MUFA, and PUFA) supports cardiovascular health and provides balanced fatty acids essential for growth.

• Children with T1D have the same micronutrient requirements as other children. Regular intake of fresh fruits and vegetables is encouraged to provide antioxidants and prevent micronutrient deficiencies without relying on supplements.
• Children with T1D should engage in at least 60 minutes of physical activity daily, including muscle-strengthening exercises. Meal planning and insulin adjustments are recommended to support stable blood glucose levels around exercise.
• Regular monitoring of height, weight, and BMI is critical to detect growth issues early. Proper nutrition and lifestyle guidance are key for managing healthy body weight, particularly given the potential for obesity due to insulin therapy during puberty.

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Chapter 4: Assessment of Current Dietary Habits

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4.1. BACKGROUND AND RATIONALE

Nutrition is integral to Type 1 Diabetes Mellitus (T1D) management. The ideal diet meets caloric, macro-, and micronutrient needs, optimizes glycemic control while minimizing glycemic variability, and is suited to the cultural and socio-economic preferences of People with Diabetes (PwD). The dietary recommendations for T1D mimic those for the healthy population of the same age and gender.[1] Thus, it is important to eliminate the concept of a "diabetic diet" and promote "mindful eating."

Dietary management can be challenging in India due to varied meal practices across different regions and social strata.[2] It is best to modify the family's diet rather than make drastic changes to an individual's diet. Assessing the current diet intake and practices at the first visit and periodically after that is important.

4.2. METHODS OF ASSESSMENT OF DIETARY HABITS

A good dietary history plays a pivotal role in dietary management. We discuss how to assess diet habits so that recommendations can be planned.
Dietary recall is one of the easiest methods in the Outpatient Department (OPD) practice to understand a person's dietary pattern. A 24-hour recall, i.e., food consumed in the last 24 hours, gives a rough estimate of dietary habits.[3] A weekly recall is superior as it allows a more comprehensive understanding of eating habits on weekdays, weekends, and holidays, but it is less accurate unless noted down each day.
The following points must be considered for a thorough understanding of an individual's dietary habits:

a) ***Dietary pattern:***
• *Food restrictions*: Vegetarian/ Non-vegetarian/ Ovo-vegetarian/ Lacto-vegetarian/ Vegan; any other restrictions: always (e.g., no pork or no beef), or at particular times (e.g., vegetarian food only on specific days of the week or at specific times of the year).
• *Food allergies*: e.g., prawn, brinjal, peanuts, etc.
• *Food intolerance*: e.g., gluten intolerance, lactose intolerance, etc.
• *Food likes and dislikes* of the individual.

b) ***Frequency of meals and insulin administration:***
• Understanding the frequency of all meals consumed (which includes meals taken in school or elsewhere), along with the insulin regimen (timing of insulin administration, dose) with respect to food.

c) ***Rough estimate of total calories, carbohydrates, fats, and proteins consumed.***
• *Total calorie estimation:* Amounts consumed must be asked for.
• *Carbohydrate estimation:* The quality and quantity of carbohydrates have an immediate and major effect on the post-prandial (PP) glycemic profile and must be assessed. The quality of carbohydrates depends on whether they are processed or unprocessed, the method of cooking, and the fiber content.[4]
• *Protein estimation* also needs to be assessed because the quality and quantity of protein also affect the PP glycemic profile, but more slowly and to a lesser extent. The nutritive quality of proteins depends on their source (plant vs. animal), fiber content (e.g., whole *dals* have plenty of fiber, while egg has none), and cooking method.[5]
• *Fat estimation* alters the glycemic response, and also affects cardiovascular health. It is best done by taking the family's history of consumption of all the different fats over a month and calculating the average consumption per person per month. This would enable an understanding of the types and varieties of fats and the quantity of each fat used. For example, when asked for the amount of fat consumed, a family may state the amount of mustard oil used for cooking but not realize the other fats must also be tracked, e.g., the sunflower oil used for frying, sesame oil for seasoning, butter for making cakes and sandwiches, ghee for making *dosas* or *parathas*, in addition to mayonnaise and sandwich spreads, and the fat content (fat percentage) of the milk and other dairy products consumed. Hence, all these fat categories should be specifically asked for, since it is important to know the total and relative quantities of all oils, ghee, butter, vanaspati, dairy fat, mayo, spreads, etc.[6]

d) ***Technology to assess dietary habits:***
• Compared to conventional food records, various mobile applications and digital platforms offer much more information than just the food consumed. Data may be self-administered, or the applications may have an interviewer-based dietary assessment.
• Technology allows people to assess foods consumed and specific brands accurately; image-based assessment with food photographs allows the application to approximately measure the portion size consumed. Real-time documentation of food and estimation of calories, proteins, micronutrients, and water intake, accessed from any location, is the greatest advantage of dietary assessment with digital methods.[7]
• The major challenges with the use of such applications include the need for internet access, computer literacy, the accuracy of the applications used, the need for better standardization of calorie/ nutrient content of food items across various digital platforms, and the availability of software that includes a wide variety of cuisine to allow data entry.[8]

e) ***Frequency of eating out/ ordering-in meals/ parties/ other events:***
• This is an important parameter to analyze the amount of fat, salt, and sugar intake: the time of eating out and the items ordered should be included in the recall as there may be Blood Glucose (BG) spikes after foods with refined carbohydrates or sugar or sugar-sweetened beverages, or delayed BG spikes after high-fat or high-protein foods. If alcohol is consumed, it's frequency, quantity, and type need to assessed.

f) ***School meals:***
• The number and timings of the snack/ meal breaks at school - whether the child eats food provided by the school, buys from the school cafeteria, or takes tiffin from home, and whether tiffins are shared. The food portions and options given for meals during or before any physical activity in school should be asked for: they are also more likely to have high fat, sugar, and salt content.[9]

g) ***Analyzing snacks given during hypoglycemia:***
• Often, children are inappropriately fed high-calorie, high-fat foods (desserts, biscuits) instead of simple sugars to overcome an episode of hypoglycemia. Enquiring about foods given during hypoglycemia helps identify this pattern and correct it because high-fat foods do not correct hypoglycemia, and there is a risk of this wrong practice becoming a habit wherein children might skip meals after insulin or take higher doses of insulin to induce hypoglycemia in order to enjoy frequent desserts.[10]

h) ***Assessment of bedtime snacks:***
• The risk of night-time hypoglycemia is often worrisome for parents of PwD. Knowledge of bedtime snacks can help improve night-time BG levels and help adjust basal or before-dinner bolus insulin doses.
• While not generally needed by all individuals with T1D, bedtime snacks become important in toddlers and those using Regular insulin for bolus doses, PwD with late evening or night-time physical activity, PwD with a past history of hypoglycemic unawareness, alcohol consumption, or bedtime BG <120 mg/dL.[11]
• Snack options with high protein and fat content, which will provide a more stable glycemic level, are preferred, with no established superiority of one over the other in preventing hypoglycemia.[12]

i) ***Tools and resources used to quantify the foods:***
• *Measuring Tools:* As the sizes of cups and ladles vary from household to household, it is important to know the size of the measuring cup to quantify the food while doing a dietary recall. Standardized cups, spoons, and bowls of different sizes in the OPD can allow for easier portion size estimation. The family can be asked to measure ingredients for the initial few days to get an idea of amounts; later eyeball estimation often suffices. (Figure 17.2 A & 17.2 B)
• *Foods Atlas:* shows images of foods of various sizes and enables the family to confirm the portion size they are referring to.
• *Recipe calculator:* Web-based applications are available with recipe calculators, which help increase the accuracy of assessment of the amounts of different macro- and micronutrients present. The accuracy would depend on whether the same ingredients are used; for example, in *kheer/ payasam*, the calculations would depend on the fat content of the milk used, which may range from 0.5-7.5%.[13]
• *Food diary:* Maintaining food records is very helpful in understanding consumption patterns and thus being able to modify the foods eaten, adjust insulin requirements, identify food intolerances and allergies, and assess individual responses to any particular food. Ideally, the exact quantities of ingredients used should be measured, e.g., the weight of the flour used in each *chapati* or the weight of the lentil in the bowl used at home. Since most home cooking is internally consistent, meticulous weighing is needed only for the initial few days or when something unusual is made. The initial effort of weighing ingredients is worthwhile, making carbohydrate counting easier and more accurate.[14] While maintaining the food diary, along with the time and quantity of food, PwD should also note down mood, physical activity, insulin dose, the site of injection, the sleep schedule, and other factors that affect BG levels (Table 4.1).
• *Food plate images:* The PwD/ family can be asked to record pictures of the meals and snacks, making it easier to analyze the Glycemic Index (GI) and Glycemic Load (GL) of food consumed.
• *Meats, Eggs, Dairy, Fried foods, fat In baked goods, Convenience foods, fats added at the Table, Snacks (MEDFICTS) Dietary Questionnaire:* The MEDFICTS questionnaire was developed by the National Cholesterol Education Program Adult Treatment guidelines. It is quick, easy to administer, and a validated tool for assessing calories from total and saturated fat.[15]

Table 4.1. Example of Food Diary

Date	Glargine dose	BG before break fast/time/ bolus dose	Breakfast	BG before school tiffin/ time/ bolus dose	Tiffin meal	BG before lunch/ time/ bolus dose	Lunch	BG 2 hours after lunch	Evening snack/ time/ physical activity	BG before dinner/ time/ Bolus dose	Bedtime BG/ time	2-3 AM blood glucose
01/01/24	12u	154/ 7 AM/ 2u	200 ml milk, half banana	115/ 12 Noon/ 2u	One roti paneer vegetable roll	190/ 2.30 PM/ 3u	One roti, One cup dal, One cup curd, 1/2 cup mixed vegetable	145	250ml milk, 20 peanuts/ 6 PM/ One-hour football	182/ 8 PM/ 3u	156/ 10 PM	134
02/01/24												

4.3. MEAL PLANNING

a) *Determining calorie requirement:* Energy intake is derived from macronutrients. It should be such that it provides adequate calories for normal height and weight gain, including the growth spurt of puberty, and avoids obesity.[16] Caloric requirements additionally depend on weight goals, amount of physical activity, and pre-existing calorie intake. The requirements of PwD are the same as those of a person of the same age and gender without diabetes, though they may be higher soon after an episode of diabetic ketoacidosis and go back to normal after catch-up weight gain has occurred. Steady growth and normal pubertal progression in children are good markers of calorific adequacy, so accurate growth tracking is a good way of assessing adequacy. In children, the daily caloric requirement is calculated based on the age, sex, and activity status of the child. For a child between 2 and 3 years of age, the recommended daily caloric intake is 1000 to 1400 kcal/day; this requirement increases with the age of the child. Children during a growth spurt, require higher amounts of calories to maintain the body as well as to grow. The daily recommended caloric intake for children 11 to 12 years range between 1800 and 2200 kcal/day. Another way to

generalize caloric need is that an infant needs 100cal/kg/day, ages 1 to 3 years need 80 kcal/kg/day, 4 to 5 years needs 70kcal/kg/day, 6 to 8 years needs 60 to 65 kcal/kg/day and 9+ needs 35 to 45 kcal/kg/day.

b) *Carbohydrates:* Carbohydrate requirements vary depending on age, gender, and activity. While recommended carbohydrate intake is up to 45-55% of total energy needs[1,17], Indian diets may have up to 70% carbohydrates, with low protein and variable fiber content.[18] Assessment of all three components of dietary carbohydrates: starch, sugar, and fiber: is required, as they have differing effects on PP glycemic excursions, and those carbohydrates should be advised, which will minimize glycemic excursions.

- **Complex carbohydrates**: Whole grains, legumes, pulses, non-starchy vegetables, and fruits are good sources of complex carbohydrates.[19]
- **Refined carbohydrates**, like white rice, maida, and semolina (*suji, rawa*), produced when grains are stripped of fiber and almost all micronutrients, are nutritionally inadequate and absorbed like simple sugars, leading to higher PPBG excursions.[20]
- **Simple sugars**, like sucrose, other simple sugars, and sugar-containing beverages like cola drinks, "energy" drinks, "health" drinks, and fruit juices, cause sharp BG spikes that are difficult to cover with insulin and should contribute no more than 5% of total energy requirement.[21] Moreover, their consumption should be spaced out and accompanied by a fiber-rich meal.
- **Dietary fiber** includes non-digestible complex carbohydrates, and mainly comes from plant sources. A high-fiber diet with at least 4 to 5 servings of vegetables and fruits ensures an appropriate intake of other micronutrients such as phytonutrients and antioxidants as well.[22] It provides several benefits, including bulking up the meal, promoting satiety, reducing the consumption of energy-dense foods, and promoting gut microbiota. Fiber in the food frequency questionnaire, understanding the frequency of intake of vegetables, whole grains, millet, nuts, and seeds, can help estimate the fiber intake.

c) *Proteins:*

- The dietary requirement for protein varies with age, with higher requirements in children and adolescents. Sources include legumes and pulses, cereals, dairy products, eggs, fish, and meats. Plant-based sources also have fiber and complex carbohydrates and are better tolerated by the kidneys.[23]
- At the same time, animal-based proteins contain all essential amino acids but have higher sodium and fat content.[24] The Indian Council for Medical Research-National Institute for Nutrition (ICMR-NIN) 2024 guidelines recommend a cereal-to-pulses ratio of 3:1 with about 250 ml of dairy products to meet daily protein requirements in vegetarian adults.[17]
- The cooking of proteins helps improve the bioavailability of protein: different methods have different impacts, and hence, the cooking method should be asked for.
- Cooking methods include boiling, steaming or poaching, frying, grilling and broiling, and microwaving; under-cooking and over-cooking should be avoided. Boiling legumes helps reduce the phytochemicals and increases bioavailability, but boiling in excessive amounts of water can lead to the loss of proteins in water.[25] Hence, cooking in the right amount of water and using excess water in other dishes helps to avoid wastage due to leaching.
- Charring the proteins during grilling/ boiling causes the development of harmful hydrocarbons. Cooking at a high temperature can lead to the breakdown of sulfur-containing amino acids like cysteine and methionine.

d) *Fats:*

- Dietary fats may be visible fats (cooking oils, butter, and ghee) or invisible (inherently present in various cereals, pulses, milk products, chicken, and meat).
- Visible dietary fat can be estimated by enquiring about the total consumption of all fats, by the entire family in a month, i.e., all oils, ghee, butter, spreads, and hydrogenated oils used so that fat intake per person per month can be assessed.
- In addition, history should include the frequency and amount consumed of foods likely to have high-fat content, such as processed foods/ eating out/ calling in food, cheese, paneer, mayonnaise, spreads, nuts, and seeds. Some fats benefit the cardiovascular system, while others are harmful, so the quality and quantity of fat consumed are pertinent.[26,27] Sources of fats[28–30] are given in Table 4.2.

Table 4.2: Sources of fats

Unsaturated fats	Saturated Fats	Trans fats
• Monounsaturated fatty acids (MUFA): ground nut, sesame, rice bran, mustard, olive, canola oils, almonds, avocado • Omega-3 fatty acids: Cold water fatty fishes (mackerel, salmon, sardine, herring, tuna), flaxseeds, walnuts, chia seeds, soybean oil, kidney beans, tofu, spinach, broccoli, cauliflower • Omega-6 fatty acids: Vegetable cooking oils (sunflower, safflower, soy, cottonseed, corn, canola, groundnut, and sesame), pulses, cereals, eggs, and poultry.	Full-fat dairy products, fatty meats, and high-fat snacks. (Should be <5-10% of total energy intake)	Deep-fried foods (French fries, doughnuts, chips, namkeens, fried chicken), hydrogenated cooking fats, and baked goods (cakes and cookies). (Must be restricted to <1% of total energy intake)

a) *Vitamins, minerals, and Salt:*

- Like macronutrients, the micronutrient requirements in PwD are the same as in age and gender-matched healthy peers.[24]
- Documenting intake of packaged foods and condiments is necessary to be aware of "hidden" salt and other micronutrient sources. PwD and their families must be taught to read food labels and check the salt content of packaged and canned foods, pickles, *papads*, sauces, and Chinese food, as these contain high amounts of salt.

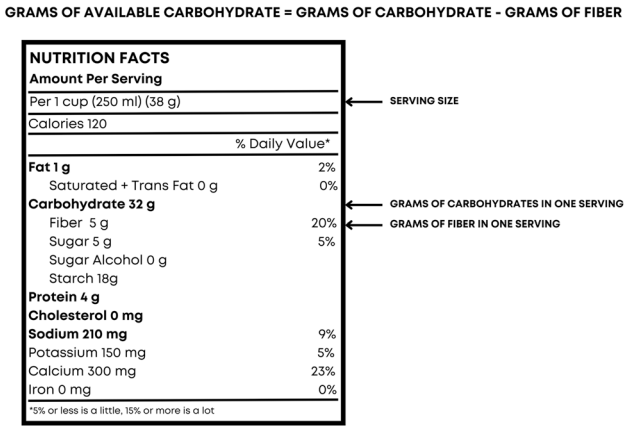
4.4. DIETARY EDUCATION

a) ***Carbohydrate Counting (CC):*** It allows a more accurate estimation of bolus insulin dosing, thus improving the glycemic profile. Methods of CC include:

- *Manual measurement:* use of a food weighing scale at home must be encouraged, at least in the initial few months of diagnosis of diabetes, to estimate the amount of food intake. Most food items we consume are not purely carbohydrates; there is some amount of protein, fiber, and fats even in cereals. Carbohydrate is estimated by weighing the serving size of the food, finding the amount of total carbohydrate present in the serving size, and then subtracting it from the total fiber content in grams in the serving size; to get the total available carbohydrate in the food.[31] (Refer to Chapter 5)

Figure 4.1 shows the nutritive value of bran flakes: according to the label, 34 g of bran flakes contains 28 g of carbohydrates, but the entire 28 g will not be absorbed. It also contains 5 g of fiber, which cannot be digested; hence, 28 - 5 = 23 g of carbohydrate is the actual carbohydrate available to digest and increase BG.

Figure 4.1: Nutritive value of bran flakes.



A carbohydrate factor represents the percentage of a food's weight that consists of carbohydrates. It calculates the carbohydrate content in foods, particularly those that are difficult to measure, using standard volume measurements like a cup. Table 4.3 gives details of the carbohydrate factor of common Indian food items.[32]

Table 4.3: Carbohydrate factor of Indian foods

Food Item	Carbohydrate Factor (per gram of food item)
Cooked Rice	0.3
Roti/ Chapati	0.4
Cooked Lentils	0.25
Appam/ Dosa/ Idli	0.21-0.25
Leafy vegetables (Spinach, amaranth, and others)	0.12
Mixed vegetable curry	0.1
Potato curry	0.17
Raw paneer	0.02
Khichdi	0.15

• Use of standard measures available at home, e.g., cup sizes (100 ml/ 200 ml, etc.), teaspoons, tablespoons. (Figure 17.2 A & 17.2 B)
• The use of hand measures is the least accurate but is a practical way to estimate.
• *Food exchange list:* Families must be provided with food exchange lists, which include items that can be exchanged with other food items without grossly changing the carbohydrate count or calorie content.[33,34] Table 4.4 shows the carbohydrate exchange list of common Indian foods.[35,36]

Table 4.4: Carbohydrate exchange list of common Indian food items

BREADS and CEREALS	
One slice of bread (white, wheat, or whole grain)	1/2 cup *poha*
One *Roti* (6" diameter) made with about two tablespoons of whole wheat flour.	1/2 cup *dalia* cooked
1/2 *roti (bajra, makai, jowar)*	1/2 cup *Upma* cooked
3/4 *paratha* or *thepla* (6" diameter)*	1/2 cup cooked pasta
Two *puris* (5" diameter)	1/3 cup cooked white or brown rice
1/2 paneer *paratha*	½ cup *khichdi* cooked
1/2 aloo *paratha*, 6"	1 mini *uttapam* (4" diameter)
One small *idli*	1/3 cup tamarind rice
One *dosa* (approximately 10" diameter)	1/3 cup *matki usal*
PULSES/ DAL/ BEANS	
1/2 cup lentils cooked	One cup *rasam*
1/2 cup kidney beans cooked	1/2 cup *sambar*
1/2 cup chickpeas cooked	1/3 cup *besan*
1/2 cup *lobia* cooked	
FRUITS/ DRY FRUITS	
One small apple	Three tablespoons raisins
One small banana or 1/2 medium-sized banana	One medium custard apple
One medium chiku	1 1/4 cup watermelon cubes
Three dates	1/2 mango
1 1/2 dried figs or two medium fresh figs	Six *jamun*
One small orange	17 grapes
One cup of papaya cubes	One kiwi
DAIRY	
One cup skim milk (1%)	One cup of plain yogurt, regular*
One cup of 2% whole milk*	One cup of flavored yogurt with artificial sweetener
One cup buttermilk	One cup *lassi**, artificial sweetener
1/2 cup evaporated skim milk	One cup of tea made with 1% milk

* are equivalent in carbohydrate content but may have a higher fat content.
• *Books and web-based tools:* Numerous books and web-based tools are available for carbohydrate counting that may be used by PwD and their families.

b) ***Reading food labels****:* In the era of increased consumption of packaged foods, reading labels is an important skill for PwD and their family members to learn. The Food Safety and Standards Authority of India (FSSAI) has established guidelines to ensure a standard format for the nutrition labeling of food items. The nutrients that are typically included on nutrition labels are calories, total fat, saturated fat, trans fat, cholesterol, sodium, total carbohydrates, dietary fiber, sugars, and protein.[37] Follow the following steps when reading labels.

• **Portion size**: The manufacturer's definition of portion size may differ from what an individual eats. Therefore, it is essential to calculate the given calories and other macro- and micronutrients for the serving size that is actually consumed.
• Check the **total calories** in the amount consumed.
• Check **total carbohydrates**, which include carbohydrates from starchy components, sugar, and caloric sweeteners.
• **Sugar content**: Look for the quality and quantity of all sugars, including natural sugars like lactose in milk and fructose in fruits. Labels reading sucrose, agave nectar, honey, jaggery, maple syrup, syrup, invert syrup, cane sugar, and molasses indicate that the food contains added sugar. "Sugar-free" items often have high-fat content to improve palatability: fat content increases the total calories. Foods labeled "no added sugar" may have naturally occurring sugar in the food and should not be confused with sugar-free foods. Sweeteners such as maltitol do contribute carbohydrates to foods. Many products, including certain "sugar-free" or "low-sugar" chocolates, utilize maltitol and similar sweeteners.
• **Fiber content**: Nutrition labels include fiber in the total carbohydrate content of a food item, mentioned in grams. The amount of fiber must be subtracted while counting carbohydrates to calculate the bolus dose. When faced with multiple options for the same food item, choosing an option with greater fiber content may be wiser.
• **Salt content**: Calculate total salt content rather than getting confused by labels that mention the Recommended Daily Allowance (RDA) percentage since foods are often high in salt content. The sodium content on the label gives an idea of the salt content of the food item and other sources like baking powder.

c) ***Planning meals:*** The plate/ thali model method is an easy, visual method to teach families about the relative portion size of different food elements in a meal. The basic idea is to provide a balanced diet that includes all macro- and micronutrients. (Figure 17.1)

4.5. DIET AT SCHOOL

Restarting school after diagnosis of T1D can be difficult for the parents as well as the child, with anxiety about diet, glycemic monitoring, and insulin administration. Indian school-going children can be broadly divided into these three groups to decide their meal patterns.

• Leave early for school and return home by lunchtime. These children often have a light snack or glass of milk before leaving for school, breakfast during recess, and lunch at home.
• Leave later, by mid-morning, and return by mid-afternoon-evening. These children have breakfast at home, lunch during recess, and a snack upon returning from school.
• Leave early for school, have breakfast and lunch at school, and return by mid-afternoon evening.

History has to be taken of the food sent from home, food provided by the school, and any food purchased from the school canteen. Most school meals contain high-fat, high-salt-containing items like fried foods, salad dressings, unhealthy snacks, and desserts. The family and child should discuss with the school how to modify the situation so that the child gets healthy food without being separated from other children or made to feel different.[9,38]

Often, parents ask for ways to avoid taking insulin in school by insisting on sending only low carbohydrate snacks like nuts and seeds, eggs, fish, grilled chicken/chicken salad, sauteed paneer/tofu, curd, nut milk, vegetable soup or stir-fried vegetables. This means the child cannot share food with friends, feels different, and is left out. BG does rise despite this by early afternoon, so it is not compatible with good glycemic control, and BG variability increases.[39] For good glycemic control during school time, it is best to tailor the diet and insulin regimen for the child. Table 4.5 gives options for school tiffin describing meal and snack options.

Table 4.5 School time snack options

Food options	Carbohydrate content (in grams)
Snack Options	
Khandvi	15
Roasted *chana* (30 g)	15
Makhana (23 g)	15
Sprout chat (60 g)	15
Egg Omlette/ Boiled egg	0
Tossed Paneer (85 g)	10
Fruits + Nuts/ Seeds (100 g)	15-20
Chana chat (200 g *chana* + 1 cup vegetables)	20
Meals	
Uttapam 1 piece with 100 ml *sambhar* and 100 ml *chutney*	90
Idli 2 pieces (80 g) with 100 ml *chutney*	35
Pesarattu 2 pieces with 100 ml *chutney*	21
2 *Rotis* with 1 cup dal and 1 cup *sabzi*	50
Pulao (170 g) with *raita* 1 cup	45
2 Egg rolls with mint *chutney*	30
Poha (80 g) with scrambled eggs/ paneer *bhurji*	35-40

4.6. CORRELATION WITH CONTINUOUS GLUCOSE MONITORING GRAPHS

Continuous glucose monitoring (CGM) provides real-time data on BG levels as well as trends. Reading the CGM graph with the dietary log records allows for analyzing which foods reduce or increase glycemic variability and helps adjust for the latter. Adults with diabetes using CGM were found to be more likely to pick fiber-rich, low-GI foods and more likely to go for a walk when BG was high or on a rising trend.[40] CGM thus can provide positive and negative reinforcements for making dietary and lifestyle changes; glycemic control improves, and acute and chronic complications are reduced.

4.7. CHALLENGES IN DIETARY HABIT FORMATION

Diet modification, an important pillar of diabetes management, is easier said than done. It goes beyond the understanding of knowing what to eat and what not to eat and making rational choices to change dietary habits. This is often met with challenges in day-to-day clinical settings. The most common challenges include willingness to make the change, knowing dietary modifications, and discipline to continue it in the long term. Social challenges that are commonly encountered include food insecurity, making PwD dependent on any available food instead of being able to choose healthier options, not being able to afford fresh fruits and vegetables, negotiating with family members who may not agree with the dietary options imposed on PwD or want separate meals to be cooked for them and managing the social significance of food.[23,41] As healthcare professionals, it is important to encourage families to make healthy food choices. At each visit, have open-ended conversations to understand the challenges faced in providing the necessary diet and figure out ways to overcome these challenges.

4.8. SUMMARY AND RECOMMENDATIONS

• Diagnosis of T1D can be devastating for the child and family. Encouraging modifications in the current diet rather than drastic changes goes a long way in ensuring good compliance.
• A detailed dietary history, which includes the individual's and family's food preferences and patterns, allows for the best diet tailoring.
• A well-balanced diet must be prescribed to meet the individual's macro- and micronutrient needs.
• Ideally, the ingredients in food items should be weighed or measured with spoons/ cups of standard sizes to know the content of components.
• Carbohydrate counting must be taught as soon as T1D is diagnosed. It allows a more accurate estimation of bolus insulin dosing while providing greater dietary freedom to PwD.
• Use of and understanding Exchange Lists should begin at the time of diagnosis/ when first seen.
• Food labels on packaged foods must be read carefully, with special attention paid to the calorie, carbohydrate, sugar, and salt content. Labels may be misleading, with tags like "sugar-free" or "no added sugars" or confusing ingredient names.
• Management in school may pose a challenge in meal planning and ensuring proper BG testing and insulin dosing. Discussing care with school staff and matching meals to insulin regimens allows the best glycemic control.

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Chapter 5: Macronutrients

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5.1. INTRODUCTION

Developing and customizing a diet plan for individuals with Type 1 Diabetes Mellitus (T1D) is of paramount importance, as it requires careful consideration of multiple factors unique to each person. A comprehensive approach considers the individual's age and gender, sociocultural background, food availability, family environment, and school or work schedules. By addressing these diverse elements, Healthcare Professionals (HCPs) can create a tailored nutritional strategy that effectively manages Blood Glucose (BG) levels and aligns with the lifestyle, preferences, and practical constraints of People with Diabetes (PwD), leading to better adherence and improved health outcomes.

Tailored Biopsychosocial Approach:

• A basic foundation of macronutrients in percentages recommended for the general population is given in Table 5.1.[1,2] The macronutrient distribution for children with diabetes is similar to that of the general population.[3]
• A tailored biopsychosocial approach is required to address individual needs, personal differences, and social dynamics of health: food availability, stress, family environment, availability of resources of healthcare and education.

The simplest and most effective way to achieve a balanced diet with the right proportions of macronutrients is to follow the Joslin Diabetes Center's plate method.[4] This approach emphasizes the importance of balanced meals for managing BG levels, using a 2:1:1 ratio.
• Half the plate (2/4): Non-starchy vegetables (primary source of fiber),
• Quarter of the plate (1/4): Whole grains or starchy vegetables (rich in carbohydrates),
• Quarter of the plate (1/4): Lean protein options (e.g., pulses, low-fat dairy, eggs, white meat).

This method ensures that all macronutrients are included in the right proportions and appropriate portion sizes. It is also recommended to include sides such as healthy fats in moderation. By combining the Joslin plate method with a personalized approach, PwD can effectively manage BG while meeting their unique nutritional and lifestyle requirements.

Table 5.1: Macronutrient distribution

Carbohydrate: 45-55% [Low Glycemic Index (GI), Glycemic Load (GL)]
Sucrose: <5% of energy
Dietary Fiber: 15 g/1000 calories
Protein: 15-20% of energy
Fat: 25-30% of energy
Monounsaturated Fatty Acids (MUFA): 10% energy + any calories left from carbohydrate portion
Polyunsaturated Fatty Acids (PUFA): 10% of energy
Saturated fats: <10% of energy (<7% in case of dyslipidemia)
Cholesterol: <300 mg/day (<200 mg/day in case of dyslipidemia or risk of cardiovascular disorders
Trans fats: Intake should be as low as possible.

5.2 CARBOHYDRATES

Carbohydrates are crucial as macronutrients in the human diet for providing energy and comfort, and aiding growth. They can be categorized into four groups: sugars, polyols, oligosaccharides, and polysaccharides. Digestible carbohydrates are divided into starches and sugars. Starches are complex carbohydrates that undergo slow digestion and absorption, resulting in a gradual rise in BG levels without sudden spikes.[5] They also offer vital fiber and nutrients. Starches can be consumed in their natural form or refined form. Sugars (glucose, fructose, lactose, and sucrose or table sugar) are simple carbohydrates that occur naturally in foods like fruits, milk, sugarcane, and vegetables, or are added during production or before consumption. They lead to quicker fluctuations in BG compared to starches.[3]

Blindly eliminating or sharply reducing carbohydrates can adversely affect health. Adults should aim to consume a minimum of 130 g/day of carbohydrates to provide the brain with essential glucose for energy.[6] The minimum recommended carbohydrate intake is 175 g/day in the second and third trimester of pregnancy.[7] The International Society for Pediatric and Adolescent Diabetes (ISPAD) 2022 Guidelines and the recent Indian Council for Medical Research-National Institute for Nutrition (ICMR-NIN) 2024 guidelines advise consuming 45-55% calories as carbohydrates.[1,2]

India achieved food self-sufficiency due to the Green Revolution in the late 1960s, with technological advancements and policy continuing the colonial focus on wheat and rice.[8] As incomes rise and poverty decreases, it is possible to revert to more traditional and balanced mixed meals ("thali") with greater nutrient and fiber content. Healthy sources of carbohydrates include whole grains [whole wheat, broken wheat (*daliya*), oats, unpolished rice, millets], whole pulses and legumes, plantain flour, pseudocereals like amaranth, whole fruits, and vegetables. Consumption of millets can be encouraged as production and availability again increase. A staple in Indian diets historically, millets are being "re-discovered" due to their numerous health benefits and sustainable cultivation, particularly in drought-prone areas. They offer complex carbohydrates [low Glycemic Index (GI)], high fiber and protein content, vitamins, and minerals (they are rich in calcium, magnesium, iron, zinc, and phosphorus), and are gluten-free. Millets are, therefore, a promising dietary choice for PwD.[9] Refined carbohydrates (refined flour or maida, white rice) and simple carbohydrates, including sugar, honey, High Fructose Corn Syrup (HFCS), maltodextrins, etc., found in sugar-sweetened foods and beverages and in most processed foods, should be sharply limited, providing less than 5% of total daily calories. Glucose and sucrose should be kept available to prevent or treat hypoglycemia.[6]

5.2.1. Carbohydrate Counting

Carbohydrates have the maximum effect on post-meal BG levels, requiring insulin. The increase in BG due to proteins and fats is lesser and slower. Attempts to maintain good glycemic control, therefore, must focus most of all on the carbohydrate content of a meal. Carbohydrate Counting (CC) is a method of assessing the quantity of carbohydrates that enables precise calculation of the required pre-meal insulin doses. CC increases flexibility in food choices while improving glycemic control.[10] (also refer Chapter 8)

There are three levels of CC[11]:

• Level 1 (Basic): Using exchange or portion lists with defined amounts of food, promotes the consumption of the same amount of carbohydrates in each meal.
• Level 2 (Intermediate): Identifying trends in BG responses to carbohydrate consumption and exercise, and adjusting insulin dosage appropriately, gives more precise control.
• Level 3 (Advanced): Based on the anticipated amount of carbohydrates in the meal/ large snack and physical activity, and the pre-meal BG level, determining the necessary bolus insulin dose before the meal/ large snack by using the Insulin-to-carbohydrate Ratio (ICR) and Insulin Sensitivity or Correction Factor (ISF or ICF), gives the most precise control.

5.2.1.1. Components Required for Advanced Carbohydrate Counting

Calculating a bolus dose before a meal requires both ICF and ICR. If a meal is not consumed, only ICF is needed, since only the correction dose will be given.

Insulin to Carbohydrate Ratio (ICR)

• ICR is the number of grams of carbohydrates covered by 1 unit of bolus insulin. It is calculated by the empirical **"rule of 500"** (for rapid-acting insulin).[12]
• **ICR= 500 ÷ Total Daily Dose (TDD),** where the TDD is the amount of insulin taken in a day = Basal + Bolus doses.
• For example, a child Ms. M, is taking 11 units of glargine, with Humalog, 3 units before school, 3 units in school, 4 units before lunch, and 4 units before dinner. Her TDD would be 11+ 3+ 3+ 4+ 4 = 25 units. Her ICR would be 500 ÷ 25 = 20, i.e., 1 unit of insulin would cover 20 g of carbohydrates in her meal.
• Age, sex, stage of puberty, and physical activity may all have an impact on ICR. ICR also fluctuates somewhat throughout the day, typically peaking in the morning, declining by mid-day till the afternoon, and rising again in the evening.[10,13] Therefore, for the same amount of carbohydrates, a somewhat higher dose may be needed before school or in school, while a slightly lower dose may suffice before lunch, and a small evening snack often does not require insulin cover. (refer to Chapter 8)

Insulin Correction Factor (ICF)

ICF, also known as insulin sensitivity factor (ISF), indicates how much BG (in mg/dL) will be reduced by 1 unit of bolus insulin, and is used to calculate the amount of bolus insulin required to bring the pre-meal BG to the target level. It is obtained by dividing 1800 (if rapid-acting analog is being used) or 1500 (if Regular insulin is being used) by the TDD.[10]
• Rule of 1800 (Rapid-acting analogs): **ICF = 1800 ÷ TDD**
• Rule of 1500 (Regular, i.e., soluble insulin): **ICF = 1500 ÷ TDD**
• Correction dose = Actual premeal BG – target BG ÷ ICF.

This has to be added to the premeal bolus dose which is needed to cover the carbs in the meal. Negative correction may be needed, i.e. dose is reduced by 1–2u if premeal BG is low.

For example, if Ms. M is using Regular insulin for pre-meal bolus dosing, her ICF would be 1500 ÷ 25 = 60, i.e., 1 unit of insulin would reduce her BG by 60 mg/dL. So, if she is planning to eat a meal with 40 g carbohydrates and her pre-meal BG is 225 mg/dL, her pre-meal bolus dose would be calculated as follows:

Her lunch has only 40 g of carbohydrates, so she needs 2 units of insulin. Her target BG is 100, so 225-100 = 125 mg/dL needs to be corrected, for which she needs 125 ÷ 60 = 2 units. Thus, her pre-meal dose would be 2+2 = 4 units of Regular insulin.

Case Study: Profile of Ms. D, 15 years old with T1D.

• HbA1c: 7.5%.
• Bolus Insulin - Aspart: dose Before School - 4 units, School tiffin - 3 units (holidays Breakfast – 7 units), Lunch – 6 units, Dinner - 8 units
• Basal Insulin - Glargine: dose 20 units
• Her TDD = Basal + Bolus dose = 4 + 3 + 6 + 8 + 20 = 40 units
Exercise 1: Ms. D has a before-breakfast reading of 195 mg/dL on Sunday
Breakfast: 2 chapatis + 1 bowl of seasonal cooked green vegetable + 1 glass (200 ml) toned milk + 1 medium apple.
Total Carbohydrate Content = 15 x 2 (chapati) + ~5 (seasonal veg) + 10 (milk) + 15 (apple) = 60 g
• ICR, considering the rule of 500 = 500 ÷ TDD = 500 ÷ 40 = 12.5, i.e., for 12.5 g of carbohydrates, Ms. D needs 1u of Insulin.
• Bolus Insulin dose = Total carbohydrates consumed (in grams) ÷ ICR = 60 ÷ 12.5 = 4.8, i.e., ~ 5 units of bolus.
• ICF = 1800 ÷ TDD (since Ms. D is using aspart, which is a rapid-acting insulin) = 1800 ÷ 40 = 45
• Correction insulin dose = (195 – 100) ÷ 45 = 95 ÷ 45 = 2 units of correction.
So, her before-breakfast total bolus insulin dose = 5 + 2 = 7 units
Exercise 2: Ms. D had a snack in the evening without taking insulin; hence, her pre-dinner BG was 306 mg/dL.
Dinner: 1 bowl of plain unpolished rice + 1 bowl of sambar + salad
Total Carbohydrate Content = 30 (rice) + 15 (sambar) + 5 (salad) = 50 g
• ICR is 12.5, so for 45g carbohydrates, Ms. D needs 45 ÷ 12.5 = ~ 3.6 units of bolus.
• ICF is 45, so the correction dose is (306 – 100) ÷ 45 = 206 ÷ 45 = 4.5 units of correction.

So her pre-dinner total bolus insulin dose = 3.6 + 4.5 = 8.1 units, i.e., 8 units.

Table 5.2 shows common foods consumed in India and their carbohydrate content.[14]

Table 5.2: Common foods consumed in India[12]

Name	Number/ Weight	Carbohydrate Content
Homemade *Idli*	2/ 80 g	15 g
Homemade *Vada*	4/ 50 g	15 g
Homemade *Dosa*	1/ 50 g	15 g
Rice *Puttu*	40 g	15 g
Ragi *Puttu*	40 g	15 g
Poha	80 g	30 g
Upma	100 g	30 g
Pongal	200 g	30 g
Rice *Vermicelli*	100 g	25 g
Sago Khichdi	120 g	60 g
Chillas	2/90 g	15 g
Chola with bhatura	200 g (1 bowl) *chole* with 2 (200 g) *bhatura*	150 g
Batata vada	1/ 80 g	30 g
Cooked *Dal*	1 bowl/ 200 g	30 g
Rasam	1 bowl/ 200 g	5 g
Cooked *Chole*	1 bowl/ 200 g	30 g
Rajma curry	1 bowl/ 280 g	30 g
Sambhar	1 bowl/ 200 g	15 g
Curd curry	1 bowl/ 200 g	5 g
Vegetable stew	1 bowl/ 190 g	15 g
Vegetables without potato	1 bowl/ 200 g	5 g
Chokha	1 bowl/ 200 g	15 g
Oondiyo	1 bowl/ 100 g	20 g
Fish curry	1 bowl/ 200 g	5 g
Meat curry	¾ bowl/ 200 g	5 g
Green leafy vegetables	¾ bowl/ 200 g	5 g
Baingan bhaja	6 pc./ 100 g	4 g
Wheat chapatti	1/ 40 g	15 g
Millet *roti*	1/ 50 g	20 g
Puris	2/ 30 g	15 g
Naan	1/100 g	50 g
Thepla	1/ 25 g	15 g
Koki	1/ 50 g	15 g
Luchi	1/ 27 g	15 g
Ragi mudde	1/ 50 g	20 g
Aloo paratha	1/ 80 g	30 g
Pav	1/ 35 g	15 g
Baati	1/ 20 g	13 g
Litti	1/ 40 g	20 g
Steamed rice	1 bowl/ 110 g	30 g
Khichdi	1 bowl/ 280 g	35 g
Cow milk	200 ml	10 g
Buffalo milk	120 ml	10 g
Paneer	85 g	10 g
Curd	1 bowl/ 250 g	10 g

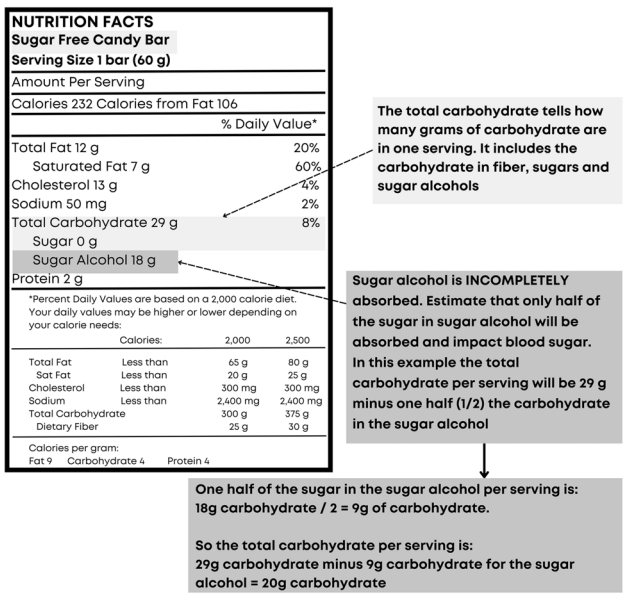
5.2.1.2. Carbohydrate Counting at Home and When Using Food Labels

Home-cooked food is generally safer and much healthier, as ingredients can be controlled, and the need for preservatives and additives is minimal. Doing CC with home cooking means the ingredients must be weighed before preparation for the first few times. This is initially tedious but very rewarding in the long run.

When eating packaged foods, information about the carbohydrate content has to be obtained from the food labels. Reading food labels is a skill that needs some practice.[15] (Figure 5.1) The following information is required for appropriate meal planning:

- *Ingredient list:* It is always in descending order by weight, and usually, the total carbohydrate amount is mentioned, either as 'in one serving' or 'in 100 g'.
- The fiber grams must be subtracted from the total carbohydrate weight for accurate CC.[16]
- The sugar alcohol grams should be halved and then added to the CC.
- *Serving size:* Verify the serving size (the quantity that individuals typically eat at one time) and compare it with the amount consumed. The serving size specified on the label determines the quantity of calories, fat, and other nutrients taken; therefore, if the serving size mentioned is one cup but the amount eaten is two cups, then the calories, fat, and other nutrients being consumed are double than what is listed on the label.

Figure 5.1: Carbohydrate counting using food labels (Reproduced with permission from Salis S. Diet In Diabetes Simplified : Your Personal Diabetes Nutrition Coach. India: Notion Press; 2020.)



Choosing packaged foods; discerning misleading claims

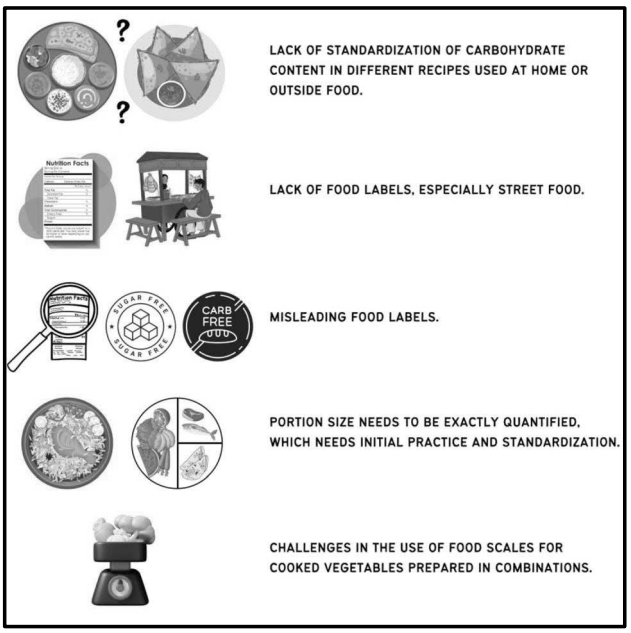
- It is important to note that "sugar-free" does not mean "carbohydrate-free," "calorie-free," or "fat-free." When manufacturers reduce sugar, they often add fat to ensure taste so the calories may be even higher than in the original product.
- "No added sugar" claims do not always mean fewer carbohydrates, as compounds like maltodextrins raise BG sharply since they have a high GI. Ingredients such as sucrose (i.e., table sugar), fructose, or other sugars,

may not always appear in the ingredient list with clarity; ingredients such as HFCS, rice malt syrup, maple syrup, maltodextrin, molasses, etc., all indicate the presence of added sugar in the product.[17] Honey, *'khand,' 'boora,'* and jaggery have the same impact as table sugar. Look for the total carbohydrates and total calories in both the "sugar-free" and the standard product.

- "Sugar-free," "no sugar," and "sugarless" products should have less than 0.5 g of sugar per serving. Foods labeled "No added sugar" may contain naturally occurring sugar, sugar alcohols, or artificial sweeteners. Similarly, "unsweetened" foods may have naturally occurring sugars. Products labeled "Reduced sugar" should have at least 25% lower sugar content than the standard product.[18]
- Look at the detailed ingredient list to see whether the carbohydrates are from good sources like whole grains or high GI sources like refined flour, and if there are added sugars. A bread that may declare "100% whole wheat" in large font on the front of the label may have only 30-60% whole wheat mentioned in tiny letters in the ingredient list at the back of the label.
- Foods labeled as "diabetic" are generally more expensive, with higher fat and calorie content, and may have sweeteners like sugar alcohols, which do have calories and may have laxative effects.[19] They are not recommended in general.
- Similarly, "fat-free" foods have high carbohydrate content and may not have lower calories than the standard product.
- Thus, "sugar-free" products, "diet" foods, and "diabetic-friendly" foods must be scrutinized very carefully as they are often misleading. Sometimes, food labels or calorie counts in menu cards are incorrect. All these factors must be kept in mind before choosing a product.[16]

It has been demonstrated that improved nutrition knowledge and practices are correlated with reading food labels. In general, nutrition labeling gives consumers greater power and facilitates the selection of healthier foods, though it is essential to stay alert and aware. Challenges faced during CC, especially in the Indian scenario, are given in Figure 5.2.

Figure 5.2: Challenges faced during carbohydrate counting



5.2.2. Fiber

Dietary fiber is complex carbohydrates in plant-based foods, which resist digestion and move through the digestive system without being fully absorbed. Fiber is most appropriately classified into water-insoluble (less fermented fiber) and water-soluble (well-fermented fiber). Insoluble fiber, including cellulose, hemicellulose, and lignin, promotes laxation by accelerating the intestinal transit time and boosting stool volume, thus averting constipation and hemorrhoids.[20] Soluble fiber, including pectin, gums, and mucilage, absorbs fluid in the gastrointestinal tract, forming a thick, gummy substance that delays gastric emptying and increases intestinal transit time. This helps to reduce postprandial glycemic rise and overall glycemic variability and improve satiety.[20] This, in turn, reduces craving for energy-dense foods and prevents weight gain. Due to increased water content, soluble fiber binds to bile acids, preventing cholesterol absorption and reducing the risk of dyslipidemia and Cardiovascular Disorders (CVD).[21–24]

Fiber requirement can be calculated as age (in years) +5 g for children >2 years of age NIN ICMR recommends 15g per 1000 kcal for adults. Excess intake (>60 g/day) or rapid increase in amount, especially without adequate fluid intake, can lead to abdominal discomfort and osmotic diarrhea.[26]

5.2.3. Nutritive Sweeteners

Sweeteners are of two types: nutritive and non-nutritive. Among the nutritive sweeteners, fructose is comparable to sucrose in terms of calories but has a lower GI of 29 vs. sucrose's 69.[27] This is useful if consumed in small amounts, as in fruits. However, fructose may negatively impact serum lipids and is hepatotoxic in large quantities, e.g., when consumed as HFCS in processed foods. So, fructose in large amounts is not advisable as a substitute for sucrose in the diet.[28]

Sugar alcohols like xylitol, sorbitol, maltitol, and mannitol have half the calories of sucrose, and more favorable GI. They are safe in moderate amounts, but an intake of over 20 g (15 g for maltitol) can induce diarrhea. Hence, they are not recommended for children.[7] Although erythritol is generally considered safe and is often a preferred sweetener for children due to its minimal impact on dental health, recent findings suggest caution, with studies in vitro and in animal models showing that elevated fasting plasma levels of erythritol are clinically associated with an increased risk of CVD and enhanced potential for thrombosis.[29–31]

Sucrose and foods that contain sucrose can be a part of a healthy diet if they provide <5% of total daily caloric needs. When consumed, sucrose needs adequate insulin cover; its effect on glycemia is the same as isocaloric amounts of starch. It can be used instead of glucose to prevent or treat hypoglycemia. Large amounts of sugar, especially in Sugar-sweetened Beverages (SSB), cause high postprandial BG peaks, which may not be adequately controlled by insulin, and also cause weight gain.[1] Consumption of SSB, e.g., soft drinks, cold coffee, shakes, and "health drinks," should be discouraged for the whole family.[1] As alternatives, non-sugar or low-calorie drinks such as buttermilk (*chaach*), coconut water, salted lemonade, *sattu* in water, kokum, homemade *jal jeera*, etc. are preferable. Sucrose should always be available to prevent or treat hypoglycemia.

5.2.4. Special situations

To address the challenges during sleepover with friends:

• *Designate a buddy:* Assign a responsible friend or family member to help the child keep track of carbohydrates consumed and remind them about insulin doses.
• *Pre-planning:* Discuss the sleepover menu with the host family in advance, if possible, to better prepare for carbohydrate counting.
• *Portable measuring tools:* Where practical, consider providing the child with easy-to-use measuring cups or a food scale to help estimate portions.
• *Frequent monitoring:* Encourage more frequent BG checks or Continuous Glucose Monitoring (CGM) during sleepovers.
• *Snack alternatives:* Pack some diabetes-friendly snacks that the child can share with friends.
• *Hypoglycemia supplies and Emergency kit:* Ensure the child has all necessary supplies, including extra insulin, test strips, and treatments for hypoglycemia, such as glucose tablets, glucose powder, or sugar sachets.
• *Communication:* Make sure the host family and the designated buddy understand the basics of diabetes management and know when to call for help.

By implementing these strategies, children with T1D can safely participate in sleepovers while maintaining good glucose control. Remember, the goal is to allow the child to enjoy the social experience while staying mindful of health needs.

5.2.5. Summary for Carbohydrates in T1D

• *Meal Structure*: Emphasize the importance of choosing complex carbohydrates over simple and refined carbohydrates; provide meal suggestions and guidelines for a balanced diet.
• *Involve the family:* Ensure the entire family has a healthy diet with nutritious, low GI meals and snacks, containing complex carbohydrates, adequate proteins, and fiber.
• *Collaborate with Schools:* Meet with teachers, parents, and school nurses to educate on the role of nutrition, healthy school tiffins, the need to control BG well by checking BG and taking insulin before eating school meals/ snacks, with additional carbohydrate snack provision/ permission for physical education, and hypoglycemia prevention/ management.
• Teach the practice of CC soon after diagnosis; reinforce often.
• *GI education*: Provide education on which are low GI foods and strategies to reduce GI of foods: e.g. mix high fiber millet flours or ground *dals* in wheat flour for chapatis; use aged, cooked and cooled rice/ potatoes as this increases the content of resistant starch; use unpolished and/ or long grain rice; make millet *chillas*, *chapatis*, or *pulao*; incorporate lemon juice or tamarind or gooseberry in meals; prefer boiling and sauteing to frying and baking; avoid overripe fruit.
• Emphasize a diet rich in vegetables, fruits, and protein-rich foods like lentils (*dals*) or peanuts and low-fat dairy while reducing intake of cheap processed carbohydrates and fats (biscuits, commercial breads, fried foods, and snacks).
• Discuss portion sizes of culturally preferred and affordable foods.
• Explore local resources for healthier options, like kitchen gardens in rural areas and pots in cities.
• Encourage structured mealtimes to discourage grazing on carbohydrate-rich, processed snacks that can lead to postprandial hyperglycemia.
• Ensure insulin is administered 15-40 minutes before meals, as needed.
• Ensure substantial protein in each meal to ensure adequacy of protein and mitigate postprandial spiking of BG.
• Teach all families, regardless of economic status or educational background, the fundamental principles of healthy eating habits, maintaining a balanced diet, and adequately counting carbohydrate intake.[32]
• Address the obstacles that hinder dietary compliance, such as the challenges posed by joint family systems, evolving lifestyles, and ingrained nutritional behaviors. Foster positive parental role modeling and early family meal involvement to promote healthy food choices and cooperation.
• Teach how to effectively manage special situations like festivals, parties, playdates, sleepovers, and hostel living, and adjust food, insulin, and activity to control BG levels.

5.3. PROTEIN

Protein is a macronutrient that forms the structural and functional components of cells and is essential for the development of muscle, bone, and other tissues, immune function, and hormone production. Amino acids, the building blocks of proteins, are crucial for developing, synthesizing, and repairing body tissues. There are 20 amino acids, of which nine are essential and must be obtained from the diet. The quality of dietary protein to provide all essential amino acids is very important (Table 5.3). Protein requirements vary with physiological states, activity levels, and stress, with higher requirements during infections, illnesses, or other periods of stress.[1,8,28]

Table 5.3: Protein Sources

Animal-Based	• Dairy, eggs, fish, poultry, and meat. • These sources contain all essential amino acids. • They can be higher in saturated fats and salt. • It is best to remove skin and visible fat when preparing animal protein.
Plant-Based	• Cereals, lentils, legumes, nuts, and seeds. • They often lack some essential amino acids. • They provide fiber, complex carbohydrates, essential vitamins and minerals, and lower levels of saturated fats. • They are less expensive than animal proteins.
Vegetarian Diets	• A combination of cereals and pulses in a ratio of 3:1 (by raw weight), along with nuts and seeds, can provide all essential amino acids. • Including dairy daily can further enhance protein quality.
Non-Vegetarian Diets	Provide high-quality protein, but combining with plant-based protein is recommended to avoid high fat and salt intake.
Protein in Indian Diets	Indian diets are typically cereal-based and may lack sufficient protein, highlighting the importance of awareness and education about diverse protein sources.

Recommended intake

- *Infancy:* 2 g/kg/day
- *Childhood to early adolescence:* 1 g/kg/day
- *Later adolescence:* 0.8-0.9 g/kg/day
- The protein energy ratio should be 15-20%, especially for children and adolescents, to support normal growth and development.[1]

5.3.1. Protein and Blood Glucose Management

- *Hypoglycemia:* Protein-rich foods are not suitable for correcting hypoglycemia. Instead, fast-acting carbohydrates like glucose or sucrose (table sugar) are recommended.
- *Role in blood glucose control:* It helps overall BG management by slowing digestion and absorption of carbohydrates.
- Adequate protein helps in weight management by controlling appetite.
- *Meal Sequence:*
- *Optimal meal order:* Consuming protein and fats at the beginning of a meal, followed by carbohydrates, can slow the rate of carbohydrate absorption, potentially leading to more stable post-meal BG levels.[33]
- *Satiety and caloric control:* Incorporating protein and fiber-rich foods early in the meal can enhance satiety and help control overall calorie intake, which can benefit both weight management and glycemic control. Figure 5.3 shows meal sequence options for increased satiety response.

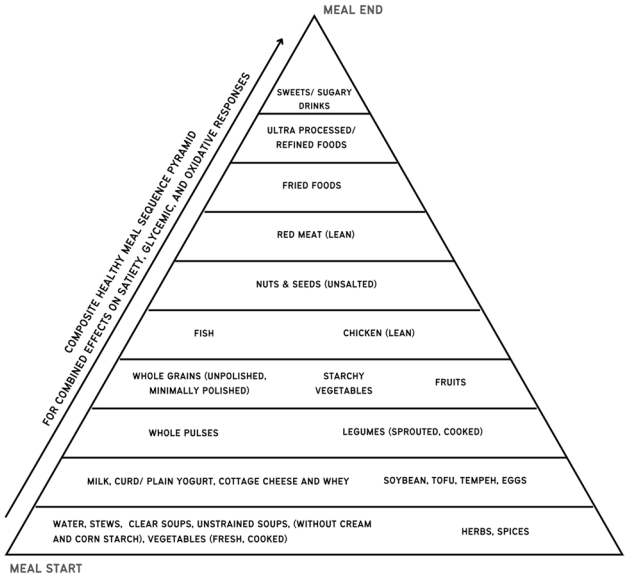


Figure 5.3: Meal sequence options for increased satiety response[34] (Adapted from Shapira N. The metabolic concept of meal sequence vs. satiety: glycemic and oxidative responses with reference to inflammation risk, protective principles and Mediterranean diet. Nutrients. 2019 Oct 5;11(10):2373.)

Foods are ranked according to fullness-related satiety per contribution to gastric filling. Foods at the base of the pyramid provide the greatest satiety, while those at the top are the most energy-dense, highly processed, and should be consumed in limited amounts.

Challenges

- Indian diets are generally low in both quantity and quality of proteins. It is essential to plan a protein-rich but balanced diet.
- Adequate and good quality protein can be obtained from only vegetarian sources with knowledge and meal planning.
- Protein powders are generally not required or recommended. They may contain added sugars, non-caloric sweeteners, and additives. Additionally, the presence of Branched-chain Amino Acids (BCAAs) can increase the risk of non-communicable diseases.[35] Prolonged consumption of large amounts of protein can also pose risks, such as bone mineral loss and kidney damage.

5.3.2. Protein Intake in Diabetic Nephropathy

- To manage kidney health, it is recommended that high protein intake (>25% of total energy) be avoided. However, reduction is rarely needed, as Indian diets rarely have high protein.
- Protein intake should be at the lower end of the Recommended Dietary Allowance (RDA) based on age, sex, weight, and physical activity to ensure average growth and development, with a minimum of 0.8 g/kg/day.
- No evidence supports protein restriction (<0.8 g/kg/day) for nephroprotection, CVD, or glycemic control. Such restrictions can increase the risk of malnutrition.
- Plant-based proteins are often preferred for kidney health due to their lower saturated fat and sodium content than animal proteins.[36]

5.3.3. Summary for Proteins in T1D

- *Monitor Protein Intake:* Ensure adequate protein intake, which does not exceed the limits suggested for diabetic kidney health, under the guidance of an experienced dietitian or HCP.
- *Consider Meal Composition:* Structure meals with a mix of protein, fats, and carbohydrates to optimize BG control. Prioritize low-GI foods and balanced meals to maintain stable BG levels.
- *Choose Quality Proteins:* Focus on high-quality animal and plant-based protein sources to support overall health while being mindful of their impact on BG and kidney function.
- *Stay Informed and Flexible:* Regularly monitor BG levels and kidney function; adjust protein intake based on age-appropriate dietary needs and changing health conditions.

5.4. FATS

Fat is an energy-dense macronutrient that provides energy and crucial fatty acids for several physiological and metabolic functions. These include cell membrane and hormone biosynthesis, central nervous system development and functioning, cell signaling, and gene expression. Fat plays a significant role in the absorption of fat-soluble vitamins and in lipoprotein metabolism. Additionally, it contributes to the texture, flavor, and taste of food, and enhances satiety.[37–39]

The National Institute of Nutrition emphasizes the quantity and quality of cooking oils, recommending rotation or using blended oils for balanced fatty acid intake. Traditional saturated fats like ghee and coconut oil should be limited to no more than 7-10% of daily calorie intake. Pomace olive oil offers no significant advantage over more cost-effective regional oils. Avoid using reheated oils.[2] Types of fats and sources are given in Table 5.4.

Excess fat intake can be avoided by using low-fat cooking methods instead of frying. Frying (in traditional cooking) and heat-processing

methods like grilling, broiling, roasting, and searing (which modern diets rely heavily on), result in high levels of advanced glycation end products. While these occur naturally in uncooked animal-based foods, high-temperature cooking also leads to their formation. These contribute to increased oxidative stress and inflammation, which are associated with increased insulin resistance and CVD. Transition to healthier cooking techniques like sauteing, steaming, boiling, and baking with less fat, can preserve flavors without adding excess calories.

Many households add water to milk in their attempt to reduce its fat content (and cost). This is not recommended: *low-fat milk is not diluted milk*. Use of low-fat i.e., toned or double-toned milk and milk products is advisable, to ensure proper availability of protein, carbohydrates, vitamins, and minerals.

Table 5.4: Type of fats and sources

Type of fat	Dietary recommendation	Characteristics	Sources
Saturated Fatty Acids (SFAs)	<10% of energy, <7% in case of dyslipidemia	• They increase Low-density Lipoprotein (LDL) cholesterol levels and are linked to the development of CVD through inflammation, atherogenesis, and insulin resistance. • High intake of SFAs may worsen insulin sensitivity and complicate diabetes management.	Coconut oil, palm oil, ghee, egg yolk, whole milk, cheese, butter, cream, cream-based sweets, ham, bacon, and red meats
Monounsaturated Fatty Acids (MUFA)	10% energy + any calories left from the carbohydrate portion	• They help improve insulin sensitivity by reducing LDL cholesterol and enhancing High-density Lipoprotein (HDL) cholesterol. • They also improve glycemic control and reduce CVD risk. They are the healthiest fatty acids.	Almonds, avocados, sesame, groundnut, peanut, rice bran, mustard, and canola oils
Polyunsaturated Fatty Acids (PUFA)	10% of energy	• ***Omega-3 PUFAs:*** Help lower serum triglycerides and may improve insulin sensitivity. They benefit overall cardiovascular health, which is particularly important for PwD. • ***Omega-6 PUFAs:*** Can help lower LDL cholesterol. • However, a higher omega-6/omega-3 ratio (>5-10) increases the risk of CVD. • As the omega-6/omega-3 ratio is higher in the Indian diet, a mix or alternate oils rich in omega-6 and omega-3-rich oils are recommended for better balance.	***Omega-3:*** Broccoli, spinach, cauliflower, Chinese cabbage, kidney beans, tofu, flaxseeds, walnuts, chia seeds, soybean oil, canola oil, and cold-water fatty fish (e.g., mackerel, salmon, sardine, herring, tuna). ***Omega-6:*** Vegetable cooking oils (e.g., safflower, sunflower, soy, cottonseed, corn, canola, peanut, sesame), poultry, eggs, cereals, walnuts, and seeds.
Trans Fatty Acids	As low as possible	• Trans fats, found in hydrogenated and partially hydrogenated oils (e.g., vanaspati, margarine) and produced during high-temperature cooking (e.g., frying, baking), have adverse effects such as reducing HDL cholesterol and increasing LDL cholesterol, endothelial dysfunction, decreased insulin sensitivity, and increased risk of diabetes, breast cancer, colon cancer, preeclampsia, disorders of the nervous system, and vision in infants.	Vanaspati, butter, fried foods (e.g., French fries, doughnuts, fried chicken), baked goods (e.g., cakes, biscuits), and snack foods (e.g., potato chips).

Recommended intake

• *Infants and children under two years:* 35-40% fat intake for optimal growth and brain development.
• *Children above two years:* 25-30% of total calorie intake.
• Calculating non-visible fat (non-added fat that is an integral part of food) is important. For example, cereals contain 2-3% invisible fat but contribute to higher fat intake as they form the bulk of Indian diets.[28]

5.4.1. Fats and Blood Glucose Management

• Fats can delay post-prandial BG rise, leading to early hypoglycemia and late hyperglycemia (2-6 hours post-meal).
• Insulin doses may need to be adjusted to account for these late effects.[40,41]

Challenges

• *Ketogenic and Fad Diets:* These are generally not recommended due to potential risks, including imbalanced nutrient intake and increased risk of hypoglycemia.
• *High-Fat Diets:* Excessive fat, particularly trans fats and saturated fats, can exacerbate insulin resistance and increase the risk of complications, including CVD and double diabetes.
• High-fat consumption can lead to early hypoglycemia and delayed hyperglycemia.[42]

5.4.2. Special Situations

• *Dyslipidemia:* It is recommended that the Cardiovascular Health Integrated Lifestyle Diet or CHILD 1 and CHILD 2 diet plans be followed, tailored according to the severity of the condition. The CHILD 1 plan is typically suited for mild dyslipidemia and focuses on general dietary adjustments to improve lipid levels. The CHILD 2 plan is designed for more severe cases and includes stricter dietary guidelines, such as increasing dietary fiber, reducing saturated fats, and incorporating heart-healthy fats. (Refer to Chapter 14)
• *Hypertension:* To manage hypertension effectively, adopting the DASH (Dietary Approaches to Stop Hypertension) diet pattern is recommended. This diet emphasizes consuming fruits, vegetables, whole grains, and lean proteins while reducing sodium intake, red meats, and added sugars. The DASH diet is well-established for its role in lowering blood pressure and improving cardiovascular health.[43] (Refer to Chapter 14)
• *Obesity:* For weight reduction, overall calorie reduction and following the Plate Method help. This approach involves having balanced meals: half the plate is filled with vegetables and fruits, one quarter with lean proteins, and one quarter with whole grains. (Refer Chapter 14)

5.4.3. Summary for Fats in T1D

• *Types of fat*: For balanced fatty acid intake, oils can be rotated or blended, with a limited intake of saturated fats (use of low-fat dairy and lean-cut meats).
• *Prioritize Unsaturated Fats:* To reduce CVD risk and improve insulin sensitivity, the inclusion of unsaturated fats (MUFA and PUFA) should be emphasized.
• *Balanced Diet:* Ensure a balanced intake of carbohydrates, proteins, and fats to avoid excessive fat consumption and manage overall caloric intake effectively.
• During CC, it is important not to increase total fat content, as this may lead to an increased risk of overweight, obesity, and dysglycemia.
• *Nuts and Seeds:* Adding small amounts of nuts and seeds to meals can help blunt postprandial hyperglycemia. They provide MUFAs, protein, fiber, and antioxidants. They are also low in carbohydrates, making them a good choice for diabetes management.[44]
• *Cooking Methods:* Advise opting for healthier cooking methods such as boiling, sautéing, steaming, or dry roasting instead of deep frying. Reheated oils should be avoided.
• *Plant Sterols and Stanol Esters:* These can modestly lower cholesterol levels in children under five with elevated LDL cholesterol, used in consultation with an HCP.

5.5. SPECIFIC DIETS

• **Low Carbohydrate Diets (LCD):** the carbohydrate intake is limited to 20-120g/day. Extreme of any macronutrient, high-fat, or high-protein elements in meals may cause delayed hyperglycemia, requiring close monitoring and insulin adjustments.[45] Therefore, LCDs are not recommended in growing children except in extreme situations for short periods.
• **Very Low Calorie Diets (VLCD):** also known as ketogenic diets, comprise extremely low carbohydrate intake (<20-50 g/day), and aim to achieve nutritional ketosis (blood ketone bodies >0.5 mmol/L), which occurs when the body uses fat instead of carbohydrates for fuel.[46] VLCD, historically used to manage seizures in pediatric epilepsy, gained attention for weight loss in type 2 diabetes mellitus. They lack essential nutrients and can potentially hinder growth. Also, the extreme carbohydrate restriction increases the risk of hypoglycemia and may inhibit glucagon action.[1] These diets require careful, intensive supervision and are not recommended for T1D.

5.6. OBESITY HUNGER PARADOX

India and other Lower- and Middle-income Countries (LMIC) face a unique challenge: the obesity-hunger paradox. The high prevalence of malnutrition and hunger is steadily decreasing in India, but there is a growing problem of obesity, particularly among those in the low socioeconomic strata. Due to the high minimum support prices given for rice and wheat, these are lucrative and dominate over other crops. The food industry mass-produces and aggressively advertises hyper-palatable, nutrient-poor, energy-dense foods, which cause and worsen obesity and its consequences, including hyperglycemia, hypertension, and hyperlipidemia.[47] Food insecurity has been shown to increase Body Mass Index (BMI) despite consumption of fewer calories. To address this, dietary interventions should promote accessible and affordable nutrient-rich foods like seasonal and local vegetables and fruits, and protein-rich foods like low-fat dairy, pulses, and eggs while considering financial constraints.[1] (See Chapter 15)

5.7. SUMMARY & RECOMMENDATIONS

• It is important to have a balanced diet, with a balance between carbohydrates, proteins, and fats.
• Ensure the PwD and the entire family have adequate but not excessive amounts of each food group.
• Resistance to dietary changes may arise in joint families. Educating key caregivers on how the T1D diet aligns with healthy eating principles, which benefits them, can foster acceptance of the recommended modifications.
• Regular diabetes education, including CC, from the time of diagnosis, is crucial to enhance understanding of the relationship between macronutrient (especially carbohydrate) consumption and insulin requirements.
• Most people follow a routine meal pattern that remains consistent daily. Teaching the concept of carbohydrate exchanges can be straightforward and beneficial for PwD who adhere to a regular diet.
• Starting CC guidance early, utilizing ICR for meal planning along with ICF, empowers PwD and families to make flexible food choices while effectively adjusting insulin doses, thereby improving glycemic control. This education is more important for individuals with variable meal schedules or carbohydrate intake. Insulin adjustment for specific foods or snacks can provide additional flexibility in making dietary choices.
• Incorporating lemon, mint, ginger, garlic, tamarind, basil, oregano, and other spices in meals ensures that the flavor and joy of eating are retained while reducing the need for excess fat, salt, and sugar, and improving nutrition.
• Transition to healthier cooking techniques (saute, steam, boil, bake) can ensure flavor without excess calories and advanced glycation end products.
• During festivities and special events, portion control of high-fat and high-sugar foods, and incorporating some nutritious options like

steamed vegetables or fruit toppings for desserts facilitates BG control and reduces the chances of rebellion and stealing.

- *Beware of Marketing Claims:* Teach caution of marketing gimmicks like "fat-free" and "sugar-free" foods; "sugar-free" options may be high in fat or sweeteners to enhance palatability.
- *Reading Food Labels:* should be taught, to permit informed choices about food selection.
- *Family Involvement:* Encourage the whole family to maximize home cooking, adopting cooking methods and recipes to ensure taste and nutrition while avoiding high-fat, high-salt, and high-sugar. Elders following this diet set a positive example for children, while also benefiting themselves.
- *Custom Orders:* When eating out, custom orders can be requested, e.g. skipping cheese, adding extra vegetables, choosing steamed vegetables over fries, and opting for low-fat sauces and grilled or roasted options instead of deep-fried items.
- *Caution about Bakery Foods:* Bakery items like *khari*, patties, puffs, and biscuits are inexpensive and readily available, and should be advised against as they are nutrient-poor and high in fat and refined flour.
- *Low-fat milk is not diluted milk:* Diluting milk is not recommended; use of low-fat dairy is.
- *Fad and extreme diets:* cause problems in physical growth and emotional development, adversely impacting growth, energy levels, and overall well-being. They should be discouraged.

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CHAPTER 6. MICRONUTRIENTS IN TYPE 1 DIABETES

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6.1. INTRODUCTION

Vitamins and minerals play an essential role in the vital functioning of the body, with their specific roles in metabolism, gene expression, and the progression of chronic diseases, including diabetes. In vitro studies have shown the importance of various vitamins and minerals in glucose regulation and metabolism, as well as lipids and proteins, including insulin action and their anti-inflammatory and antioxidant role.[1] While intake of adequate amounts in the diet and recognition and correction of deficiencies are important, routine supplementation is not recommended. Similarly, there is insufficient evidence to support the role of routine supplementation in people living with Type 1 Diabetes Mellitus (T1D).

6.2. MICRONUTRIENTS IN THE DIET AND ROLE OF DIETARY SUPPLEMENTS IN THE GENERAL POPULATION

6.2.1. Vitamins and Minerals

Vitamins and minerals, though needed in small amounts, are vital for the working of important enzymes and hormones, and act as cofactors in the functioning of proteins and growth factors. A wholesome diet consisting of a balance of grains, legumes, vegetables, fruits, dairy, nuts, seeds, eggs, fish and meat, usually fulfills the needs of most essential vitamins and minerals.[2] (Tables 6.1, 6.2, 6.3) However, as per Global Health Risk[3], micronutrient deficiencies are estimated to contribute to 10% of total disease burden and 7% of death rates in low-income countries. With better understanding, food fortification programs for iodine and vitamin A established in many countries, and improved economic status, the prevalence of severe deficiencies did come down.[4] However, with rising obesity and unhealthy eating patterns, there is a shift in the global pattern of micronutrient deficiencies.[5]

For the estimated average requirement of vitamins and minerals for children and adolescents <19 years, refer to Table 3.3.

Table 6.1: Sources of water-soluble vitamins[6]

Nutrient	Sources
Vitamin B1 (Thiamine)	Whole grains, cowpeas, red gram, soybean, peas, nuts and seeds.
Vitamin B2 (Riboflavin)	Dairy, e.g., yogurt, Brazil nuts, soybeans, almonds, drumstick leaves, pigweed leaves (*bathua*), spinach, salmon, mushrooms, and eggs.
Vitamin B3 (Niacin)	Brown rice, legumes, poultry, peanuts, hemp seeds, and chia seeds.
Vitamin B5 (Pantothenic acid)	Legumes, soybean, sunflower seeds, eggs, dairy, oats, mushrooms, and avocado.
Vitamin B6 (Pyridoxine)	Chickpeas, dark leafy greens, papaya, poultry, fish (e.g., *rohu*, *hilsa*, pomfret, salmon (*rawas*), mackerel, bombay duck), nuts, and seeds.
Vitamin B7 (Biotin)	Sweet potatoes, eggs, avocado, salmon, flaxseeds, garden cress seeds, cottage cheese (*paneer*), nuts (e.g., walnuts, pistachios), colocasia leaves, knol-khol leaves, pointed gourd (*parwal* or *potol*), bitter gourd (*karela*), sweet potato, proso millet, and little millet (*samai*).
Vitamin B9 (Folate)	Dark leafy vegetables, legumes, beans, peanuts, other nuts, organ meats like liver.
Vitamin B12 (Cobalamin)	Fish, meat, poultry, eggs, milk, other dairy products, clams, oysters, liver.
Vitamin C (Ascorbic acid)	Citrus fruits (e.g., orange, lemon, gooseberry (*amla*), sweet lime), guava (pink & white), bell peppers, berries, tomato, dark leafy vegetables, cashew fruit, kiwi, strawberry, brussel sprouts, broccoli, raw mango.

Table 6.2: Sources of Fat-Soluble Vitamins[6]

Nutrient	Sources
Vitamin A	Dairy products, eggs, fish, organ meats, dark green leafy vegetables (e.g., amaranth (red or green), fenugreek (*methi*), spinach), carrots, orange-fleshed sweet potatoes, squashes/pumpkins, yellow maize, mangoes, and papayas.
Vitamin D	Fortified foods, fatty fish (trout, salmon, tuna, mackerel), liver, egg yolks, milk, yogurt, and tofu.
Vitamin E	Sprouts, nuts and seeds, spinach, broccoli, kiwifruit, mango, sunflower, safflower, and soybean oil.
Vitamin K	Leaves of amaranth/ drumstick/, colocasia/ pumpkin/ mustard, spinach, kale, avocado, broccoli, soybeans, edamame (frozen), lady finger, orange pumpkin, baby corn, fresh peas, pine nuts, walnuts, custard apple, pear, pomegranate, strawberry, ripe jackfruit, lotus root, gingelly seeds (*til*), mushrooms, eggs, and poultry.

Table 6.3: Sources of Minerals[6]

Nutrient	Sources
Calcium	Dairy products, dark green leafy vegetables, plant based "milks" if fortified, finger millet (*ragi*), tofu, beans, sesame seeds, dry coconut, amaranth (*rajgira*) and horse gram (*kulthi*).
Iron	Bajra, amaranth, red lentil (whole, dal), bengal gram, rajma, chickpea, cowpea, horse gram, leaves of dill/ amaranth (red, green)/ drumstick, onion seeds, and garden cress seeds.
Phosphorus	Dairy products, meats, beans, cereals, legumes, cocoa, all nuts, animal products, and egg yolks.
Magnesium	Nuts, seeds, and leafy greens.
Sodium	Salt, processed foods, canned soup, dry fish, shrimp, pickles, and *papad*.
Chloride	Salt, processed foods, and sago.
Potassium	Broccoli, tomatoes, soybean (matured, raw), lima beans, bananas, apricots, and potatoes.
Sulfur	Dry lotus stem, cauliflower, green gram (dal, whole), brussels sprouts, peas (roasted, dry), horse gram, moth beans, Bengal gram (whole/dal), red gram, black gram, foxtail millet, fenugreek leaves, cowpea, finger millet (*ragi*), buckwheat, pearl millet (*bajra*), kesari dal, drumstick & its leaves, whole wheat, maize (tender, dry, flour), rice flakes, and *rohu*.
Zinc	Red meat, poultry, seafood, nuts, whole grains, legumes, soybeans, eggs, black and white sesame seeds, pumpkin seeds, and pine nuts.
Selenium	Brazil nuts, seafood, sunflower seeds, beans, lentils, brown rice, whole wheat bread, eggs, fish, and chicken.

6.2.2. Role of Screening for Deficiencies in the Indian Population

Micronutrient deficiencies continue to remain a challenge in India, with iron, vitamins A, D, B12, and zinc being the commonest - iron deficiency in 40%, zinc deficiency in 44% of children under five years of age, Vitamin D deficiency in 70-100% across all regions and ages, and vitamin B12 deficiency in 44-66%, especially vegetarians.[4] Rising obesity with nutrient-poor diets, and continuing high prevalence of undernutrition, are contributing factors. In People with Diabetes (PwD), chronic uncontrolled hyperglycemia contributes to urinary loss of minerals. However, routine screening for micronutrient deficiency is not suggested.

6.2.3. Role of Micronutrient Supplementation in T1D

Role of routine supplementation

• There are limited clinical trials in individuals with T1D to assess the role of vitamin and mineral supplementation in improving glycemic control. Studies on chromium, vitamin E, nicotinamide, and vanadium showed no significant effect on glycemic control.[7–9] The International Society for Pediatric and Adolescent Diabetes (ISPAD) 2022 guidelines state there is no role of routine micronutrient or vitamin supplementation in those with T1D to improve outcomes or glycemic control.[10] The American Diabetes Association (ADA) and the American Dietetic Association also recommend adequate natural food sources to meet mineral/ vitamin needs rather than supplementation. Thus, supplementation is recommended only for those with deficiencies.

Micronutrient deficiencies in T1D

• Children with T1D were found to have several micronutrient deficiencies (50% with iron, zinc, riboflavin, and beta-carotene, 60% with thiamine and calcium deficiencies), with most being corrected by dietary modifications.[11] For all PwD, a thorough diet assessment for possible micronutrient deficiencies is imperative, with advice to meet vitamin/ mineral needs by a balanced diet, including low-fat dairy products, vegetables, fruits, nuts and seeds, and animal foods. Screening of PwD for micronutrient deficiencies is not recommended unless clinically indicated, e.g., in those who are symptomatic, recently detected to have Celiac Disease (CD), persistently underweight, pregnant, or lactating. Laboratory assessments can be done in those for whom it is necessary, and dietary adjustments or supplements can be advised accordingly.

6.2.4. Sodium Intake in T1D

• *Dietary reference intake of sodium for adults:* PwD have requirements for sodium intake similar to the general population. The World Health Organization (WHO) recommends sodium intake of <2 g/day, equivalent to <5 g/day of salt, in adults (>16 years of age). All-cause mortality from cardiovascular disease is significantly reduced in adults consuming < 2 g/day of sodium.[12]
• *Dietary reference intake of sodium:* across different age groups was established by the Indian Council of Medical Research - National Institute of Nutrition (ICMR-NIN), as follows: 500 mg daily for infants 0-6 months; 650 mg daily for infants 7-12 months; 1000 mg daily for children 1-3 years old; 1,300 mg daily for 4-6 years old; and 1,600 mg daily for 7-9 years old.[13]

A maximum tolerable upper limit has not been determined; however, the sodium Chronic Disease Reduction Risk (CDRR), i.e., the sodium intake above which reducing intake is likely to reduce the risk of chronic disease, is as follows: 1200 mg/day for children ages 1-3 years, 1500 mg/day for 4-8 years, 1800 mg/day for 9-13 years and 2300 mg/day for those above 14 years.[14]

• *Sodium intake in the Indian population:* Indians consume ~ 11 g/day of salt, equivalent to 4.4 g/day of sodium, significantly higher than the WHO recommendations, with added salt being the major contributor to the excess salt intake.[15] Several foods commonly consumed in Indian households are high in sodium and should be carefully taken in moderation. This includes traditional Indian items like the wide variety of *namkeens/ farsaan* and pickles, *chutneys*, *papad*, dry fish, etc., particularly commercial preparations. Almost all processed foods also contain high sodium, including sauces, soups, instant foods, canned foods, biscuits, breads, etc. It is important to read food labels carefully to get an idea of salt content. However, sometimes, the label may not give the actual salt content.[16]
• *Alternative Salts:* A variety of other salts, including Himalayan pink salt and rock salt (*sendha namak*), are widely available for commercial use in India. Limited studies are available to understand the benefits of these salts, if any. Pink salt is known for its higher mineral content; however, products are not standardized or iodized (Table 6.4), with various commercially available pink salts shown to have wide variations in the content of nutritive and non-nutritive minerals, and contain significant amounts of non-nutritive toxic minerals originating from areas of industrialization. Therefore, without strong evidence of actual nutritive value, its routine use (which may contribute to iodine deficiency) is not recommended.[17]

Table 6.4: Mineral content of Pink Himalayan Salt and Table Salt[18]

Minerals	Pink Himalayan Salt	Table Salt
Calcium	1.6	0.4
Potassium	2.8	0.9
Magnesium	1.06	0.0139
Iron	0.0369	0.0101
Sodium	368	381

6.2.5. Prebiotics and Probiotics: Their Role in Daily Use and its Significance in Glycemic Control

According to an expert panel of the International Scientific Association for Probiotics and Prebiotics (ISAPP), probiotics are defined as "live microorganisms that, when administered in adequate amounts, confer a health benefit on the host."[19] Prebiotics are defined as "substrates selectively utilized by the micro-organisms of the host, conferring a health benefit."[20] Synbiotics are a combination of prebiotics and probiotics. Though there is strong evidence to support their use in conditions like acute viral gastroenteritis and in the prevention of antibiotic-associated diarrhea, especially in children, the recent exponential increase worldwide, mainly as non-prescription health supplements, is not desirable.[21] Well-designed studies to support the routine usage of prebiotics in T1D are lacking; at present, they are not recommended for routine use.

- *Role of gut microbiome in the pathophysiology of T1D*: Gut microbiome dysbiosis has been postulated to be one of the environmental factors precipitating T1D. Several animal and human studies have confirmed a subclinical enteropathy in the preclinical phase of T1D[22,23], but this has not yet been translated into clinical application.
- *Role of Probiotics in early onset T1D*: In The Environmental Determinants of Diabetes in the Young (TEDDY) trial, probiotics were found to be beneficial in early-onset T1D, but further work is needed before they can be recommended for possibly delaying the onset of T1D.[24,25]
- *Role of Prebiotics & Probiotics in glycemic control*: Data regarding the effect of prebiotics or probiotics on glycemic control is limited and conflicting.[26–28]

Table 6.5 lists probiotics and their sources in dishes prepared in various parts of India. Natural prebiotic sources are also provided.[29]

Table 6.5: Probiotics (Fermented foods) and their sources

North India	• *Kulu* (wheat flour, buttermilk) • *Bhaturu* (wheat flour) • *Wari* (black gram, moong dal, soybeans) • *Masyaura* (black gram/green gram, colocasia tuber, radish) • *Chhurpi* (yak milk) • *Chhu, Philu, Shyow* (yak/ cow milk)
South India	• *Idli* (rice, black gram) • *Dosa* (rice, black gram) • *Koozhu* (*ragi* flour, boiled rice, curd) • *Ambali* (*ragi* flour, rice) • *Pazhaiya soru* (rice, curd) • *Kallappam* (boiled rice, coconut toddy) • *Mor Kuzhambu* (buttermilk, gram, vegetables)
East India	• *Raabdi* (flour of barley, pearl millet, corn, buttermilk) • *Kinema* (soybeans) • *Tungrymbai* (soybeans) • *Gundruk* (leaves of cauliflower, radish, or mustard) • *Sinki* (radish root) • *Soibum/ Soidon/ Eup* (bamboo shoots)
West India	• *Wadi* (black gram) • *Sinki* (radish root) • *Sauerkraut* (cabbage) • *Khalpi* (cucumber) • *Dhokla* (Bengal gram, rice), *handvo* (bottle gourd), *khandvi* (gram flour, yogurt), *kadhi* (buttermilk/ curd)
Natural Prebiotic Sources in India	• Milk • Wheat/ quinoa/ barley/ oats/ black rice • Green gram/ black gram/ red lentil/ chickpeas/ kidney beans • Cabbage/ raw banana/ plantain/ radish/ carrot/ beetroot/ yam/ sweet potato/ chicory root/ ash gourd/ bottle gourd/ snake gourd/ pumpkin/ tomato • Onion/ ginger/ garlic • Flax/ chia/ pumpkin/ hemp seeds • Blackberries/ blueberries/ ripe banana/ apple/ jackfruit/ custard apple.

6.2.6. Artificial Sweeteners

Sucrose and other simple sugars (fructose, maltose, lactose) provide 4 kcal/g energy.[30] They can be taken by PwD in permissible limits of up to < 5-10% of total daily energy intake.[31] Artificial sweeteners are generally classified as nutritive and Non-nutritive Sweeteners (NNS). Nutritive sweeteners are sugar alcohols, also known as polyols (e.g., xylitol and sorbitol), that, due to incomplete absorption by the body, provide energy of ~2 kcal/g.[32] NNS, also known as 'high-intensity sweeteners,' are several times sweeter than sucrose and provide little to no energy. NNS approved as food additives by the US Food and Drug Administration (FDA) and by the Food Safety and Standards Authority of India (FSSAI) for use in India are aspartame, sucralose, saccharin, neotame, and acesulfame potassium,[33] while two naturally occurring NNS, steviol glycoside and monk fruit extract, come under the Generally Recognized as Safe (GRAS) category as they are considered safe for consumption.

Artificial sweeteners in small amounts can help avoid glucose spikes and are useful for improving compliance. However, frequent use of sweeteners has a negative impact on the gut microbiome, suppresses the taste response to sugar, and negates the potential benefit of glycemic control.[33] Nutritive sweeteners in large amounts can also cause osmotic diarrhea. Foods labeled "sugar-free" and even other processed foods and juices may contain NNS, sugar alcohols, or both. Therefore, care is needed when reading food labels. In response to WHO's conditional guideline on NNS, FSSAI acknowledged the paucity of data in Asian populations and the need for country-specific guidelines due to unique dietary habits in India. Additionally, stringent labeling and thorough scrutiny are required before allowing NNS in food products.[34]

6.2.6.1. Artificial Sweeteners in Children

Intake of NNS in children (mainly through beverages) is more likely to exceed the Acceptable Daily Intake (ADI) due to their lower body weight. While the American Dietetic Association[35] asserts that consuming NNS is safe for children within acceptable intake limits, the US Institute Of Medicine (IOM) highlights the lack of sufficient evidence and recommends avoiding their use in childhood.[36] NNS may negatively impact cardio-metabolic health and development. However, there is limited evidence about the health effects of NNS use in children compared to adults.[37]

6.2.6.2. Pregnancy

The use of NNS during pregnancy has increased in recent times, with approximately 30% of pregnant women consuming sugar substitutes intentionally.[38] Stevia and sucralose are safe for consumption; however, there is limited information on the safety of using acesulfame potassium and polyols.[39] Although sucralose consumption within permissible limits is generally considered safe, ongoing research aims to keep practitioners informed about emerging safety concerns, particularly for children and older patients.[40] Saccharin is known to cross the placenta and concentrate in the fetal tissue; hence, it is not recommended in pregnancy.[41] Even the selected NNS, which are permissible, should be used in limited amounts, well within the ADI during pregnancy.

In summary, nutritive sweeteners and NNS may be used occasionally in small, age-appropriate amounts only after the age of two years. Frequent use and in large amounts should be discouraged.

6.3. SPECIALLY LABELED FOODS FOR PwD

6.3.1. Sugar-free Foods

Consumers often use the three terms "Sugar-free," "no added sugar," and "Unsweetened" interchangeably when defining foods and beverages, which is incorrect.

- **Sugar-free foods or beverages** contain less than 0.5 g of sugar per serving or less than five calories. This includes naturally occurring and added sugars.
- **No Added Sugar** label means that no sugar is added during processing, packing or delivery (including ingredients that contain sugar). Thus, if no sugar is added manually, the beverage can carry a label of "No Sugar Added". However, there may be naturally occurring sugars, artificial sugars, NNS, and sugar alcohols already in the beverage.[42]
- **Unsweetened** labels mean no sugar content in the food/ beverage, neither naturally occurring artificial sweeteners, nor sugar alcohols.

6.3.2. Low-calorie Foods

Low-calorie foods (less than 40 kcal/100 g for solid foods and for liquids 20 kcal/100 ml) are food products with a lower calorie content than traditional alternatives.[43] These foods are typically designed to provide nutritional benefits while promoting weight management, so they may be useful for obese people with diabetes. Food labels must be read carefully and scrutinized to understand the substitutes used and nutrient-poor components included. Home-based cooking using seasonal, regionally appropriate foods with lower glycemic indexes is a better alternative to help lower the calorie intake of PwD.[44]

6.4. SUMMARY & RECOMMENDATIONS

- Though micronutrient deficiency is common among the Indian general population, and in PwD, testing is suggested when clinically indicated, not routinely.
- Routine supplementation is not recommended in the general population or in PwD. No supplement has a significant effect on glycemic control. Vitamin and mineral requirements should be met by a balanced diet, including whole grains, vegetables, fruits, nuts, and seeds, as well as foods of animal origin, including dairy. If a deficiency is suspected, it should be documented and corrected.
- Sodium intake should be restricted as per age recommendations, up to 2.3 g per day for individuals older than 14 years of age, and lower amounts at younger ages. Salts like pink salt and *sendha namak* do not add nutritive value, and should not be used exclusively.
- There seems to be some role of probiotics in the pathogenesis and progression of T1D and glycemic control in PwD, but more evidence is needed to recommend their routine use in T1D.

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Chapter 7: Glycemic Index & Glycemic Load; Management of Mixed Meals

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7.1. BACKGROUND

The concept of Glycemic Index (GI), which measures Blood Glucose (BG) response to carbohydrate-containing foods, originated from Dr. David Jenkins' research at the University of Toronto in the late 1970s and early 1980s.[1,2] GI is a measurement system that evaluates carbohydrate-rich foods according to their impact on BG levels, relative to a standard reference food, typically glucose or white bread. GI is a numerical value assigned to a particular food, quantifying the speed with which it raises the BG compared to glucose (which is taken to have a GI of 100). Foods are categorized into three groups based on their GI values: Low GI, which includes foods with a GI of 55 or less; Medium GI, comprising foods with GI values ranging from 56 to 69; and High GI, encompassing foods with a GI of 70 or more.[3]

Glycemic Load (GL), introduced by Dr. Walter Willett and colleagues at the Harvard School of Public Health in the late 1990s, is a metric that considers both the quality and quantity of carbohydrates in a food serving.[2,4] It combines the GI of the food/ meal with the quantity of carbohydrates in a specific portion of the food/ meal[5], thus offering a more complete evaluation of the glycemic impact of foods. GL is computed by multiplying the GI of a food by the amount of carbohydrates in a serving and dividing by 100.[3] Foods are categorized into three groups based on their GL values: Low GL, which includes foods with a GL of 10 or less; Medium GL, comprising foods with GL values ranging from 11 to 19; and High GL, encompassing foods with a GL of 20 or more.[6] GL has been incorporated into dietary guidelines worldwide.[7] Usually, high GI foods have high GL, but they do not always overlap. For example, watermelon has a high GI of 74, but so much water content that there is little carbohydrate content, so the GL of a 100 g serving is only 4.

Table 7.1 provides the GI and GL values of various foods.

Table 7.2 provides the mean GI and GL of a few tested food varieties.

7.2. WHY ARE GI AND GL IMPORTANT IN TYPE 1 DIABETES MELLITUS?

- Foods with a high GI lead to rapid increases in BG levels, whereas those with a low GI induce a slower, more gradual rise.
- Foods with higher GL require more insulin.
- GI and GL are, therefore, important concepts in managing Type 1 Diabetes Mellitus (T1D): they help People with Diabetes (PwD) understand more effectively how different foods affect BG.
- By understanding the GI and GL of foods, they can make informed food choices and calculate insulin doses more accurately.
- This helps them manage their BG levels better and prevent acute and chronic complications.
- Consumption of low-GI foods has been associated with enhanced short-term and long-term glycemic control.[8]

7.3. BENEFITS OF USING GI AND GL

- **Improved glycemic control:** Consuming foods with lower GI and GL prevents rapid spikes and crashes in BG, promoting better glycemic control and less glycemic variability.[5]
- **Weight management:** Lower GI and GL foods can help individuals feel satiated for long periods, curbing overall calorie consumption and supporting weight loss.[9,10]
- **Improved energy levels:** Foods with lower GI and GL sustain energy levels longer, avoiding the energy crashes associated with high-GI foods.[1,6] This can help maintain alertness and productivity throughout the day.
- **Practicality in meal planning:** GI and GL values provide practical guidance for meal planning and food choices.[11]

7.4. PITFALLS OF USING GI AND GL

- **Complexity and variability**: Variability in food processing, cooking methods, and individual metabolic responses can make determining the GI and GL of foods complex and challenging.[12]
- **Limited focus on overall dietary patterns, with potential for overemphasis on carbohydrates**: GI and GL primarily focus on the carbohydrate content of foods and may lead to an overemphasis on carbohydrate quality and quantity in dietary recommendations while overlooking other important factors such as total calorie intake, overall composition of other macronutrients (proteins and fat) and micronutrients, nutrient density, portion sizes, food combinations,[5] and overall dietary quality.[13]
- **Limited data on Indian foods**: The available data for GI and GL of Indian foods is very limited.
- **Risk of disordered eating behaviors**: Constantly monitoring GI and GL values of foods may contribute to obsessive behavior and an unhealthy relationship with food, particularly in individuals who are predisposed to disordered eating patterns or anxiety about BG control. This risk underscores the importance of promoting a balanced and flexible approach to nutrition.[14]

7.5. FACTORS AFFECTING GI AND GL IN T1D

Various factors, including food variety, ripeness, processing, and cooking, can alter GI values. Meal characteristics such as fat and fiber content also affect the BG response. In addition, there may be person-to-person variations.

- **Consistency and composition of food**: The composition of food, particularly carbohydrate content, significantly affects BG levels. Foods with high carbohydrate content, particularly high amounts of available carbohydrates, tend to raise BG levels more quickly, while foods high in protein, fat, and dietary fiber have a slower impact. Fiber content (slows down the absorption of carbohydrates) and type of carbohydrate also affect the BG response.[15] Similarly, foods containing resistant starch generally have a lower BG response since digestion occurs in the large intestine, where intestinal bacteria ferment it.
- **Order of eating**: The order in which foods are consumed can affect BG levels. For example, eating carbohydrates before fiber, protein, and fat may cause BG levels to rise more quickly than eating them

afterward because fiber, protein, and fat can help reduce the absorption of carbohydrates.[16,17] Thus, eating salad and some *paneer*/ curd before having rice or rotis may result in a slower and smoother BG rise.

• **Cooking methods**: GI is affected by cooking methods (pressure cooking, boiling, etc.), the form of food (porridge, roti, *idli, dosa*, plain cooked grains, etc.), and food composition (nature of cereals or pulses, vegetables, etc.). Studies have shown medium GI for pressure-cooked parboiled brown rice, high GI for pressure-cooked white rice[18] or pressure-cooked unpolished foxtail millet (*kangni*) and little millet (*kutki*) [19], and low GI for pressure-cooked pulse-based preparations like *sundal*.[20] In addition, finger millet balls (prepared by boiling fine flour from finger millet to a thick consistency) and rotis prepared by roasting flattened dough (unleavened pancakes) prepared from maize, sorghum (*jowar*), and pearl millet (*bajra*) have shown high GI.[20] Thus, cooking methods, along with the form of food and its composition, determine the GI of the food.

• **Quality of grains**: The processing method and refining level impact the GI and GL. Whole grains have a lower GI than refined grains due to their higher fiber content and slower digestion.[4,21]

• **Storage of food**: Storage conditions such as temperature and humidity affect GI and GL. For example, refrigerating boiled rice, pasta, or potatoes, and consuming them later without much heating increases the resistant starch content and lowers the GI. Methods that decrease the water content of starchy foods, such as toasting, also produce resistant starch, which, along with refrigerating the food after cooking, helps to lower glycemic responses.[22]

• **Stage of ripeness**: The ripeness of fruits and vegetables influences their GI. Unripe fruits and vegetables have a lower GI: their sugar-to-starch ratio changes as they mature. In the earliest stages, e.g., a slightly green banana, the proportion of resistant starch is high, making digestion slower and reducing the BG response.[23] The size, texture, and viscosity of fruits and vegetables also affect their GI.

• **Acid content of foods:** Generally, pickles, chutneys, and other highly acidic foods have a lower GI, as gastric emptying is slowed. Adding lemon to a salad or lemon/ tamarind/ gooseberry (*amla*) to dals and other dishes makes them tastier and more nutritious while improving BG response. However, caution should be exercised; for example, pickles, though low in GI, are high in salt, increasing the risk of hypertension and heart disease.[24–26]

• **Particle size:** The particle size of sprouted wheat and barley *dalia* generally being marketed was found in the range of 1.41 to 2 mm; sorghum and pearl millet had a particle size of 0.954 to 1.41 mm.[27] Larger particle size, i.e., lesser surface area for digestion, reduces GI; thus, oats[28] and *dalia* have lower GI than when used as flours. Millets have lower amylose content, contributing to their chewy texture. Due to this texture, unpolished millets may result in finer cooked grain particles, increasing the surface area. Similar to rice, prolonged chewing of millet may elevate glycemic responses, suggesting that simply using a whole grain might not assure a low GI.[19,29,30]

• **Accounting for fat and protein**

Fat: Fats slow down gastric emptying, thus slowing the digestion of carbohydrates and delaying the rise in BG.[31] The gradual rise in BG over several hours with high-fat meals makes predicting and managing BG levels challenging. High fat intake may also lead to increased insulin resistance and the need for higher insulin doses.[17] It is important to track the *total* cooking fat used at home, be mindful of portion sizes, and choose healthy fat sources such as vegetable oils (groundnut/ sesame/ mustard oils), nuts, and seeds.

Protein: Animal foods like dairy, eggs, poultry, and fish, as well as plant foods such as legumes, are protein-rich foods. Protein also affects BG levels, but its impact is less significant than carbohydrates and fats. Protein-rich meals, especially those low in carbohydrates, may cause a slower but more sustained rise in BG.[32] Meals that consist of high fat and high protein cause lower but extended rise in BG levels, even up to 5 hours; this may protect from hypoglycemia[33,34] but contribute to sustained hyperglycemia. Insulin treatment considering carbohydrates, fat, and protein content is more effective than relying solely on carbohydrate counting. Further research is needed to establish the optimal balance for accounting for fat and protein, especially in individuals utilizing multiple daily insulin injections.[35]

• **Functional foods** are regular foods in which certain vital nutrients and food constituents provide health benefits beyond basic nutrition. Nutrient-packed foods such as whole grains (brown rice, millets, whole wheat, broken wheat, oats, and barley), legumes (peas, beans, lentils, peanuts), nuts (almonds, pistachios, walnuts, and hazelnuts), fruits (berries, cherries, grapes, plums, pomegranate, etc.), vegetables (garlic, onions, tomatoes, cabbage, cauliflower, spinach, etc.) and seafood, especially fish, as well as almost all herbs, spices, and condiments are often considered functional foods. Adding these foods regularly to the diet helps prevent deficiencies, promote proper growth and development, and enhance overall health.[36]

• **Millets:** The advantage of consuming millets is that they have higher fiber and protein content, and many of them are beneficial sources of phytochemicals. Several varieties of millets (including pearl millet, finger millet, sorghum, little millet, proso millet, kodo millet, barnyard millet, brown top millet, foxtail millet, and Guinea millet) are available in India. Different types of millet are recommended for consumption to ensure the adequacy of different nutrients.[37] The National Institute of Nutrition (NIN) recommends that the proportion of millets consumed should be 30-40% of the total recommended cereals in raw weight.[38] Certain food preparations like *upma*, roti, pancake, etc., made of foxtail millet and barnyard millet have low mean GI (<55); while pearl millet, finger millet, kodo millet, little millet, and sorghum-based preparations have intermediate GI (55–69),[37] whereas plain pressure-cooked unpolished foxtail and little millet show high GI (88).[19] Mostly unpolished millets are nutritionally superior to refined millets and can strengthen the refined white rice-based high-GL Indian diet. Combining them with different legumes, pulses, and green leafy, high-fiber vegetables can help improve BG profiles and dietary diversity and contribute to health and well-being.

• **Fiber (Soluble and Insoluble)**: Foods rich in soluble fiber such as fenugreek seeds[39], chia seeds[40], psyllium husk, flax seeds, and aloe vera (which contains soluble fiber like glucomannan, and can be added in juices)[41] have been proven to reduce the GI of foods. Soluble fiber creates a gel-like substance in the digestive system, which effectively delays glucose absorption and helps stabilize BG levels. Insoluble fiber does so by bulking up the diet, increasing satiety, and slowing down digestion.[42,43] Onion and garlic contain sulfur compounds such as allicin and allyl propyl disulfide, which have been proven to increase insulin sensitivity and decrease postprandial BG levels.[44]

7.6. RECOMMENDATIONS AND PRACTICAL TIPS TO ENSURE CONSUMPTION OF LOW GI AND GL FOODS

Eating in a certain order (starting a meal by consuming vegetables first, followed by protein and fat, and completing it with carbohydrates) can help manage BG levels, but choosing the right types of foods is more important. Whole grains, non-starchy vegetables, legumes, and fruits like berries are low-GI foods.

Here are some general practical tips to reduce GI[45–47]

1. **Include plenty of non-starchy vegetables** like fenugreek, red amaranth, cowpea leaves, spinach, drumstick/ moringa leaves, purslane, mustard leaves, *bathua*, and other greens, numerous vegetables grown locally in each region of India, particularly in monsoons. These should be incorporated into the diet to the maximum extent possible. Cauliflower, cabbage, bottle gourd, ivy gourd and other gourds, pumpkin, radish, brinjal, french beans, cluster beans, cucumber, ladyfinger, bell peppers and other vegetables including seasonal vegetables should be plen-

tiful. These vegetables are high in fiber, vitamins, and minerals but low in carbohydrates.

2. **Choose lean protein sources,** such as beans, lentils, peas, low-fat paneer, soybeans, skinless chicken, and fish. The slower absorption of carbohydrates stabilizes BG and promotes satiety, which can prevent overeating.
3. **Incorporate healthy fats**, such as vegetable oils, nuts, and seeds, in small amounts, as discussed above, because fats also slow down digestion and promote satiety.
4. **Limit and choose the Right Carbohydrates**: Complex and lente carbohydrates such as whole grains, legumes (such as lentils, soybeans, whole grams and split grams, chickpeas, kidney beans, green peas, etc.), oats, and barley, are digested more slowly, and have less impact on BG levels. To sweeten foods, use fresh and dry fruits instead of simple sugars. Avoid packaged, ultra-processed, and processed foods like commercial breads, biscuits, and commercial cereals, which often have added sugar and fructose, including high fructose corn syrup.
5. **Choose whole grains and unpolished lentils,** such as unpolished rice varieties [3,18] (Bapatla brown rice, basmati parboiled long grain, *moolgiri* white rice), whole wheat rotis or broken wheat *dalia*, unpolished millet-based dishes, black, white, and green gram, black-eyed peas, *moth* and kidney beans, and lentils, because all these have a lower GI. Barley has a low GI: its flour can be mixed with wheat flour.
6. **Fiber is key**: Aim to include foods high in soluble fiber, such as oats, beans, lentils, and unpeeled fruits (wherever possible), such as apples, pears, guavas, and berries. Soluble and insoluble fiber both help.
7. **Drink water** regularly to stay hydrated throughout the day. Sugary drinks and juices (fresh or packaged) should be avoided. Instead, opt for water or homemade (not commercial) drinks like lemon water, *jal jeera, chaas,* kokum drinks with low salt, herbal teas, *rasam*, and whey.
8. **Control portion sizes:** One should be mindful of portion sizes, especially when consuming carbohydrate-rich foods like polished rice, millets, lentils, wheat preparations, and fruits such as mangoes and ripe bananas, as well as fat-rich foods like fried items and full-fat products. Using smaller plates helps limit portion sizes and prevent overeating.
9. **Watch cereal intake:** Limit the amount of rice/ wheat consumed, while including plenty of non-starchy vegetables and lean protein. The Indian Council of Medical Research - National Institute of Nutrition (ICMR-NIN) 2024 guidelines recommend restricting cereal intake to less than 45% of total energy.[38,48]
10. **Be mindful of sauces, gravies, and chutneys:** They may contain added sugars and fats, which can contribute to BG spikes, and high amounts of salt.
11. **Use healthy cooking methods,** such as grilling, steaming, stir-frying with minimal oil, or baking.
12. **Be mindful of desserts and sweets,** such as cakes, pastries, biscuits, *gulab jamun*, *jalebi*, *barfis*, and *laddus*, which are high in fat and sugar. Instead, choose healthy dessert options like fruit salad, yogurt with fresh fruit, or a few dates/ dried figs/ apricots.
13. **Regular meal timings**: Consistent meal timings can help regulate BG levels and insulin requirements. Healthcare professionals should develop a meal plan that adapts to the family's needs and current practices.
14. **Use BG monitoring:** at least pre- and post-meal daily [preferably Continuous Glucose Monitoring (CGM)] to understand how different foods and meals affect BG levels, so that the meal plan and insulin dosage can be adjusted as needed.

Management of mixed meals

Most Indian meals consist of a combination of carbohydrates, fats, and proteins that, in the right proportions, provide all nutrients and allow good glycemic control. A basic understanding of the carbohydrate content, GI and GL, as well as the fat and protein content of a meal, helps determine the bolus insulin doses. For a meal containing >20 g of fat and >25-30 g of proteins, 125% of the calculated insulin dose must be given to PwD on Multiple Daily Injections (MDI), and a split bolus given to those on the insulin pump, with 60-70% of the dose given before the meal and 30-40% over 2-3 hours after the meal.[49] BG levels 90-120 minutes after the meal assess the impact of carbohydrates, while levels after 3-4 hours assess the impact of fats and proteins. The link below provides traditional Indian dietary practices to support pediatric diabetes management.[17,50,51]

7.7. SUMMARY & RECOMMENDATIONS

- The concepts of GI and GL provide valuable insights into managing BG levels and promoting overall health.
- GI computes how carbohydrates in food increase BG levels compared to a reference food, while GL considers both GI and the amount of carbohydrates in a serving.
- Low GI foods help smoothen post-prandial BG, reduce glycemic fluctuations, and help improve BG management, weight control, lipid profiles, and satiety.
- Functional ingredients like fiber, fenugreek, other seeds, and cinnamon can lower the GI of foods. However, complexity in determining GI and GL, limited dietary focus, potential for disordered eating, and individual response variability pose challenges.
- Several factors, including food composition/ constituents, eating order, cooking methods, grain quality, fat and protein intake, affect BG profiles in T1D.
- Tips for managing BG levels include prioritizing non-starchy vegetables, lean proteins, healthy fats, and whole grains while limiting refined carbohydrates and sugary foods. In addition, monitoring portion sizes, consuming fiber-rich foods, staying hydrated, maintaining regular meal timings, and understanding BG profiles help manage BG effectively and promote overall health, particularly in PwD.

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Table 7.1: Glycemic index (GI) values and glycemic load (GL) values[3]

S No.	Food items[1#]	Test portion (G)[3]	Available carbohydrate Test Portion	GI[2] ± SEM (Glu = 100)	Glycemic load
1	Basmati, parboiled long grain rice UO[4] (N)	64	50	52 ± 6	23
2	Rice dosa* (N)	193	50	76 ± 5	27
3	Rice idli (commercially available dry mix) * (N)	162	50	85 ± 4	30
4	Upma* (N)	310	50	71 ± 6	25
5	Basmati rice, cooked in a microwave, consumed with 20 g coconut *sambol* (N)	147	50	43±2	15
6	Basmati rice, cooked in rice cooker, consumed with 20 g coconut *sambol* (N)	147	50	54±3	19
7	Broken wheat upma, made from broken wheat and whole green gram, served with chutney (N)	180	50	39	14
8	Dhokla, leavened, fermented, steamed cake; dehusked chickpea and wheat semolina	250	50	31 ± 6	11
9	Dhokla, leavened, fermented, steamed cake; dehusked chickpea and wheat semolina (N)	250	50	35 ± 4	12
10	Dosa, made from *germinated* whole finger millet (Eleusine coracana) flour and black gram dal, cooked in fry pan, served with 30 g Bengal gram chutney	97	75	71	25
11	Dosa, made from whole finger millet flour and black gram dal, cooked in fry pan, served with 30 g Bengal gram chutney	97	75	62	22
12	Dosa, made from rice flour and black gram dal, cooked in fry pan, served with 30 g Bengal gram chutney	97	75	82	29
13	Dosa, made from foxtail millet and black gram dal (N)	290	50	42	15
14	Dosa, made from rice and black gram dal (N)	140	50	55	19
15	Idli, brown, made with parboiled rice and black gram (Phaseolus mungo) dal, served with sambar (N)	148	50	48	17
16	Laddu (popped amaranth, foxtail millet, roasted legume powder, fenugreek seeds) in hot sweet syrup (N)	80	50	24 ± 4	8
17	Laddu (popped amaranth, foxtail millet, roasted legume powder, fenugreek seeds) in hot sweet syrup	80	50	29 ± 4	10
18	Lentils, Moth bean, sprouted and cooked in buttermilk (N)	180	50	30	11
19	Parantha, radish, made from wheat, moth bean and Bengal gram dal, served with curd (N)	180	50	41	14
20	Poha, made from rice flakes and ground nuts, consumed with lemon tea (N)	154	50	43	15
21	Porridge, made from scoured wheat, consumed with Bengal gram, green gram and black gram (N)	NS	50	39±6	14
22	Porridge, made from decorticated finger millet, eaten with Bengal gram, green gram and black gram (N)	NS	50	66±5	23
23	Porridge, made from popped rice (*aralu*), consumed with Bengal gram, green gram and black gram (N)	NS	50	77±6	27
24	Porridge, made from expanded rice (puri), consumed with Bengal gram, green gram and black gram (N)	NS	50	75±4	26

25	Roti, made from germinated whole finger millet flour, cooked on hot griddle, served with 34 g Bengal gram curry	93	75	61	21
26	Roti, made from wheat flour, cooked on hot griddle, served with 34 g Bengal gram chutney	93	75	69	24
27	Roti, made from whole finger millet flour, cooked on hot griddle, served with 34 g Bengal gram chutney	93	75	58	20
28	Thalipeeth, made from wheat flour, bengal gram dal flour, green gram dal flour, served with chutney (N)	150	50	31	11
29	Uppuma kedgeree (millet, legumes, fenugreek seeds; roasted and cooked in water) (N)	230	50	18 ± 3	6
30	Uppuma kedgeree (millet, legumes, fenugreek seeds; roasted and cooked in water)	230	50	19 ± 3	7

Food items 1-4 were tested using a method consistent with ISO. Food items 5-30: are determined from studies with method deviations from ISO (Tested in type 2 diabetes participants). (N) denotes tested in normal participants. [1]Country of food production is India; [2]GI values reported on the glucose scale = 100. Values determined using white bread as the reference food were converted using a factor of 0.71. [3]Test portion weight as reported in the original article, may refer to dry or wet weight. *The year of the test is based on the testing year as reported in the paper if available, manuscript submission date, or paper publication year. [4]Sydney University's Glycemic Index Research Service (Sydney, Australia), UO - unpublished observations. NS, not specified. # Included studies done after 2000. (**Reference:** Atkinson FS, Brand-Miller JC, Foster-Powell K, Buyken AE, Goletzke J. International tables of glycemic index and glycemic load values 2021: a systematic review. Am J Clin Nutr.2021 Nov 8;114(5):1625-1632. doi: 10.1093/ajcn/nqab233. PMID: 34258626.)

Table 7.2: Mean glycemic index and glycemic load of a few tested food items [18–20,52–54]

Food	Cooked weight of the food providing 50 g available carbohydrate	Glycemic index and its classification Mean (standard error of the mean) - grading	Glycemic load *
	Millet preparations		
Finger millet stiff porridge (ball)	187	98 (6) - High	49
Sorghum roti	114	84 (7) - High	42
Sorghum idli	182	61 (5) - Medium	31
Pearl millet roti	105	70 (3) - High	35
Decorticated finger millet with a lower degree of polish -Upma	175	85 (8) - High	42
Finger millet flakes Upma	218	82 (7) - High	41
Finger millet vermicelli Upma	245	65 (5) - Medium	33
Finger millet extruded snack	39.5 (25g available carbohydrate)	65 (7) - Medium	16
Unpolished foxtail millet, plain cooked (Earth 360, Kadiri, Andhra Pradesh, India)	183	89 ± 9 - High	44
Unpolished little millet, plain cooked (Earth 360, Kadiri, Andhra Pradesh, India)	171	89 ± 9 - High	44
	Wheat preparations		
Wheat dosa	154	62 (6) - Medium	31
Broken wheat upma	190	52 (7) - Low	26
Wheat flakes snacks (chivda)	95	72 (3) - High	36
Methi paratha	118	60 (7) - Medium	30
Whole Wheat flour roti	107	45 (3) - Low	23
Atta mix roti	98	27 (2) - Low	14
	Maize preparations		
Maize roti	116	75 (5) - High	37

Pulse preparations			
White peas *sundal*	323	30 (4) - Low	15
White chickpeas *sundal*	225	24 (3) - Low	12
Adai	156	66 (3) - Medium	33
Rice Varieties			
Parboiled Brown Rice Bapatla" (BPT-5204)	249	58 ± 7 - Medium	29
Under Milled Rice (polished) Bapatla" (BPT-5204)	241	73 ± 5 - High	36
White Rice (polished) Bapatla" (BPT-5204)	185	80 ± 7 - High	40
Sona Masuri (polished)	235	72 ± 5 – High	36
Ponni (polished)	236	70 ± 4 – High	35
Surti Kolam (polished)	259	77 ± 4 - High	39

*GL calculated for the amount of cooked foods providing 50 g of available carbohydrates (except for Extruded snack which provides 25g of carbohydrates).

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Chapter 8: Synchronizing Food with Insulin

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8.1. BACKGROUND

Managing Type 1 Diabetes Mellitus (T1D) is basically getting a balance of food, insulin, and exercise, based on constant monitoring of Blood Glucose (BG) values, either through Self-monitoring Blood Glucose (SMBG) or Continuous Glucose Monitoring (CGM) devices, to ensure glycemic control and minimize glycemic variations. Good diet quality, including adequate vegetable and protein intake, following a predictable eating pattern, preventing grazing or snacking throughout the day, and ensuring proper preprandial insulin dosing, are essential for this.[1] In the diverse cultural and lifestyle landscape of India, People with Diabetes (PwD) face unique challenges in synchronizing their food with insulin therapy. By implementing targeted strategies and fostering collaboration between PwD, their families, Healthcare Professionals (HCPs), educators, employers, and community stakeholders, it is possible to overcome these challenges and empower individuals to achieve optimal glycemic control and improve quality of life. Physiological insulin replacement with basal-bolus regimens and effective dietary synchronization with insulin help optimize glycemia, which reduces the frequency of acute complications and also markedly delays the development of long-term vascular complications for up to 30 years, as shown by the Diabetes Control and Complications Trial (DCCT) and Epidemiology of Diabetes Interventions and Complications (EDIC) studies.[2] This can become a reality with continued education, support, and advocacy.

Prandial boluses depend on carbohydrate and other macronutrient intake and circadian variation of insulin sensitivity, current BG levels, and anticipated physical activity.[1] Carbohydrate intake can be monitored by Carbohydrate Counting (CC) or experience-based estimation. CC is a prerequisite for successfully determining bolus insulin requirement and focuses on improving glycemic control while allowing flexibility in food choices. The use of Insulin-to-Carbohydrate Ratio (ICR) in Multiple Daily Injections (MDI) regimens or pump therapy, regular meal patterns, and consistency in carbohydrate intake all help optimize glycemic control.[3]

8.2. CARBOHYDRATE COUNTING (CC)

CC enables precise dosing of the insulin bolus to match the carbohydrate intake of a particular meal. Carbohydrate intake varies with age, with younger school-age children consuming 30–60 g per meal and older children and adolescents consuming up to 60–90 g.[4] Dietitians or diabetes educators familiar with T1D can develop individualized food plans tailored to each child's nutritional needs, considering factors like age, usual eating habits, body weight, activity level, and insulin regimen.

8.2.1. Methods of Carbohydrate Quantification

Two primary methods for carbohydrate quantification include consistent carbohydrate intake through standardized serving sizes or exchange lists of measured quantities of food and flexible carbohydrate intake. In the exchange list method, CC is done as a dynamic approach to meal planning, with flexibility in food choices. Mealtime insulin doses are matched to carbohydrate intake, with individualized ICR for those willing and able to put in the time and effort to do the measurements and calculations, especially those on Continuous Subcutaneous Insulin Infusion (CSII, i.e., pump therapy).[5] (refer to Chapter 5 for more details)

Use of the exchange system

Foods can be divided into groups, including grain/ starch, fruit, milk, etc. Food groups are standardized for carbohydrate content as per certain portion sizes, with 12-15 g of carbohydrates picked up as one serving. Counting the number of servings in each group helps to count the total number of carbohydrates in each meal. Non-starchy vegetables contain minimal carbohydrates and can be counted as 5 g in a 100 g cooked portion. One carbohydrate serving, such as a small apple, can be exchanged for a bowl of *makhana (*fox nut) or any other item containing the same quantity of 15 g of carbohydrate. (Table 8.1 & 8.2)

Table 8.1: Sample menu for a school-going child who is back home from school at 2-3 pm

Time	Exchange pattern	Sample menu	Carbohydrate count (grams)
7 am	One carbohydrate	Poha one bowl 80 g or Dalia, one bowl of 100 g	30 g
	One fruit	20 small grapes 100 g	15 g
	One protein	200 ml cow's milk	10 g
			Total 55 g
11 am	Milk product	Paneer 85 g	10 g
		One roasted *khakra*	10 g
			Total 20g
2 pm	Three carbohydrates	*Cheelas*/ dal (pulse), two *dosas* (90 g) or two chapati (20 g)	15 g
	One protein	Chicken one bowl (or dal one bowl with chapati) – 200 g	5–15 g

	Milk product	Curd one bowl (250 g)	10 g
			Total 30 g
5 pm	One fruit	Watermelon two slices (220 g)	15 g
		Sprouts ½ bowl 60 g	15 g
			Total 30 g
8 pm	One carbohydrate	Brown rice, one bowl (100 g)	25 g
	One protein	Dal ½ bowl (100 g)	15 g
		Vegetables (no potato) (200 g)	5 g
	Milk product	Cows milk 200 ml	10 g
			Total 60 g

Table 8.2: Conventional sample menu for a college goer or young adult

Time	Exchange pattern	Sample menu	Carbohydrate count (grams)
8 am	Two carbohydrates	Poha two bowls, 80 g (x2=160 g) Or Upma two bowl 100 g (x2=200 g)	60 g
	One fruit	20 small grapes 100 g	15 g
	One protein	200 ml Cow milk	10 g
			Total 85 g
1 pm	Three carbohydrates	Cheelas/ dal (pulse), four dosas (180 g), or four poori (60 g)	30 g
	One protein	Chicken handi one bowl – 200 g	5 g
	Milk product	Curd one bowl (250 g)	10 g
			Total 45 g
5 pm	One fruit	Watermelon two slices (220 g)	15 g
		Sprouts ½ bowl 60 g	15 g
			Total 30 g
8 pm	Two carbohydrates	Rice vermicelli two bowls - 100 g (x2=200 g)	50 g
	One Protein	Dal ½ bowl (100 g weight)	15 g
		Vegetables – without potato (200 g)	5 g
	One milk product	Cow milk 120 ml	10 g
			Total 80 g

Three levels of CC are

• **Level 1 (Basic)**: Individuals are encouraged to include consistent amounts of carbohydrates in their meals and snacks by means of exchange lists. The information can be gathered from various sources, such as carbohydrate lists, books, the Internet, and nutrition labels on packaged foods. Visual aids like food models, pictures, and plate models aid in understanding, especially for younger children. See Chapter 17 for teaching aids.
• **Level 2 (Intermediate):** CC involves pattern management, where deviations in BG levels are analyzed in relation to food intake. Based on recorded data, adjustments to food plans or insulin regimens can be made in collaboration with the diabetes care team.
• **Level 3 (Advanced):** Individuals are expected to understand CC principles, including reading food labels, and have the mathematical proficiency to do the multiple calculations needed daily. When reading food labels, one must be cautious in finding the amount of carbohydrates per 100 g, how much is present in one serving, and how many servings are being consumed; protein and fat should also be considered. The amount of fiber is subtracted from the total carbohydrate content. Bolus insulin doses are then calculated based on a formula that considers the amount of carbohydrates consumed, BG level, and anticipated physical activity.[4] It is well documented that practicing precise CC prevents errors.

The Importance of Prandial Insulin Bolus Timing

Timing of the prandial bolus is as important as the quantity of the bolus dose. Routine bolusing of Rapid-acting Analog (RAA) insulins 15-20 minutes before and of Regular insulin 30-40 minutes before the meal leads to improvement of several glycemic parameters, including post-prandial hyperglycemia (by ~ 30%) and post-prandial hypoglycemia.[6] It is crucial to make sure that insulin is always given before the meal; if there is uncertainty about how much food will be eaten (e.g., toddler, vomiting, or other illness), a major portion of the insulin can be given before the meal, and the rest, if any, after the meal.[7–9] Postprandial hyperglycemia can be reduced or prevented by replacing foods with high Glycemic Index (GI) with low GI foods. (refer to Chapter 7)

Using the Insulin Carbohydrate Ratio (ICR) and Insulin Correction Factor (ICF)

ICR helps determine the dose of insulin needed to cover the carbohydrate content of a meal or snack. For most PwD, the rule of 500 works well (ICR = 500/total daily dose or TDD). For toddlers and young children, who need smaller insulin doses for the same meal, the rule of 330 or even 250 may be more appropriate.[10,11] Conversely, adolescents

may require higher insulin doses for the same carbohydrate content because of higher insulin resistance. Caregivers may find it disconcerting to give the high doses of insulin needed in adolescence, and must be taught not to underdose; otherwise, it leads to postprandial hyperglycemia. Reviewing the ICR at least once a year is essential since it changes with age and other factors.

ICR can also vary during the day, being higher in the morning and early night, when insulin resistance is higher, and lower in the afternoon and early evening. Thus, a higher insulin dose may be needed for the same carbohydrate amount in the morning than in the evening.[12] Caregivers and PwD are often reluctant to test BG and take insulin in school. Since the insulin needed in the mornings is higher, they must be taught the importance of covering the school meal/ snack with an appropriate dose instead of trying different ways of avoiding this dose. Because the ICR in the afternoon and early evening is lower, which is often the time for physical activity, the evening snack usually does not require any insulin cover.

Individualizing the ICR improves Quality of Life (QoL) and increases flexibility in food intake. Such carbohydrate quantity and distribution advice should be tailored to the individual's age, energy requirements, previous dietary patterns, activity levels, and insulin regimen, making it desirable to have education provided by a dietitian or nutritionist experienced in T1D care who works closely with the family.[5] She/ he has to provide comprehensive nutrition education at diagnosis, along with updates when available, assess caloric and nutrition intake in relation to weight status, and deliver macronutrient choices. If someone with the requisite training is unavailable locally, reaching out to an appropriate HCP virtually is helpful.[13] On an ongoing basis, having been taught the basic principles correctly, the family can learn by trial and error.

In addition to the ICR, caregivers must be taught how to calculate the Insulin Correction Factor (ICF, also known as the Insulin Sensitivity Factor or ISF). This is the amount of insulin that is added to the bolus dose to bring the BG to within the target range. For PwD using Regular insulin, the ICF is taken as 1500/TDD, and for those on RAA, it is 1800/TDD.[14] If the premeal BG is low or dropping sharply, a "negative correction" is needed, i.e., the family should be taught to reduce the insulin dose instead of giving the dose after the meal. ICF calculations must be taught from the time of diagnosis, as dose requirements change dramatically in the initial days and months, with the initial hyperglycemia (and glucotoxicity) giving way to the honeymoon phase, and finally settling down to a steadier situation. The calculations for ICR and ICF allow the individuals and caregivers to understand the doses to be given, thus improving glycemic control. Applications may be used for this if desired. (refer to Chapter 5)

8.3. SYNCHRONIZING FOOD PRACTICES/ FOOD FOR BASAL-BOLUS THERAPY – MEAL VARIATIONS

8.3.1. Synchronizing Food Practices/ Food for Basal-Bolus Therapy, with Fixed Carbohydrates as Meals

When twice-daily premixed insulin regimens were used, fixed regimens with minimal variation were advocated, with insistence on fixed insulin doses and timings, eating fixed meals with the same or similar composition (with similar quantity of carbohydrates) on all days, with fixed physical activity levels. Maintaining such a rigid and monotonous lifestyle in the long run is difficult and impractical, especially with growing children. In situations of food insecurity, it can even be dangerous. In extremely low numero-literacy and learning ability settings, in the initial few days, fixed carbohydrate content in meals, with fixed doses of basal and bolus insulin doses, can be an option, with revision periodically; efforts should be made to use simple ways of dose titration over time.[15] For most families, it is easy to understand that higher BG and more food require more insulin, and vice versa; while increased activity means lesser doses are needed. Flexible basal-bolus regimens with insulin dose adjustment according to the quantity and variety of the carbohydrates eaten in each meal and the premeal BG level are necessary to maintain even reasonable glycemic control.[16]

8.3.2. Synchronizing Food Practices/ Food for Basal-Bolus Therapy, with Flexible/ Customized Meals

The carbohydrate content of a meal is calculated by CC, e.g. by carbohydrate exchange planning. The dietitian teaches the family to determine the number of carbohydrates consumed at each meal and snack, initially by weighing ingredients, and later by visual approximation of home-cooked foods; and by reading food labels for packaged foods. Dose adjustments are made based on carbohydrate content, usual eating habits, insulin regimen, body weight, nutritional goals, and activity levels. Most people with diabetes are advised moderate carbohydrate intake (45-55% of total calories), balanced with adequate proteins and healthy fats.

8.3.3. Synchronizing Food Practices/ Food for Basal-Bolus Therapy, with Carbohydrate Exchanges

This method can be used where precise quantification is not possible, with lists of carbohydrate exchanges provided. The quantity is matched to the list provided, and the number of exchanges in each group is added to provide the total carbohydrate content of the meals. This amount is then used to calculate the bolus dose.

8.3.4. Synchronizing Food Practices/ Food for Basal-Bolus Therapy, with Occasional High-Fat High-Carbohydrate Meals

The entire family should consume a healthy, balanced diet - adequate protein and adequate (not excessive) total fat, less saturated fat, sufficient fruits and vegetables, a routine eating pattern, avoidance of grazing or snacking through the day; the PwD takes well-timed, adequate doses of preprandial insulin; to achieve optimal glycemic levels.[17] During festivals or celebrations, high-carbohydrate, high-fat meals may be consumed, e.g. (non-vegetarian or vegetarian) biryani, pizza, pasta, *naan* with a gravy dish, *poori-alu*, ice cream, fried desserts, etc. On such occasions, because high-fat causes initially lower, but later sustained, rise in BG, there may be early postprandial hypoglycemia followed by marked, late-onset hyperglycemia. This may need splitting the bolus dose, giving most of it before the meal, and the rest 1.5-2 hours later (e.g., if this is at lunchtime, the rest of the dose can be given in the evening or with a pre-dinner dose, and if this was in the evening or at dinner, the rest can be given at bedtime).[18] For meals containing more than 20 g fat and 25-30 g protein, it may be necessary to consider additional dosing (start with 20% extra).[19]

Many Indian snacks and beverages, when prepared in a low-carbohydrate form, might not need a pre-snack insulin bolus, especially in the evening, due to the higher insulin sensitivity in the evenings.[20] Often, there may also be active play simultaneously (evening play must be

encouraged in all). However, high-carbohydrate meals and snacks need adequate insulin coverage. This is particularly important in the morning: since insulin resistance is high, any such snack (e.g., a classmate's birthday cake and snacks in school) can cause significant hyperglycemia if a proper pre-snack bolus is omitted.[21]

8.4. SYNCHRONIZING FOOD PRACTICES/ FOOD FOR BASAL-BOLUS THERAPY – DIFFERENT TYPES OF INSULINS

Insulin type and regimens can differ in PwD based on affordability, access, and schedule, including school timings. Regular (also called soluble) insulin and Neutral protamine Hagedorn (NPH) are conventional insulins, which are less expensive but more inconvenient to use. NPH insulin has a distinct peak of action, resulting in a higher risk of hypoglycemia, especially at night.[15] It comes as a suspension, which results in wide variability in action profile, even in the same individual from day to day. Analog insulins used for basal needs – glargine (U100 and U300), detemir, degludec – have little or no peak and far less variability in action profile, giving smoother control. The very long-duration insulins - U300 glargine and degludec - offer greater convenience; however, this comes at the cost of lesser flexibility in making short-term changes. U100 glargine can be quite affordable as it is also available as biosimilars, and has now been included in the Essential Medicines List (with price controls). The other basal analogs are more expensive.

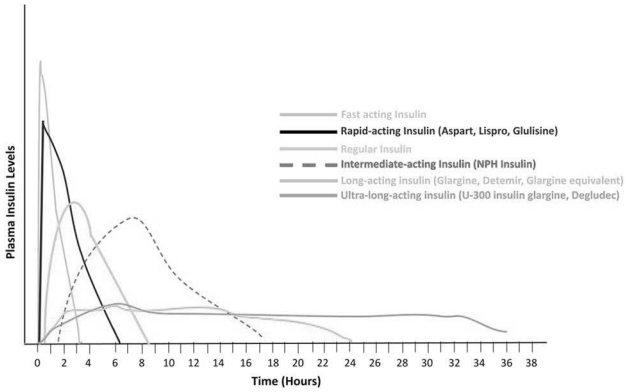
Regular insulin must be given 30-40 minutes before the meal and peaks later than the peak in BG levels, so mid-meal snacks are needed to reduce the risk of hypoglycemia. RAA can be given 15-20 minutes before eating, and their peak and decline in action match the postprandial BG profile after carbohydrate consumption.[22] This increases convenience and quality of life, avoids the need for frequent eating, and reduces the risk of hypoglycemia. (Table 8.3) Inhaled insulin, as a prandial insulin, has recently been launched in India. It has a rapid onset of action but has several caveats for use, and is not approved for individuals under 18 years of age.

Table 8.3: Regimens

RAA for basal and bolus doses given with an insulin pump
Once or twice daily long-acting analog with boluses of RAA insulin before each meal and large snack
Once or twice daily long-acting analog with boluses of Regular before each meal and large snack
Once or twice daily NPH insulin with boluses of Regular insulin before each meal and large snack

It is very important to remember the action profiles of different types of insulin so the best choices can be offered to an individual. Frequent reminders to the individual and family of these action profiles are necessary, as this understanding is crucial in synchronizing food to different insulin regimens. With bolus insulins, it is important to focus on the onset and duration of action and match them with the BG level and the meal composition. If a particular pre-meal BG is high, along with adding the correction dose, the gap between the bolus and the meal can be increased. If the BG pattern is a sharp rise after the meal, with hypoglycemia afterward, the gap between the bolus and the meal should be consistently increased. With basal insulins, the duration of action and the presence or absence of peak effect are crucial. (Figure 8.1)

Figure 8.1: Profile of Insulin and analogs[23,24] (Modified and adapted from Valitutto M. Common crossroads in diabetes management. Osteopath Med Prim Care. 2008;2:4. Published 2008 Feb 15. doi:10.1186/1750-4732-2-4, Becker RH et al. New insulin glargine 300 Units/mL provides a more even activity profile and prolonged glycemic control at steady state compared with insulin glargine 100 Units/mL. Diabetes Care. 2015;38(4):637-643)



NPH = Neutral Protamine Hagedorn

Long-acting analogs and NPH insulin, as basal doses, can be given once or twice a day, depending on the individual's BG profile, affordability, age group, and pattern of activity. The timing of the once-daily basal insulin can be altered according to the meal patterns, BG patterns, and time of hypoglycemia, if any. In most PwD, especially toddlers, giving the basal dose in the morning instead of at night can help prevent nocturnal hypoglycemia and early morning hypoglycemia. It might benefit adolescents to split the basal doses to prevent nocturnal hypoglycemia and early morning hyperglycemia.

8.4.1. Synchronizing Food Practices/ Food for Basal-Bolus Therapy with Basal and Bolus Analog Insulins

If both the basal and bolus insulins are analog insulins, there is no need for mid-meal snacks.[25] This is due to the shorter duration of action of the analog bolus insulin and the peakless glucose profile of the basal analog insulin. RAA should be given 15-20 minutes before food, ultra-RAA should be given 10-15 minutes before food, and Regular insulin should be given 30-40 minutes before food, to match the insulin action profile and glucose release following a meal's ingestion.[16] Hypoglycemia can occur if there is a mismatch between insulin dose, insulin timing, and the meal. RAA helps reduce HbA1c levels, postprandial BG levels, total hypoglycemic episodes, nocturnal hypoglycemia, and severe hypoglycemia.[26] However, they are 3-6 times as expensive as Regular insulin, while basal analogs are 2-5 times as expensive as NPH.

Most children have a substantial meal in school, which needs a pre-meal BG check and cover with insulin. Parents are sometimes advised to give the child low-carbohydrate snacks for school or various combinations of insulin before school to avoid taking the school insulin dose. This almost always results in sub-optimal BG control, with frequent occurrence of hypoglycemia before the school snack and hyperglycemia before lunch. If the child is forced to eat an unusual snack and never be allowed to share tiffin with friends and classmates,

it further alienates her/him; if she/ he does share or eat something extra, it is with the burden of guilt and more hyperglycemia (see Section 8.5).[27]

Low-carbohydrate or non-carbohydrate snacks such as peanuts, other nuts and seeds, eggs, cottage cheese, plain curd, and buttermilk can be useful in between meals without needing insulin cover. Milk or a date-nut ladoo/roll can be given as a bedtime snack if post-meal BG is low or if on Regular insulin for dinner.

Sugary drinks, such as juices (packaged or fresh), carbonated and other packaged drinks like iced tea, "energy" and "health" drinks, etc., cause a sharp BG spike, which is difficult for insulin doses to handle. They are also not good for health.[28] They should be replaced with options like plain water, lemon water (*nimbu pani*), *jal jeera, rasam*, etc., for general use, and also avoided for correction of hypoglycemia. (see Chapter 13)

8.4.2. Synchronizing Food Practices/ Food for Basal-Bolus Therapy with Analog Basal Insulin and Regular Insulin for Bolus Doses

Due to their peakless profile, glycemic variability, and the frequency of nocturnal hypoglycemia and between-meals hypoglycemia are reduced when analogs are used for basal needs. Basal analogs cause less nocturnal hypoglycemia when given in the morning rather than at night. The action profile of Regular insulin: onset at 30 minutes, peak at 2-2.5 hours (at about the time the glucose absorption from food is declining), and duration of 4-6 hours, is the reason why it must be given 30 minutes before eating, and why hypoglycemia can occur unless a small carbohydrate snack is consumed between meals and at bedtime (to prevent midnight hypoglycemia).[26,27] This is even more important if the adolescent is physically very active, e.g., sports, helping out with farm work, etc. The mid-meal snacks with portioned, moderate-carbohydrate, and moderate-protein content could be fruit with nuts and seeds, low-fat dairy, or pulse-based (roasted or boiled pulses, pulse pancake, etc.) The school dose of Regular insulin should be taken one period before the snack break to allow an adequate gap between insulin and food.

8.4.3. Synchronizing Food Practices/ Food for Basal-Bolus Therapy with NPH for Basal Doses and Regular Insulin for Bolus Doses

Where affordability is an issue, twice-daily NPH insulin given separately or mixed in a syringe with pre-meal Regular insulin (***not pre-mixed insulin***) can provide reasonable glycemic control through greater glycemic variability. NPH has a distinct peak of action. With NPH given in the morning, the bolus dose of Regular insulin has to be slightly decreased. In some individuals, the night dose of NPH may be better provided in the evening or before dinner rather than late at night to prevent nocturnal hypoglycemia. However, in case this worsens early morning hyperglycemia ('Dawn' phenomenon), NPH may be given at bedtime, with a low-carbohydrate, moderate-protein-and-fat, snack like nuts at bedtime to prevent nocturnal hypoglycemia.[29,30] Mid-meal and after-dinner hypoglycemia due to the peak of Regular insulin has to be prevented by mid-meal snacks as above.

8.4.4. Basal-Bolus Therapy with NPH for Basal Doses and RAA Insulins for Bolus Doses

Given the high glycemic variability and risk of hypoglycemia with NPH, it is best avoided. A family that can afford RAA should switch to using a long-acting analog for basal insulin.

8.4.5. Synchronizing Food Practices/ Food for Insulin Pumps with Different Bolus Types

RAA insulins are recommended for CSII, as individuals who can afford a pump should be able to afford RAA. Regular insulin can be used for CSII, but more care is needed due to the different action profiles. Insulin pumps provide insulin in the most physiologic way and offer considerable flexibility in delivering bolus doses with differing profiles, including straight, square, and dual-wave boluses. Each bolus type has implications for mealtime insulin delivery and dietary synchronization.[31] Straight boluses are suitable for meals with a high carbohydrate content and, therefore, rapid absorption. Square and dual-wave boluses are preferred for meals with prolonged or mixed carbohydrate absorption profiles.[32] Dual wave boluses are especially useful for high-fat meals/ snacks, as the delayed rise in BG can be safely tackled. Tailoring bolus types to meal composition optimizes postprandial BG excursions. It must be remembered that even with the insulin pump, the bolus dose takes 10-20 minutes to start acting and routinely must be given 10-20 minutes before eating. If the BG rises sharply after the meal, with hypoglycemia afterward, this gap between the bolus and the meal should be increased. This may be particularly important in the morning hours.

CSII allows the achievement of excellent glycemic control if appropriately used, because settings can be made near-physiologic, including the ability to alter the basal rates and give precise bolus doses based on ICR and ICF (ISF), along with the availability of finer increments for ICR below 20 g/unit and ICF below 20 mg/dL/unit.[33] The automated bolus calculator feature used for advanced CC helps achieve better HbA1c values.[34] Frequent use of the bolus adviser is associated with sustained improvements in glycemic control, with no increase in hypoglycemia.[35] As with MDI, the bolus should be taken before food, never afterward. It also remains important for the PwD not to miss mealtime insulin boluses and to give a sufficient gap before eating, otherwise glycemic control becomes suboptimal.[36]

8.4.6. Synchronizing Food Practices/ Food for Standard Insulin Pumps (without CGM) with Different Bolus Types

With the recognition of the benefits of CGM, using insulin pumps without CGM is no longer advised. Individuals doing so must ensure SMBG is frequent and carbohydrate counting is accurate to administer appropriate bolus doses and select the correct bolus type.[37] As discussed above, a straight bolus is needed for a high GI meal, and a dual-wave bolus with 60% as a straight bolus and the remaining 40% over a 2-hour period is needed for a low GI meal to help optimize the post-prandial glycemic excursions. Insulin administration 15-20 minutes before the meal (depending on premeal BG) is necessary for high-GI meals. An innovative approach suggested for high GI meals is to use a 'Super Bolus', which involves giving a bolus dose 50% more than the dose calculated on the basis of ICR and simultaneously suspending the basal dose for 2 hours.[38]

8.4.7. Synchronizing Food Practices/ Food for Sensor-Augmented Insulin Pumps with Different Bolus Types

Sensor-augmented Pump (SAP) therapy uses CGM data to enable adjustment of diet and insulin doses based on current glucose trends, facilitating more precise insulin dosing decisions and reducing the risk of hypoglycemia and hyperglycemia.[39] SAP are "open loop" systems, which needs the user to do accurate CC and decide the bolus type, as discussed above with standard pumps. SAP can improve glycemic control if appropriately used.[40]

8.4.8. Synchronizing Food Practices/ Food for Automated Insulin Delivery Systems

Automated Insulin Delivery (AID) or "hybrid closed-loop" systems also use CGM data to control insulin infusion rates, but being automated, they are more "hands-off." Ideally, the user should input the CC into the system before eating, but even if this information is not provided, the system adjusts itself by responding to the rising BG trend and brings it back to a preset range, thus facilitating tighter glycemic control and further reducing risks of hypoglycemia and hyperglycemia. The AID user is encouraged not to interfere with the system except to inform about carbohydrate counts, illnesses and other crises. If the individual frequently consumes high-calorie or unhealthy food and/or does not exercise adequately, there is a risk of obesity with its attendant problems, as for PWD. Therefore, the need for a healthy, balanced diet and lifestyle remains.[41]

8.4.9. Synchronizing Food Practices/ Food for Different Insulin Regimens During Sick Days

During an illness, maintaining glycemic control becomes challenging, due to altered dietary intake and insulin requirements. The BG usually rises due to the illness, but if intake is low due to vomiting or any other reason, hypoglycemia may occur. A light and bland diet can be consumed, including soups of grains or lentils with vegetables, with regular and increased water intake to prevent dehydration.[33] Along with frequent intake of small quantities of food, frequent monitoring of BG (and blood/ urine ketones, if necessary), is important to deal with the illness and prevent ketosis. If the PwD is not sure how much food will be eaten/ retained, part of the bolus dose may be given before eating, and the rest may be given afterward (as per amount consumed): giving the entire dose after eating should be avoided. In any case, basal insulin should not be missed. For individuals on an insulin pump, sick day management involves similar care and proactive adjustments to basal rates and bolus doses to prevent hyperglycemia and ketosis.[42] A temporary basal rate can be set for a few hours depending on current BG levels and tolerance of nutrient intake.

8.5. CHALLENGES AT SCHOOL

Children and adolescents spend half their waking hours in school, so they must be taught diabetes care in school, which includes checking BG, taking an appropriate insulin dose, and then eating, whether tiffin carried from home or meal provided by the school. Many parents or children are reluctant to perform self-care activities in school, sometimes even keeping diabetes a secret, and make different compromises, e.g., accepting that BG will be high after school, or sending very little food in the tiffin, or sending "only protein" or "low-carbohydrate" food items.[43] All these options have physical and psychological consequences. Drastically altering what the child carries in tiffin may mean insufficient nutrition during school hours, hampering the child's academic and other activities, making her/him feel isolated and different, unable to share food with friends, or sharing food with a further increase of hyperglycemia. From the time of diagnosis, the parents should be taught the need for BG checks and insulin doses in school so that the child can carry a balanced, healthy meal to school, and if necessary, adjust the insulin dose as needed.[27] For several reasons, the best place for diabetes self-care activities may be the classroom itself.[44] Challenges in school care may arise, e.g., Regular insulin has to be given 30 minutes before eating – this can be done one period before, in the classroom itself. Children like to carry food that is easy to eat quickly and conveniently: items such as paneer and vegetable wraps, *idlis* made of whole *urad dal* and unpolished rice with coconut chutney, *moong dal cheela* with vegetable or paneer filling, *dhokla* with coriander chutney, etc. can be suggested, as they are tasty and healthy.[44] The child should be encouraged to take pride in the desirable qualities of the tiffin, that it is not unhealthy food, rather than feel defensive. The child may like to share food with friends, which becomes an incentive to learn the principles of CC and dose adjustment. Parents should encourage teachers to get basic education about handling care at school, including through accurate and specific online programs (https://ispae.org.in/school-resources/). Such programs, if applied, would improve the knowledge and skills required to care for children with diabetes at schools and thus improve educational and social outcomes.[43]

8.6. CHALLENGES OF IRREGULAR HOURS AT WORKPLACE/ SHIFT WORK

Irregular work schedules and shift work pose challenges for PwD in maintaining consistent meal patterns and insulin administration schedules. Untimely eating can be a challenge faced by students attending coaching classes; some adolescents might be employed part-time. Shift work leads to changes in activity levels, meal times, and snacking habits, along with disruption of circadian rhythm. All these impact BG control: shift workers with T1D had significantly higher mean HbA1c values than non-shift workers (9.02% vs. 8.35%).[45] Hypoglycemia and hyperglycemia can cause fatigue at work and, thereby, a drop in performance. Hypoglycemia could be due to skipped or delayed meals, or being awake and working at odd night hours. Hyperglycemia may be due to eating a large meal and consuming irregular meals and snacks during late night and overnight shifts, as well as a lack of exercise or erratic timing of exercise.[46,47]

The individual and family should be educated about trying to eat major meals at usual times as far as possible and avoiding large meals after midnight. Junk food - refined starches like white bread, white rice, pasta, and potatoes, or sugary/ fried snacks - should be avoided. Whole foods are better than processed foods.[48] Therefore, planning, prepping, and carrying a meal from home when leaving for the evening/ night shift, can be very helpful as it can be made healthy and can be eaten on time. The homemade meal could contain whole grain items for carbohydrates (rotis, *cheelas*, unpolished rice or millets as *khichri*), low-carbohydrate non-starchy vegetables (greens, spinach, green beans, cucumber, cabbage, broccoli, other veggies), and protein such as curd or buttermilk, pulses in some form (e.g. sprouts, *sundal*, *dal* as curry), egg, nuts and seeds, etc.

Using ultra-long basal and ultra-RAA offers some advantage of timing flexibility with erratic meal timings, and can help reduce hypoglycemia and glycemic variability. Snacks with greens and protein can take care of hunger and prevent hypoglycemia; insulin cover might not be needed if portion sizes are small.

8.7. CHALLENGE OF EATING IN HOSTEL MESS/ COLLEGE/ CAFETERIA/ RESTAURANT/ PUB/ BAR

Increasing numbers of older children, adolescents and young adults have to stay away from home for education or work, staying in hostels and eating in a mess or outside. Adolescents and young adults also hang out with friends and eat out.

- For individuals who are outside the home for long hours, it is best to carry food from home and eat at appropriate times as far as possible. Meals/ snacks suggested above, comprising a balanced, healthy diet with all the macro- and micro-nutrients, and the correct dose of insulin taken at the proper time gap before food, can optimize glycemic control and work performance.

• If classes or work finish very late, dinner can be carried from home and eaten at the right time, between classes or at work, after checking BG, taking insulin, and eating after the correct gap, rather than having late dinner immediately after insulin and sleeping soon after. Eating large meals at night interferes with sleep and makes controlling post-dinner BG spikes difficult.
• Alternatively, those attending late-night classes can eat a proper meal during the evening or after school snack, with checking BG, injecting insulin, eating before leaving home, and carry a low-carbohydrate snack for consumption a few hours later. On returning home, another low-carbohydrate or high-carbohydrate low-GI snack can be eaten depending on the BG and hunger levels.
• Those who stay and eat outside without access to home-cooked food face a more significant challenge. They would be well advised to get/ devise as many balanced meals as possible. Trying to include more protein (lentils, milk, curd, *paneer*, eggs, fish) and fiber (salads, fruits) with portion control of carbohydrates can help improve glycemic control. Creative options that can be tried in hostel/ shared rooms and consumed regularly should be explored. Even where cooking is not permitted, supplementing meals with purchased salad vegetables, fruits, low fat unsweetened curd or milk, nuts and seeds; making dal sprouts; soaking oats overnight in curd with nuts and seeds (chia, flax seeds, sunflower, pumpkin, cucumber, or melon seeds); having *sattu* or banana with milk or yogurt, and so on. These can serve as snacks and an excellent meal, if necessary, rather than commercial fried foods or biscuits. Coffee or tea can be consumed without added sugar. All these options are also gluten-free and can easily be tried/ consumed by those with celiac disease.
• Eating out is a challenge faced by all individuals with T1D. Getting the timing and dose of insulin right can pose problems, as it may be difficult to know portion sizes and the time taken for the meal to be served. One strategy is to take part of the insulin dose on reaching the restaurant after checking BG, depending on the food ordered and likely preparation time. The rest of the insulin can be taken between or after the meal, especially useful when the snacks and food are expected to be consumed over a long duration of time. In individuals on a pump, a split bolus works well, with about 50% as a straight bolus and the remaining as an extended bolus over at least 2 hours.
• Starting the meal with protein and fiber and consuming the carbohydrates afterward is another strategy to decrease GI.[49]
• Avoiding commercial soups and fried starters might be preferable because of hidden ingredients and extra calories. Starting with protein (grilled paneer/ chicken/ fish) and salad (without creamy dressing) helps keep GI low. If sharing food or serving from a buffet, serving oneself on a plate before consuming can help estimate carbohydrates and thus optimize the insulin dose.
• Choosing items with lower fat (e.g., *roti* instead of *paratha* or *puri*; reduced or no ghee on roti), opting for steamed or grilled food, keeping portion size reasonable, using minimal or no dressings served on the side, and avoiding sugary drinks and fatty sauces are a few tricks to eating sensibly.[50] Hypoglycemia can be prevented by reducing the insulin dose if alcohol is being consumed, or there is physical activity (e.g., dancing). Fruits can be chosen for desserts. Focusing on protein (dairy, eggs, fish, chicken) and fiber (vegetables) helps balance meals and make them healthier. Mindful eating helps people make the right choices on all occasions.[51]

8.8. BASAL BOLUS REGIMENS IN DIFFERENT FOOD PRACTICES/ FOOD

8.8.1. Ketogenic Food Practices/ Food

Characterized by high fat (60–85%), moderate protein (15–30%), and low carbohydrate (5–10%) content, keto diets lead to fat utilization as the primary energy source in the body.[52] In T1D, insulin doses have to be reduced if a ketogenic diet is undertaken. Basal insulin may need to be decreased by 10-20% if HbA1c is near target, with additional correction doses of short-acting insulin if hypoglycemia occurs. Weekly adjustments are often required initially due to individual factors such as weight loss and adherence to the ketogenic diet, aiming to minimize the risk of hypoglycemia. The efficacy and safety of a low-carbohydrate, ketogenic diet in adults with T1D are still uncertain, with some evidence suggesting benefits such as weight loss (which may be useful for the obese T1D) and improved glycemic control.[53] However, caution is warranted due to potential risks of dyslipidemia, diabetic ketoacidosis, and hypoglycemia, requiring close monitoring. Further research is needed in this area. It is not recommended for children and adolescents, as it may interfere with growth and development, and can cause growth failure.

8.8.2. Mediterranean Food Practices/ Food

The Mediterranean Diet significantly impacts treatment, with a reduction in postprandial hyperglycemia and insulin resistance, lower insulin requirement, lower HbA1c, lower cardiovascular risk, improved dyslipidemia, and weight loss.[54] It does improve insulin sensitivity and BG regulation but has potential cost concerns and requires additional guidance for carbohydrate management. Larger, longer clinical trials across different regions are needed to validate its efficacy and flexibility.

8.8.3. Other Food Practices/ Food

• The DASH food practices/ food prioritizes nutrient-dense foods, aiding control of blood pressure and insulin resistance, but struggles with high carbohydrate content and sodium restrictions. Very low salt intake has been shown to increase insulin resistance.[55]
• The Flexitarian food practices/ food promotes plant-based foods with limited meat consumption, offering higher fiber and nutrients, but lacks clear limits on egg and dairy consumption.[56]
• The Ornish food practices/ food advocates a whole-food, plant-based approach that is beneficial for diabetes in general but may be challenging due to low-fat restrictions and potential vitamin insufficiency. Such specific diets impose further financial and psychological costs on the individual and family and are best avoided during childhood and adolescence.[57]

8.9. CHALLENGES IN THE INDIAN CONTEXT

PwD encounter unique challenges that impact dietary synchronization with insulin therapy. Food preparations are not standardized, with amounts and recipes varying from region to region, sometimes even household to household, so estimating carbohydrate/ protein/ fat content and insulin doses can be difficult. This is also a major strength since home-cooked food can be made healthy by avoiding excess sugar/ salt/ fat, eliminating preservatives and additives, and having several functional components to enhance taste and nutritive value.

Access to Support: HCPs familiar with the management of T1D are scarce in India, so care is provided by a variety of HCPs. Teams familiar with T1D, consisting of pediatric endocrinologists, dietitians, diabetes educators, mental health specialists, and adequate support staff, are even rarer.[58] There is a lack of formal support for families from organizations, limited awareness of available and accessible services and resources for children, adolescents, and young adults, and considerable pressure to look for cures and follow fad practices.[50]

Strategies for Addressing Challenges Specific to India

• *Language Access and Education:* HCPs should prioritize the creation of written and audio diabetes education materials in regional languages, which would promote better understanding and adherence to treatment regimens and dietary management.
• *School Support Programs:* Collaborative efforts between parents, HCPs, and school staff in providing protocols for schools to support students with diabetes- educating school staff about diabetes management, implementing structured meal plans, providing resources for diabetes self-care (BG testing and insulin administration) and handling emergencies during school hours can help children adhere to their treatment plans effectively.
• *Peer groups*: Introduction to a peer support group at diagnosis can enhance access to awareness, accurate information, and support networks.
• *Telemedicine* can greatly benefit families in rural, remote, and geographically isolated areas by enabling advice from expert teams, and even in urban environments saves time and money for families, alternating with in-person care. Accessing specialized dietary and other advice online, whether one-on-one or as part of a peer support group, can improve care and facilitate glycemic control. Improved HbA1c, along with cost and time savings, can be expected due to better and frequent specialist interaction.[5] Telemedicine can be in synchronous or asynchronous consultation, allowing families to communicate with the HCPs using external telecommunication devices, such as mobile phones, tablets, or desktop computers, as well as broadband or digital cellular networks. It can be in person visit, followed by text messages, audio or video consultations.[59]
• *Workplace Flexibility and Education:* Employers can play a pivotal role in supporting employees with T1D by offering some flexibility in work schedules and accommodating needs for insulin administration and timely meals. Workplace education programs on diabetes management can raise awareness and foster a supportive environment for individuals managing T1D while working irregular shifts.
• Occupational health practitioners can provide guidance on managing diabetes effectively during shift work.[45]
• Collaborative efforts between Non-Governmental Organizations (NGOs), private industry, and HCPs can invest in expanding access to modern diabetes technologies for underprivileged populations and addressing financial barriers to diabetes care.[60]
• Collaborative efforts by PwD, their families, the T1D community, and HCPs are crucial.

8.10. SUMMARY AND RECOMMENDATIONS

To optimize dietary synchronization with insulin therapy, HCPs should:

• Provide individualized meal plans tailored to insulin regimen and lifestyle.
• Include SMBG/ CGM, teaching about CC, ICR, and ICF, for precise insulin dosing.
• Educate about managing insulin, food, and hydration during sick days.
• Teach proper timing of insulin bolus doses (e.g., RAA 15-20 minutes before meals) for minimizing postprandial hyperglycemia and avoiding hypoglycemia, thus improving overall glycemic management.
• Educate individuals about strategies to overcome challenges specific to their environment.
• Address T1D management at school and workplaces through education, support protocols, and structured meal plans to help maintain glycemic control and reduce the feeling of isolation for PwD.
• Encourage regular record-keeping and continuous communication with the HCPs for ongoing support and guidance.
• Use telemedicine and regional language educational materials to enhance access to specialized T1D care, support adherence, and improve glycemic outcomes, especially in remote and under-resourced areas.

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Chapter 9: Festivities, Special Events, Travel, and Alcohol

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9.1. FESTIVE SEASONS AND SPECIAL EVENTS (BIRTHDAYS, SCHOOL CAMPS)

India is a land of diverse cultures, and festivals are an integral part of our lives. While festivals are associated with fun and frolic, they come with challenges, especially for young individuals with Type 1 Diabetes Mellitus (T1D).[1] Other than festivals, birthdays, weddings, or parties can be difficult to cope with. People with Diabetes (PwD) should be considered a part of the peer group and involved in family festivities/ travel/ camps, etc., for their psychosocial well-being, as these occasions are great motivators and equalizers. It is the diabetes care team's responsibility to empower them, as well as caregivers and parents, who are often primary decision-makers, with adequate self-care skills to handle these situations safely instead of avoiding them. With better care strategies like Carbohydrate Counting (CC), Continuous Glucose Monitoring (CGM), and insulin pumps, the lives of PwD are becoming more comfortable. However, not everyone has access to technology, and even with technology, the need to strike a balance between indulgence and healthy choices remains.

9.1.1. Challenges

Maintaining glycemic control is not easy during functions, when one indulges in high Glycemic Index (GI) foods, foods High in Fat, Sugar, and Salt (HFSS), eats at erratic times and in uncontrolled amounts, reduces medication compliance, engages in erratic Physical Activity (PA), experiences stress, and has altered sleep habits, among other issues.[2] It is useful to encourage the family to focus on the entire festivities, shifting the focus away from solely food. The following guidelines have been framed to enable PwD and the rest of the family to enjoy festivities with little or no compromise of metabolic control.

9.1.2. Glycemic Management During Festivities

9.1.2.1. Meal Planning

It is desirable to discuss the menus in advance and plan sensible options, wherever/ whenever possible, preferably involving a trained nutritionist. Adequate insulin doses should match meals and heavy snacks with CC and, as far as possible, be taken at fixed times. Additionally, PA should be encouraged and maximized for optimal health benefits. Pre-festive counseling should reinforce the message that festivities mean fun, without strict restrictions, with the motto ***'Indulgence in a healthier version of favorite foods.'*** Making smart choices can help maintain glycemic control.

Carbohydrates should, as far as possible, include low GI complex carbohydrates to keep Blood Glucose (BG) excursions in check.[3] Thus, preparations of whole grains (whole wheat, broken wheat, unpolished rice, millets), plantain flour, jackfruit flour, oats, barley, legumes, preferably whole (lentils, beans like rajma, soybeans & peas), fruits, non-starchy vegetables, and low-fat dairy products should be encouraged.[4] *Rotis/ parathas* of whole wheat or *missi rotis* are preferred to *luchis, pooris,* bread*,* and *naan* made of refined flour (*maida*). If bread is used, advise opting for whole-grain bread over white bread. Emphasize reading food labels to make healthy choices while buying packaged foods.[5]

Ensuring high protein content in meals also helps keep the GI low. For example, sprouts or *channa* salads, *moong dal/ pesarattu* dosa or *besan cheelas*/ vegetable tomato omelet with paneer filling, egg/ chicken/ paneer wraps, and grilled fish/ chicken/ paneer/ *sattu* may be preferred to *masala dosas (*mainly peeled potatoes filling) or other high-carbohydrates, deep fried dishes; custard made with egg has lower GI than if made with cornflour alone. Sources of proteins in food items are given in Table 9.1.

Table 9.1: Sources of protein incorporation into daily food items[6,7]

Meal	Protein source
Breakfast	One cup curd/ 50 g paneer/ one cup skimmed milk/ one egg/ one cup sprouts*/ one cup kidney beans*/ chickpeas*/ soybean*/ green gram* (either steamed or made into patties)
Lunch	One cup curd/ one cup dal*/ sprouts*/ 50 g paneer/ one cup soya granules*/ 100 g chicken or fish
Evening	One cup *chana** chaat/ sprouts* *chaat*/ one egg omelette
Dinner	One cup curd/ one cup dal*/sprouts*/ 50 g paneer/ one cup soya granules*/ 100 g chicken or fish

*Cooked portions, one cup = 200 mL

Nuts and seeds are good sources of healthy fats, protein, and fiber, which promote satiety and provide energy.[8] Thus, adding peanuts and squeezing lemon on dishes like *poha* (rice flakes) or adding some sunflower seeds, chia seeds, almonds, cashews, etc., can reduce GI, add taste, and provide much-needed satiety.[9–11] Non-starchy vegetables are included in plenty and preferably consumed at the beginning of the meals to promote satiety and blunt the post-meal BG response. Thus, *raita* or other yogurt dishes with grated vegetables or boiled greens (like spinach and *bathua*) can make food festive, appealing, and nutritious. (For the Indian healthy plate, refer to Figure 17.1)

The meal sequence should be appropriate, starting with high-fiber and high-protein starters or dishes followed by carbohydrate-rich foods. A good plan will be a meal starting with a drink like water or nimbu pani/ clear soup, then fiber and protein, e.g., a vegetable-paneer salad or crudites with hung curd dip, and then carbohydrates, to reduce postprandial BG spikes.[12] Fruits can be consumed in small portions between meals, or as a dessert in place of sugar and fat-laden dishes, including high GI fruits like mangoes, which if served as a dessert with meals, can be covered by pre-meal insulin. Combining nuts with fruits provides satiety and blunts post-meal glycemia. Choose healthier cooking methods like poaching, steaming, stewing, grilling, roasting, and boiling over deep frying; e.g., *parathas* are preferable to *pooris*. In general, deep-fried food items, whether sweet or salty, should be consumed in moderation.[13] Even *bhajis* and *pakodas* can be made on tava or in a *paniyaram* maker.

'***Being mindful of the portion size***' is the key.

Hydration is best done with plain water. If drinks are made at home rather than using commercial products, there are several healthy, sweet and/or salty options, e.g., *nimbu pani* (low sugar, low salt), *jal jeera*, *rasam*, coconut water, unsweetened kokum drink *(sol kadhi),* buttermilk (sweet or salty), fruit milkshakes without added sugar, and so on.[14] Sugary, fizzy, and energy drinks and juices (fresh or commercial) are laden with empty calories and sometimes caffeine, and are best avoided. Too much salt should also be avoided. Alcohol, another accompaniment during festivities, should be discouraged or taken cautiously, as it causes hypoglycemia and hyperglycemia. It should be consumed with food, not on an empty stomach, with regular BG Monitoring (BGM), especially watching for delayed hypoglycemia.

9.1.2.2. Carbohydrate Counts for Special Foods

Awareness of the carbohydrate counts of the special meal preparations and how to adjust insulin doses accordingly is necessary to keep BG in check. Information about analyzing food labels (refer to Chapter 5) is a part of pre-festive counseling.[15]

9.1.2.3. Monitoring BG and BG targets

BGM - ideally CGM, or with a glucometer (Self-monitoring or SMBG) or is an indispensable part of a safe and healthy festive celebration. BG should be checked before and after every meal to ensure the correct matching of the bolus doses, and during periods of PA. BG targets remain the same as during non-festive times.[16]

9.1.2.4. Insulin Dose Adjustments

Insulin dose must be adjusted and matched with carbohydrate intake, keeping PA in mind. Knowledge of the Insulin Correction Factor (ICF), also known as the Insulin Sensitivity Factor (ISF), and of the Insulin Carbohydrate Ratio (ICR) should be reinforced to family members.[17] (refer to Chapter 8)

9.1.2.5. Physical Activity and Stress Management

Festive seasons alter PA and sleep patterns. There may be dancing and increased PA, or decreased activity during festivities. Keeping an eye on CGM, or doing frequent SMBG, especially after dancing/ exertion, is necessary to detect and prevent immediate and delayed hypoglycemia. If PA levels are low, 15-30 minute walks after meals or gentle exercise will help stabilize post-meal BG spikes.[18] Encourage adequate sleep and meditation exercises to balance the stress that comes with fun and frolic.

9.1.2.6. Benefits of CGM During the Festive Season

Altered timing and type of food, PA, and medication affect the BG. CGM is a useful tool – awareness of BG excursions helps to match insulin dosage and activity. It has been proven to provide better guidance in maintaining glycemia during festivities.[19] Families who cannot afford CGM at all times may opt to use it at such times. Talk to family members and friends about helping adhere to the meal plan, adequate BGM, and taking insulin/ medications on time.[20] Encourage friends and family to avoid gifting unhealthy foods, including sweets and fried, high-salt savories on festive occasions. Gifts of healthy options like nuts and seeds or fresh fruits are welcome.

9.1.3. Managing T1D During Birthdays, Day Camps, and School Picnics

Birthdays, day camps, and school picnics are filled with excitement, fun activities, and often a departure from the routine diet and schedule. For children with T1D, these events require additional planning and flexibility to ensure they can participate fully while maintaining their health and glycemic control.

Birthdays, Day Camps, and School Picnics: Birthdays are special milestones, most often associated with the consumption of sugary treats and irregular eating schedules. Similarly, day camps and school picnics involve various activities that can affect BG levels, from physical exertion to provided meals and snacks. Proactively preparing to ensure balance is the key to managing T1D during birthdays, other parties, day camps, and picnics. Parents should be given the following advice:

- *Pre-Event Planning:* Work with camp organizers/ hosts of the party to plan the menu, incorporating healthy options that are also diabetes-friendly, as discussed above, along with traditional birthday or picnic treats. Snacks can be a mix of healthier, preferably non-fried savory and sweet options, with plenty of protein-rich choices like *chana* chaat, grilled paneer/ chicken/ fish, and low-calorie choices like salads, vegetable crudites with curd dips, puffed rice preparations, unbuttered popcorn, nuts, and fresh fruit slices, instead of fried options like samosas, vadas, fried chicken/ fish. Sugary beverages are best avoided altogether. It would benefit not just the child with T1D but also all the other children. This might include lower-sugar cakes (less icing, decorations with fruits for natural sweetness and added fiber, nuts, and edible flowers), preferably without fondant, desserts, and balanced meals with complex carbohydrates, proteins, and vegetables.
- Discuss with organizers/ hosts how to control serving sequence (protein- and fiber-rich snacks in the beginning; carbohydrate-rich foods, cake, and desserts later) and portion sizes, e.g., the cake and other junk items can be smaller sized and served in small portions to all, with the choice of taking a second portion if desired.
- *Insulin Management:* An additional insulin bolus may be needed before eating: the dose should be based on the anticipated food intake and the PA level.[23]
- *Activity Consideration:* Birthday parties often involve PA or games. Planning various fun activities would shift the focus away from food, ensure the association of PA with celebration and enjoyment, and reduce hyperglycemia due to high-calorie food. Frequent BGM is important for managing potential lows from increased activity.
- *Communication with Camp Staff/ Accompanying Teachers/ Hosts:* Ensure they know the child's T1D management needs, including dietary restrictions, if any; BGM; and insulin administration. During a birthday, if no adult is accompanying the child, then T1D and necessary precautions should be similarly discussed with the hosts.
- *Meal planning:* Collaborate with camp staff/ teachers to understand what food will be served and how to integrate the child's dietary needs.
- *Pack Smart:* Prepare a diabetes care kit with BGM supplies, insulin in a cool case, and snacks for managing hypoglycemia, if needed. Include a water bottle (and request that clean, plain water be available for everyone) to encourage hydration.[23]
- *Educate and empower:* Ensure camp staff/ teachers know whom to stay in touch with as needed, how to recognize symptoms of hypo- and hyperglycemia, and how to handle any emergencies, especially hypoglycemia.
- *Activity and BGM:* Given the increased PA typical at day camps, frequent BGM is essential. Adjust insulin and snack intake accordingly to prevent hypo- or hyperglycemia.[24]

9.1.4. Festivities Associated with Fasting

Fasting is an integral part of many festivals in our country. Most fasts are associated with feasting, which can lead to major glycemic alterations. Fasting can be day-long, week-long, or month-long.

9.1.4.1 Metabolic Changes During Fasting

Major metabolic changes occur with long-duration fasts. Hypoglycemia, especially with long fasting hours, and hyperglycemia with fried and high GI food intake contribute to dysglycemia. Dehydration and ketoacidosis may occur during fasting.[21]

9.1.4.2 Pre-fasting Counseling

All religions forbid children from fasting. Adolescents with poor metabolic control and frequent hypoglycemia should be advised against fasting on medical grounds, till better control is achieved.[21] Pre-fasting counseling must include meal planning, the need for intensive BGM, hypoglycemia awareness, and a willingness to break the fast if warranted.

9.1.4.3 Meal Plans Outside Fasting Hours

Fried, oily, highly starchy, and sugary foods [*sabudana khichri/ wada*, potato wafers, potato or sago *farsan*, amaranth (*rajgira*) *laddoos*, potatoes, *puris*, sweet lassi, fruit juices] commonly consumed during fasting, should be discouraged or consumed in small portions. The focus should be on meals consisting of fruits, vegetables, proteins, and low to moderate GI and high-fiber foods like barley, whole wheat, sweet potato, oats, millet, broken wheat, brown rice, beans, and lentils which release energy slowly, to reduce glucose variability. Hydration should be maintained during fasting hours if permissible; plain sugar-free drinks like water, lemon water, and buttermilk should be consumed during non-fasting hours.[22]

9.1.4.4. Insulin Dose Adjustments

Insulin doses need to be matched with BGM. As a starting point, the total daily dose must be reduced by 10-20%, and basal insulin, if taken at night, shifted to early morning. Pre-meal bolus should be given as per BG levels[21], and the daytime bolus is missed since no meal is consumed.

9.1.4.5. Conditions Requiring Breaking the Fast

Pre-fasting counseling must include willingness to break the fast at any time if there are any symptoms/ signs of hypoglycemia, or if BG is <70 mg/dL even without symptoms, in the event of any acute intercurrent illness, or general deterioration in health causing significant physical and mental compromise.

9.1.5. Managing T1D During Holidays/ Sleepovers/ Change in Schedule

Sleepovers or school trips (or even holidays) can be exciting yet challenging experiences since they require careful adjustment of insulin and meal timing to maintain euglycemia. While maintaining a consistent routine is ideal for good health and glycemic control, occasional deviations can be accommodated with proper planning. The biggest challenge at such times is food management, as there might be a risk for frequent, unstructured, unmeasured, and unhealthy eating, making it difficult to track insulin on board and determine appropriate dosing. Identify the adult/s who will supervise the child and ensure they have adequate diabetes care education and access to family and health care personnel in case of an emergency. Discuss his/ her role in management with the child, with the clear understanding that nights away from home are not a "free pass" for diabetes, as the possibility of becoming unwell would ruin the experience for everyone. The child must commit to taking (supervised) charge of checking BG, taking adequate insulin on time, and minimizing disruptions to the schedule by not keeping awake all night or grazing on food all day or throughout the night. Gaps between eating, CC, and adequate, timely insulin doses are important. Empower the child to take responsibility and share any issues that arise.

Across all these events, the overarching goal is to enable the child with T1D to participate fully and safely like his/her peers. By planning ahead, collaborating with event organizers, and empowering the child with knowledge and tools for self-management, it is possible to navigate the challenges of diabetes management during special occasions. This approach ensures the child enjoys these memorable experiences without compromising health, fostering a sense of normalcy and inclusion. These are also occasions when a child who has been resisting self-care may be willing, even eager, to learn to manage, whether testing or interpreting BG, self-injection, or handling/ preventing hypoglycemia.[25]

9.2. TRAVEL

Traveling to new places disrupts routine: erratic meal timings, unfamiliar food, erratic PA, weather changes, and, if applicable, being in different time zones can all disrupt metabolic control.[26,27] Planning ahead is the key to safe and trouble-free travel. CGM or SMBG are necessary to adjust insulin dosage according to BG trends.[28]

9.2.1. Prerequisites Before Travel (pre-travel planning)

- Families should be advised to contact the doctor, or where available, the diabetes care team, well in advance, preferably 2-4 weeks before the trip, with travel itinerary, for reinforcement regarding CC, dose adjustments, sick day rules, hypoglycemia, and insulin storage during travel and stay.
- Diabetes should be well controlled before travel to minimize complications and problems during travel.
- The family should remember to protect insulin from excessive heat or cold and never leave it in a vehicle.
- During travel, the family should maintain meal timings and avoid skipping meals. They should be aware of meal serving schedules and, if required, put in a request to serve at particular times to avoid BG fluctuations. If meal timings are erratic, they must keep extra snacks and supplies to treat hypoglycemia, especially since finding healthy snacks can be challenging during travel.[29]
- Determining the carbohydrate content of food items in the local cuisine is advisable to calculate bolus doses correctly, keeping anticipated PA in mind. Some adjustments of insulin doses for protein and fat should also be reinforced for the family before travel.
- The basal dose and time need adjustment if time zones are being crossed.[30]
- They should be reminded to check BG very frequently. Families familiar with CGM but unable to afford constant use may find it safer to shift to CGM during travel. The child should carry a diabetes I-card in person at all times.
- A prescription is needed permitting to carry sharps (needles, syringes, lancets), all insulin supplies and glucagon, pump, glucometer, and strips, in the hand baggage if traveling by air.[29]
- The family is advised to carry extra supplies of insulin, extra batteries, glucose testing strips, ketone strips, glucose tablets, glucagon

injection/s, and extra CGM and/or pump supplies. Children on insulin pens and pumps should also carry insulin syringes in case of pen/ pump malfunction.
• Several other precautions, not related to diet, are necessary, and can be accessed from www.ispae.org.in

9.3. ALCOHOL

Effective diabetes management extends well into lifestyle choices and requires a nuanced understanding of how various factors, including alcohol, impact BG levels. Consumption of alcohol particularly needs careful consideration because of its complex effects on metabolism and BG stability. Alcohol can induce hypoglycemia, especially if consumed without adequate food; this is of particular concern as it can also impair judgment and reduce the ability to effectively manage diabetes, such as forgetting to monitor BG or misjudging insulin doses.[31] Moreover, glucagon is less effective in correcting alcohol-induced hypoglycemia. Hyperglycemia can occur later. It is best if the PwD is accompanied by someone who is not drinking and is aware of the need to monitor BG and manage BG fluctuations. Alcohol consumption should be avoided or kept low as excessive intake also has potential long-term consequences, including weight gain, increased blood pressure, and increased risk of developing heart disease. Guidelines by the American Diabetes Association (ADA)[32] and the International Society for Pediatric and Adolescent Diabetes (ISPAD)[2], underscore the need for education and awareness of safe consumption practices to balance enjoyment with safety and glycemic control.

9.3.1. Safety Considerations

• *Low-carbohydrate options:* Light beers, dry wines, and spirits without sugary mixers are preferable for PwD due to their lower carbohydrate content.[4]
• *Moderation is key:* Regardless of the type of alcohol, moderation is crucial to avoid adverse effects.

When to Drink

• *Never on an empty stomach:* Alcohol should only be consumed with food, to minimize the risk of hypoglycemia.
• *Avoid insulin peak times:* It is advisable to avoid alcohol consumption when insulin action is peaking, to reduce the risk of hypoglycemia.[2]

How Much to Drink

The general recommendation for alcohol consumption in adults— one drink per day for women and up to two drinks per day for men[33] — applies, but PwD needs to be more cautious.

Definition of one drink (1 ounce= 30ml)[34]:
• 12 ounces of beer.
• 5 ounces of wine.
• 1.5 ounces of distilled spirits.

BG Testing Guidelines
• *Monitoring and Adjustment:* CGM or frequent SMBG is necessary to make real-time adjustments to insulin dosing, as follows:
• *Before Drinking:* Test BG before consuming alcohol to ensure they are within a safe range.
• *During and After:* Monitor BG while drinking and for up to 24 hours to watch for delayed hypoglycemia.
• *Nighttime Testing:* If alcohol was consumed in the evening, nighttime BG testing is advisable to look for and prevent nocturnal hypoglycemia.

Insulin Dosing Considerations

• *Adjusting Doses:* insulin dose adjustments should be made on days when alcohol consumption is planned, keeping in mind the possibility of alcohol-induced hypoglycemia and the chances of hyperglycemia if more snacks and food are consumed.
• Adjustments should be based on CGM/frequent BGM made, guidance of a healthcare provider.[31]

9.4. SUMMARY & RECOMMENDATIONS

• To maintain metabolic control during festivals, birthdays, other parties, picnics, day camps, or other special occasions, planning ahead is important.
• The meal/s should preferably include low-GI foods with complex carbohydrates, proteins, and fiber, including fresh, whole fruits and vegetables.
• Healthier cooking methods like roasting, grilling, or boiling are preferred over frying.
• Portion size should be considered: fried, high-salt items and sweets should be consumed in moderation.
• Hydration should be maintained with plain water or non-sugary drinks. Sugar-sweetened beverages and alcohol should be consumed in moderation, with close BG monitoring.
• Counting carbohydrates and matching insulin doses should be practiced for each meal.
• Knowledge of ICF and ICR should be reinforced to ensure correct insulin dosing.
• BG should be monitored frequently, before and a few hours after every meal, especially post-feasting, to ensure the bolus dose is well matched. BG targets are the same as during non-festive times.
• Frequent BG monitoring should continue for a few hours after dancing/ exertion to prevent/ detect delayed hypoglycemia.
• Adequate sleep and exercise must be encouraged to reduce any stress associated with festivals and holidays.
• CGM has been proven to improve metabolic control.
• Fasting may cause metabolic derangements like hypoglycemia, dehydration, and ketoacidosis and requires close BG monitoring.
• Individuals with poor metabolic control and hypoglycemia unawareness should be advised against fasting, and taught to improve control.
• Pre-fasting counseling should emphasize the need to break the fast anytime hypoglycemia or deterioration in general health occurs.
• Meals consumed pre-fasting and during non-fasting hours should contain low-GI foods, fewer carbohydrates, proteins, healthy fats, and fiber to reduce glycemic variability.
• Intensive BG monitoring is needed during fasting hours; insulin doses should be matched at every meal.
• Changes in routine can disrupt metabolic control while traveling. Planning ahead is the key to safe and trouble-free travel.
• Contact your diabetes care team in advance, preferably 2-4 weeks before the trip, for education about and ensuring understanding of dose adjustments, sick day rules, hypoglycemia, and insulin storage.
• Carry a travel letter permitting the carrying of needles, syringes, lancets, and insulin pump supplies in the handbag, as well as a medic alert bracelet with information about current medication and treatment of hypoglycemia.
• Check BG frequently.
• Always carry extra insulin supplies, a glucometer with extra batteries, glucose testing strips, ketone strips, glucose tablets, and glucagon injections. For insulin pump users, extra pump supplies should be carried along with insulin pens/ syringes with vials in case of pump malfunction.

• Researching the local cuisine and the carbohydrate content of locally available food items is advisable. Cover meals with an adequate rapid/short-acting insulin bolus.
• Do not skip meals. Maintain consistent meal patterns and be aware of meal serving schedules. Request meals according to your personal schedule to avoid fluctuations in blood glucose.
• Always keep extra snacks and supplies to treat hypoglycemia.
• *For pump users:* The same basal rate can be continued, or lower temporary basal rates can be considered to avoid hypoglycemia during long-distance travel. Frequent SMBG or CGM and carbohydrate counting is needed to adjust bolus doses. The pump clock needs to be adjusted to the local time of arrival.
• *Education about Alcohol:* Inform PwD and families about the impact of alcohol on BG levels, emphasizing the increased risk of hypoglycemia, especially when alcohol is consumed without food. They must also know the age after which they are legally permitted to consume alcohol – this varies from age 18 years to 25 years in different states of India.
• Advise safe drinking practices, such as monitoring BG before, during, and after alcohol consumption and educating on the need to consume alcohol with food to mitigate the risk of hypoglycemia.
• Implement screening for substance use as part of routine diabetes care, integrating preventive advice and intervention strategies. Provide resources and referrals to support cessation and management of substance abuse, emphasizing a multidisciplinary approach to care.

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Chapter 10: Nutritional Management of Exercise and Physical Activity

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10.1. INTRODUCTION

Children and adolescents with diabetes must get a healthy, balanced diet with adequate nutrients to achieve optimal growth and development, achieve ideal body weight, and prevent acute and chronic complications. People with Diabetes (PwD) also need adequate Physical Activity (PA) to stay physically fit, mitigate cardiovascular risk factors, achieve and maintain good control of glycemia, Blood Pressure (BP), and lipids, and improve their sense of overall well-being. However, managing PA with diabetes presents unique challenges, especially avoiding and managing hypoglycemia and hyperglycemia, whether the regimen is Multiple Daily Injection (MDI) or Continuous Subcutaneous Insulin Infusion (CSII, i.e., insulin pump) therapy.[1,2] Some PwD may need to do considerable PA as part of daily activities, e.g., farming, manual labor, walking long distances, or climbing small hills to school/ work, as in rural areas. Others may be extremely active in recreational or professional sports, where nutrition has additional performance implications. Healthcare Professionals (HCPs) and caregivers must understand the changing nutritional requirements in such situations, how different types of exercise cause metabolic and neuroendocrine responses, and advise PwD regarding food and insulin adjustments accordingly.[3]

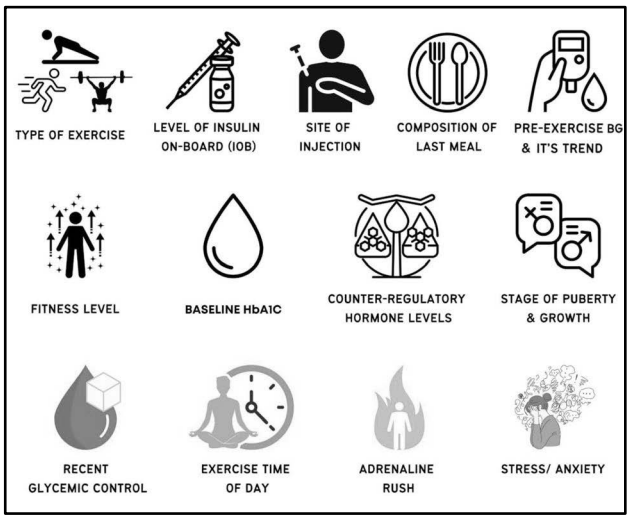
These guidelines serve as a foundation primarily for the dietary aspects of managing PA and should be customized to meet specific individual requirements.

10.2. PHYSICAL ACTIVITY RECOMMENDATIONS FOR CHILDREN, ADOLESCENTS AND YOUNG ADULTS

PA is a general term encompassing all body movements that increase energy use.[4] Though the terms are often used interchangeably, exercise is a specific form of PA which is structured, with a particular health purpose like improving fitness. Overall, reducing sedentary time and increasing levels of exercise and general PA are important for diabetes management. Whereas older children and young adults are more likely to engage in exercise, younger children are more likely to engage in unstructured free play. As per the American College of Sports Medicine (ACSM), children and adolescents without any medical condition should engage in at least 60 minutes of moderate to vigorous intensity PA daily, including muscle-strengthening and bone-strengthening activities at least three days a week.[5] This includes a combination of developmentally appropriate and enjoyable aerobic activities like running, dancing, etc.; resistance activities like playing with park equipment, climbing trees, tug-of-war, resistance bands, body weight exercises and external weights; and bone-strengthening exercises like skipping, hopscotch, *stapu*, etc. These principles also apply to PwD, who should aim for a combination of aerobic, resistance, and flexibility exercises, preferably daily, or at least five days a week.[4] Although there were concerns in the past about adolescents doing resistance training using weights, it has now been established that this is safe when done with appropriate instruction, technique, and supervision. The International Society for Pediatric and Adolescent Diabetes (ISPAD) 2022 guidelines also recommend at least 60 minutes of PA daily, primarily aerobic, with vigorous activities and muscle- and bone-strengthening activities at least three days a week.[6] Exercise forms like yoga can be useful as they incorporate the same principles of combining strength and flexibility exercises. Yoga has been shown to be beneficial in type 2 diabetes mellitus, but there is insufficient scientific research on Type 1 Diabetes Mellitus (T1D), so clearcut guidelines do not exist for T1D.[7]

For PwD, consistency in the exercise routine is important to reduce variability in blood glucose (BG) responses; hence, following a regular exercise routine every week is most desirable.[8] Figure 10.1 shows factors that cause BG variability. Children should be encouraged to play whatever they like, at relatively predictable times daily. In general, PwD should not have more than two consecutive days without PA, since irregularity markedly affects BG levels.[3,9] Keeping a similar routine helps reduce variability and help predict better BG responses. Usually, men tend to experience lower BG levels than women in response to PA. Care is needed not to administer insulin in areas actively engaged in muscle contraction.

Figure 10.1: Factors causing variability in blood glucose response to exercise[10]

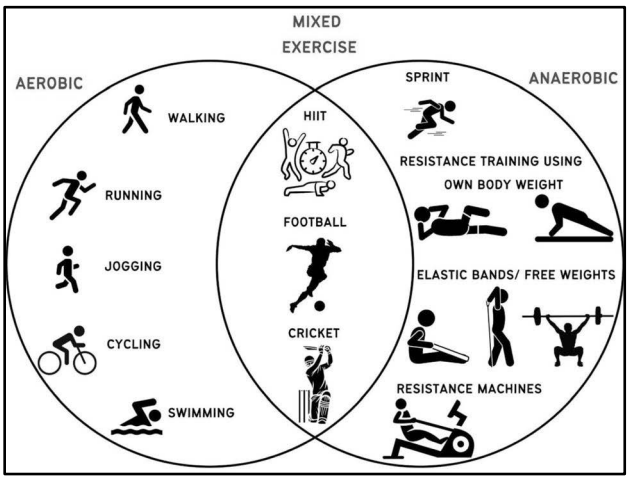


10.3. TYPE OF EXERCISE AND EXPECTED BG RESPONSE FOR PERSONS WITH T1D

The type of exercise markedly affects the BG responses. Exercise is generally classified as aerobic or anaerobic, depending on the predominant energy systems used, although most exercise and PA are a combination of both.[3] Aerobic exercise involves repeated and continuous movement of large muscle groups that rely primarily on aerobic energy-producing systems, with an increase in heart rate and respiratory rate, and includes walking, running, jogging, cycling, and

swimming.[6] The intensity of activity can be gauged by the heart rate. Anaerobic exercise involves resistance or strength training and can use one's own body weight, resistance machines, elastic bands, or free weights. High-intensity interval training (HIIT) is a relatively newer form of exercise with aerobic and anaerobic components, depending on the design.[11] (Figure 10.2)

Figure 10.2: Types of Exercise



Aerobic exercise for a long duration typically results in a fall in BG during and for several hours after the exercise.[6] Anaerobic exercises of brief duration, like weightlifting or sprinting, HIIT, and resistance exercises, typically increase BG during and soon after the exercise or keep it stable due to the release of counter-regulatory hormones, but BG may fall afterward: nocturnal hypoglycemia may also occur if not monitored and adjusted for. Although these are broadly the expected responses in T1D, multiple factors like fitness levels, duration, and relative intensity of exercise for that person also affect outcomes.

10.4. CAUTION WITH EXERCISE – HYPOGLYCEMIA AND HYPERGLYCEMIA

Hypoglycemia is a well-known risk of exercise in PwD. This could happen either during, immediately after, or many hours after exercise. Prevention of hypoglycemia requires paying careful attention to nutrition and insulin adjustment. This needs education about the effect of the type of PA on BG immediately and over the next few hours, the composition of the last meal, the starting BG levels, and the Insulin on Board (IOB).[4] Minimizing IOB by anticipatory insulin dose reduction is important as exercise induces heightened insulin sensitivity – a beneficial side effect overall.[12] PwD and caregivers must be taught to check BG before and regularly during and after exercise,[8] and adjust insulin doses accordingly (details below), while also learning from personal experience. When insulin adjustments are not possible, or if exercise is unplanned, or if PA is prolonged, increasing the intake of fast-acting carbohydrates during or after PA is needed. Other precautions to bear in mind include avoiding overcorrection with insulin, not injecting insulin into the exercising limb, and avoiding exercise at the time of peak insulin action.[13] Exercise is best avoided when BG is already high, especially when ketones are present, or during illnesses, as there is a risk of further worsening of hyperglycemia, and ketosis being induced or worsened.[3]

Anaerobic exercise increases BG acutely and may cause hyperglycemia. Knowing how to adjust insulin doses before such activity is important. Small bolus insulin doses may be needed for high stress levels or when starting HIIT and resistance exercises (see below). Since aerobic activity reduces BG, PwD may be tempted to skip insulin before such activity, which could lead to hyperglycemia. Hence, dosing should be carefully decided, using this understanding and also taking into account one's own experience by trial and error.[14]

Manual labor, even intense and prolonged labor, or intense sports activity, can be undertaken by a PwD, but with certain precautions and frequent BG checks before, during, and after PA. Intense PA should not be started if BG is under 100 mg/dL or above 250-300 mg/dL. Sufficient rapid-acting and slow-release carbohydrates should be available: if food availability or intake is limited, strenuous labor should be avoided. Strenuous PA should also be avoided while alone. During intense PA, close attention should be paid to BG patterns and possible symptoms of hypoglycemia, aiming to prevent hypoglycemia, and identify symptoms, if any, early. The protocol of anticipating, preventing, and treating hypoglycemia must be taught to friends, teachers, and colleagues, especially sports coaches, to avoid and deal with emergencies. As an additional precaution, all PwD must carry a medical ID with information on T1D.

10.5. CONTRAINDICATIONS TO EXERCISE

T1D is not a contraindication to exercise. There are several examples of sports persons with T1D. Nonetheless, as just discussed, exercise is contraindicated in certain situations, which may be transient or specific. PA should not be started in high-risk circumstances like the current level of BG <70 mg/dL or >270 mg/dL with ketones; the occurrence of serious hypoglycemia (BG <54 mg/dL) or hyperglycemia >270 mg/dL in the previous 24 hours; an environment unsuitable for handling an emergency like hypoglycemia; or presence of acute infections or injury.[15] Intense PA, including lifting heavy weights, endurance events, and competitive sports, should be avoided if there are chronic complications like retinopathy, autonomic dysfunction, or nephropathy.

10.6. IMPORTANCE OF SMBG AND CGM IN EXERCISE

In addition to daily pre-and post-meal Self-monitoring Blood Glucose (SMBG) for routine T1D care, frequent BG testing becomes important before and after PA, particularly with any change in the pattern of PA. These values guide changes in insulin doses and consumption of carbohydrates, fats, and proteins. (Table 10.1-10.3).

Continuous Glucose Monitoring (CGM) is strongly recommended for routine T1D care; it is particularly important during PA, as it provides ongoing BG levels and trends, especially at night. This helps prevent hypo- and hyperglycemia during and after exercise and at night.[16] During exercise, current sensors exhibit reasonable accuracy,[17,18] and the trend arrows do help decision-making, but several factors may affect accuracy: rapid fluctuations in BG and oxygen levels, subcutaneous tissue circulation and body temperature, and the possibility of sensor displacement by movement during exercise.[19,20] Suspected hypoglycemia and recovery should be confirmed by finger prick BG tests.[19]

The following strategies can help maintain BG within a safe range:

- A safe BG target during exercise is 125-270 mg/dL. However, if there is hypoglycemia unawareness or risk of hypoglycemia, a target of 145–270 mg/dL may be safer.
- The CGM low glucose alert should be set higher during exercise, usually at 100 mg/dL.
- The CGM glucose levels and trend arrows determine the need for carbohydrates to prevent hypoglycemia, including at night. (Table 10.2)

• Nocturnal BG checking is recommended after prolonged PA, especially with SMBG, or when using CGM without alerts and alarms.

10.7. ADJUSTING INSULIN AND FOOD INTAKE FOR PHYSICAL ACTIVITY

PwD do not have homeostatic mechanisms to maintain BG levels in the euglycemic range during PA due to the presence of externally injected insulin. As a result, prolonged PA, i.e., for a duration longer than 30 minutes (e.g., a long walk to school or work), especially if intensive (e.g., farming, football, sports coaching), requires adjustments in insulin doses and food intake to maintain euglycemia. These adjustments can confuse and overwhelm a young child and the new T1D caregivers since multiple variables affect the BG. They must be educated on these calculations while acknowledging that it would be a trial-and-error approach.

Example of Insulin/ meal strategies for exercise:

A 17-year-old boy with T1D plans to exercise for 45 minutes from 5 pm. The session will include jogging and running continuously as part of aerobic training. The last meal with bolus was at 1 pm, and dinner is usually at 7 pm. The SMBG value before exercise is 100 mg/dL.

Since the session will be aerobic activity and > 30 minutes, the boy is on MDI, and there is basal insulin on board, the BG is expected to fall, and carbohydrate supplementation would be required.

• *At the start of exercise:* a small snack of fast-acting carbohydrates (e.g., raisins/ a date) can be had, to ensure there is no immediate drop in BG, and help give minimal performance aid.
• *During exercise:* repeat BG check at 30-40 minutes would be ideal for deciding the best carbohydrate supplementation during exercise: a 15-20 g carbohydrate snack is needed for every 30-45 minutes of exercise, to maintain BG during and post-exercise.
• *Post-exercise:* The pre-dinner bolus dose depends on the BG level and meal content. If BG is between 90-270 mg/dL, a 50% reduction is recommended (Table 10.1). Ideally, after a moderate-duration aerobic session, the meal should have adequate carbohydrates and protein to prevent post-dinner and nocturnal hypoglycemia and promote muscle recovery. However, many youngsters may have a modified meal depending on their goals (weight loss, sports performance, etc), so the dose would be adjusted accordingly.
• If basal insulin dose is taken at night, dose reduction may be prudent since aerobic exercise was performed in the evening. Until the person becomes confident about how the BG behaves with such exercise, a 2-3 am BG check is recommended.
• If nocturnal hypoglycemia does occur, which is common in such situations, a bedtime snack with moderate protein and fat (e.g. milk/ curd nuts and seeds) would help prevent it. The amount of snacks can be titrated to ensure the BG is maintained, without excessive rise.

10.7.1. Carbohydrate and Protein Requirements During Various Phases of Exercise

Strategically managing insulin doses and carbohydrate intake before, during, and after exercise is important to prevent and treat exercise-induced hypo- and hyperglycemia. Preference is usually given to reducing insulin doses rather than increasing carbohydrate intake, because extra carbohydrate intake increases overweight. This is especially important for PwD aiming to lose weight or prevent obesity. However, it is important to differentiate between the carbohydrate requirement for the PA itself and the amount necessary to prevent hypoglycemia since the two are not the same. Most studies in T1D have assessed the quantity and type of carbohydrates needed for hypoglycemia prevention, not for optimizing performance.[21–23] For example, if the PwD has reduced the insulin doses in anticipation of exercise, only 15-20 g/hour of carbohydrate might prevent hypoglycemia but may be insufficient for performance.[1,10] Some PwD may need to take additional carbohydrates to ensure optimal performance, rather than reducing insulin doses.

The factors affecting BG, which impact the amount of carbohydrates needed, have been mentioned above and should be kept in mind when individualizing advice**.** The amount of carbohydrates needed to prevent exercise-induced hypoglycemia rises in tandem with plasma insulin levels.[24] Interestingly, the BG response to exercise becomes more erratic at times of peak insulin action, compared to when insulin levels are closer to basal.[25] It is best to perform exercise early in the morning, before the insulin bolus for breakfast, but this may not always be possible. Most PA in youth occurs during the afternoon/ evening.

Adequate protein and fat intake should be ensured during recovery from PA, within the overall requirements of the individual, and appropriate for age, gender, and stage of development (refer to Chapter 2). Indian diets are often low in protein: adequate intake should be ensured, but high protein intake is undesirable. Protein should come from food sources, such as dal, nuts and seeds, milk and other dairy products, eggs, and lean meats. Routine use of protein shakes and concentrates is not recommended.

10.7.2. Meal & Insulin Adjustment Before and After Exercise and at Bedtime - MDI

Suggested adjustments to be made in the two major scenarios of planned or unplanned activity for PwD on MDI exercising for > 30 minutes, adapted from ISPAD 2022 guidelines[6], are as follows:

a) Planned activity

For planned exercise >30 minutes, both food and insulin dosage are adjusted before, during, and after the exercise, as well as at night, to maintain BG within the safe range and minimize the risk of hypo- and hyperglycemia. Adjustments are based on the individual's response to different exercises by trial and error, overall health, and personal goals.[6,8]

Tables 10.1, 10.2 & 10.3 describe the insulin and food adjustments based on the type of exercise, IOB, and BG levels. Keeping a gap of 1.5 hours [if using Rapid-acting Analog (RAA) insulin for bolus] to 3 hours (if using Regular insulin for bolus) between mealtime and exercise is preferred to minimize the IOB and provide time for the carbohydrates to be absorbed. Only basal insulin is expected to be on board if exercise is >2-3 hours (for RAA users) or 3-4 hours (Regular insulin users) after mealtime.

After the completion of exercise, when injecting insulin for the next meal:

• If the last meal was consumed >2 hours before exercise, inject the usual mealtime insulin dose.
• If the last meal was consumed within 2 hours of exercise and the exercise lasted for >30 minutes, adjust the mealtime insulin dose as per Table 10.1/ Table 10.2.

Carbohydrate supplementation according to the last dose of meal-time (bolus) insulin:

• *Early morning exercise (before the breakfast bolus):* at this time, the insulin levels are close to basal, and the risk of hypoglycemia is minimal. Therefore, carbohydrate supplementation is often not necessary, but a small snack may be needed if exercise is intensive or prolonged.
• *Exercise at time of peak insulin action:* If PA is going to occur 1-2 hours post-meal (if bolus is RAA); or up to 2-3 hours post-meal (for Regular insulin): the bolus insulin should be reduced by 25-75%.[26] (Table 10.1) If dose reduction is not possible, additional rapid-acting carbohydrates up to 1-1.5 g carbohydrates/kg body weight/hour will be needed during prolonged activity.[27,28] The snack should not have much fat or protein, as these slow down the absorption of glucose. The actual body weight is used if Body Mass Index (BMI) is within the 90th percentile. If BMI is ≥ 91st centile, the Ideal Body Weight (IBW) is used unless the high BMI is due to being muscular. IBW = BMI at 50th centile for age × (height in meters)^{2}.[29] (Table 10.4)
• *Exercise several hours after a meal-time bolus or when the pre-exercise insulin dose has been appropriately reduced:* supplement with 0.3–0.5 g carbohydrate/kg IBW/hour.[30]

Carbohydrate supplementation according to the duration of activity

The type and duration of the specific activity should determine the amount of carbohydrates to be consumed before, during, and after exercise to maintain BG between 100-150 mg/dL:

• *Short-duration aerobic activity (lasting < 30 minutes):* snack may not be required, or a small portion of moderately fast-acting carbohydrates may suffice (e.g., fruit, dried figs/ raisins/ sultanas/ apricots/ dates, low-fat yogurt, a cereal like half chapati or a small amount of rice).[10]
• *Long-duration aerobic activity (lasting > 30 minutes)*: a higher amount of carbohydrates – recovery snacks containing slow-acting carbohydrates (low glycemic index) along with fat/ protein (e.g., milk, curd, sesame or peanut *laddoos*, date nut roll), is required to prevent delayed hypoglycemia. Such snacks may also be needed at bedtime in case of prolonged PA, especially in the evening.[8]

Fluid recommendations

• *Continuous fluid intake:* It is important to stay hydrated throughout PA. Regularly sipping fluids (e.g., water or *nimbu pani*/ buttermilk/ *jal jeera* with salt and sugar) can help maintain performance and prevent dehydration.
• *Short duration activities*: For PA up to 60 minutes, plain water is typically sufficient to maintain hydration.[8,31,32]
• *Longer duration activities:* If PA lasts longer, or if additional carbohydrates are needed for optimal performance or to prevent hypoglycemia, carbohydrate drinks containing 6-8% rapid-acting carbohydrates (e.g., lemon water with salt and jaggery/ sugar or buttermilk with salt and sugar) may be needed.[8,31,32]
• *During Exercise:* Fluid intake should be enough to ensure no more than 2% body weight loss.
• *Post-Exercise Hydration:* should be about 450-650 ml fluids for every 0.5 kg weight loss during the exercise.[8,31,32]

b) Unplanned activity

For short-duration unplanned exercise, no adjustment, or a small snack post-exercise may be needed. For unplanned exercise of longer duration (>30 minutes) or high intensity, additional moderately fast-acting carbohydrates will be required during and after the exercise, as per Table 10.1.[6] If PA is in the evening and/or if the bolus doses are with Regular insulin, a slow-acting carbohydrate snack after exercise and at bedtime is important to prevent nocturnal hypoglycemia. Checking the 2 am BG may be advisable to detect and, if necessary, correct nocturnal hypoglycemia. If BG is high before unplanned activity, a small correction dose would be needed; otherwise, the PA would further worsen hyperglycemia.

10.7.3. Meal & Insulin Adjustment Before & After Exercise & at Bedtime - CSII

The insulin pump offers flexibility in modifying basal infusion delivery rates, with the effect taking place within ~1-2 hours.[33] It is important to remember that the effect does not occur immediately. Monitoring BG patterns prior to starting, during, and after using CGM helps decide food and insulin doses, taking the type of exercise and individual goals into account.

For exercise >30-60 minutes:

• Basal insulin is reduced by 50–80% at least 30-60 minutes before starting exercise until the exercise stops (preferred option), or
• Pump is suspended when exercise is started, for a maximum duration of 60 minutes. This option may be useful for contact sports like football, but the duration should be minimal.
• If the exercise occurs in the afternoon or evening, the overnight basal insulin is reduced by 20%, and/or a bedtime snack is consumed without insulin to prevent nocturnal hypoglycemia.
• The bolus insulin dose for the pre-exercise meal is reduced. This is preferable to taking additional carbohydrates during exercise. Bolus dose reductions require planning in advance, as per the anticipated exercise intensity and experience.
• For prolonged exercise, the bolus dose for the post-exercise meal can be reduced by as much as 50%, and/or 1-1.2 g/kg of carbohydrate taken within 90 minutes. Dose reduction for the pre-dinner dose may be important to reduce the risk of delayed/ nocturnal hypoglycemia.[33]

10.7.4. Meal and Insulin Adjustment Before and After Exercise and at Bedtime - Automated Insulin Delivery (AID)

Automated insulin delivery (AID) systems have advanced algorithms that reduce much of the guesswork of daily BG management and moderately improve time in range during PA compared with standard care.[33] However, challenges continue in maintaining BG in the target range. Ideally, pre-planning minimizes IOB and sets a higher glucose target, reducing the need for supplemental carbohydrate intake before exercise, which is important for individuals aiming for weight loss.[34,35]

a) *Planned activity*

- Set exercise target 1-2 hours before the onset of exercise.
- Reduce mealtime bolus insulin 1-2 hours before exercise.
- Pump suspension at the time of exercise onset may reduce the need for pre-planning but should be rarely used.

With the MiniMed 780G system, the exercise target (called Temp Target) decreases insulin delivery, disables the automated bolus feature, and raises the glucose target to 150 mg/dL. The automated bolus correction feature will not resume until the exercise target is ceased.[12]

b) *Unplanned activity*

Short-duration activities (i.e., <30 minutes) may not require setting a higher exercise target. However, additional research is needed in this area.

• If the activity is >30 minutes, a higher exercise glucose target is needed until the end of the exercise to reduce the risk of hypoglycemia.[8,35]
• To reduce the risk of delayed hypoglycemia, the exercise target may be extended for 1–2 hours into post-exercise recovery and/or (cautiously) overnight, analogous to applying a temporary basal rate reduction in open-loop conditions.[36]

10.8. FOR COMPETITIVE SPORTS

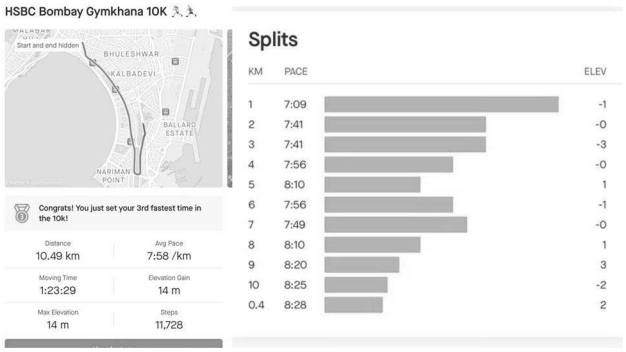
The athlete with T1D has needs similar to those of other PwD, but must also be well-prepared for training and competition days. Insulin doses and carbohydrate intake should be carefully planned in close consultation with the diabetes care team and the coach. Trying to practice at the same time of day as the events to be held, so that food and insulin changes can be fine-tuned with trial and error, may improve performance on the day of the competition. Aerobic exercise generally decreases BG levels, so careful reduction of insulin and adequate supplementation of carbohydrates and fluids is needed.[37,38]

• If using CSII: 50–80% basal rate reduction set 90 minutes pre-exercise may be needed; sometimes, the pump needs to be suspended for a short duration.[39]
• More intensive aerobic (HIIT) and anaerobic exercise may cause a rise in BG, so a reduction in insulin is not recommended; a small insulin bolus may be needed.
• If stress prior to the event raises BG, a small bolus insulin dose may be needed.

Example: A young 10-year-old boy is engaged in the competitive sport of badminton or tennis. The nature of these sports is mixed, due to the high-intensity bursts of activity over a prolonged period of constant movement. Additionally, matches often cause pre-competition anxiety, raising the BG. CGM or very frequent SMBG, including checking pre-match or pre-training BG, are integral to good management in such situations to ensure adequate nourishment throughout the match, without hyper- or hypoglycemia. Table 10.3 gives the correction doses/strategy for such situations. BG is expected to remain fairly stable for 30 minutes due to the mixed nature, followed by a probable drop due to the prolonged nature. Therefore, after 30 minutes, the athlete should consume snacks or drinks with approximately 10-15 g of carbohydrates depending on age, and how long the match is expected to continue. Post-match, BG should be checked at regular intervals, and nourishment given, to prevent hypoglycemia while ensuring adequate recovery from the sports insult to the body. Delayed falls in BG can be expected in sports, depending on the level of adrenaline, etc. In competitive sports, carbohydrate and protein loading often take precedence over reducing insulin dosage, as mentioned in Table 10.1. The competitive athlete's protein needs are somewhat higher, up to 1.2-1.5 g/kg/day.[40] Efforts should be made to obtain these from food sources rather than protein shakes and concentrates.

It is very important to note that Insulin is among the banned substances for competitive sports, so prior permission ("therapeutic use exemption") with a specific prescription is needed by sports persons with T1D playing competitively.[41] (Figure 10.3)

Figure 10.3: An example of management during a marathon run (We acknowledge Ms. Riddhi Modi for providing these images)



CGM Readings During Marathon Run

8:00 pm – Balanced dinner with stir-fried veggies, 1 bowl dal, vegetable curry, 2 medium sized mix-millets rotis, 1 bowl curd
5:40 am – 100 ml cup of black coffee + a small *Elaichi* banana (before leaving for a run)
6:30 am – a date + 2 almonds (before starting the run)
7:19 am - heart rate and BG both started rising
7:20 am – 2 units of correction dose at BG 188 mg/dL
7:53 am – completed run while keeping TIR and BG level under 200 mg/dL
8:53 am – One hour after the run, BG levels started dropping; consumed 4gm dextrose with one glass of buttermilk
Levels remained stable thereafter.
Tresiba – usual dose was 15u at 8:30 am, but on day of marathon, the dose was reduced by 20%: to 12u, taken after finishing the run.

Table 10.2: Carbohydrate requirements before and during exercise for children and adolescents with T1D in SMBG users[12]

	Expected blood glucose response during exercise	
SMBG value	Expected to fall during exercise	Expected to stay stable or increase during exercise
181-270 mg/dL	No carbohydrate supplementation	
126-180 mg/dL	0.2-0.5 g/kg/30 minutes	0
90-124 mg/dL	0.5 g/kg/30 minutes	0.2 g/kg/30 minutes
70-89 mg/dL	Delay/stop exercise for 20 minutes	
	0.3 g/kg/30 minutes	0.3 g/kg/30 minutes

Do not exceed 60 kg when calculating carbohydrate amounts to prevent suggestions greater than the peak exogenous carbohydrate utilization of 1.0–1.2 g/minute. IBW) is used, if the BMI centile is ≥91st.

Table 10.3: Carbohydrate requirements before and during exercise for children and adolescents with T1D in CGM users[12]

CGM value	Trend arrows	Expected to fall during exercise	Expected to stay stable or increase during exercise
>270 mg/dL and ketones <0.6mmol/L	→ ↗ ↑	Give ½ correction dose, wait for BG to begin normalizing, then start exercise	
	↘ ↓	No carbohydrate supplementation	
181-270 mg/dL	↑ ↗ →	0	0
	↘	0.1 g/kg/BW/20 minutes	0
	↓	0.2 g/kg/BW/20 minutes	0
126-180 mg/dL	↑	0	0
	↗	0.1 g/kg/BW/20 minutes	0
	→	0.2 g/kg/BW/20 minutes	0
	↘	0.3 g/kg/BW/20 minutes	0.1 g/kg/BW/20 minutes
	↓	0.4 g/kg/BW/20 minutes	0.2 g/kg/BW/20 minutes
90-125 mg/dL	↑	0.1 g/kg/BW/20 minutes	0
	↗	0.2 g/kg/BW/20 minutes	0.1 g/kg/BW/20 minutes
	→	0.3 g/kg/BW/20 minutes	0.2 g/kg/BW/20 minutes
	↘	0.4 g/kg/BW/20 minutes	0.3 g/kg/BW/20 minutes
	↓	0.5 g/kg/BW/20 minutes	0.4 g/kg/BW/20 minutes
70-89 mg/dL	No need to delay exercise if ↑ ↗		
	↑[a]	0.2 g/kg/BW/20 minutes	0.1 g/kg/BW/20 minutes
	↗	0.3 g/kg/BW/20 minutes	0.2 g/kg/BW/20 minutes
	If there are horizontal or falling trend arrows; delay/ stop exercise for 20 minutes and give carbohydrates as per the trend arrows below		
	→	0.3 g/kg/BW/20 minutes	0.3 g/kg/BW/20 minutes
	↘[a]	0.4 g/kg/BW/20 minutes	0.4 g/kg/BW/20 minutes
	↓[a]	0.5 g/kg/BW/20 minutes	0.5 g/kg/BW/20 minutes

[a]*consider performing BG by SMBG, as CGM value may be lagging*
Do not exceed 60 kg when calculating carbohydrate amounts to prevent suggestions greater than the peak exogenous carbohydrate utilization of 1.0–1.2 g per minute. IBW is used if the BMI centile is ≥91st.

Table 10.4: 50th BMI percentile of Indian children for Ideal Body Weight calculation[29]

Age (in years)	Boys	Girls
5.0	14.7	14.3
5.5	14.8	14.4
6.0	14.9	14.5
6.5	15.0	14.7
7.0	15.1	14.9
7.5	15.3	15.1
8.0	15.5	15.3
8.5	15.7	15.6
9.0	15.9	15.8
9.5	16.2	16.1
10.0	16.4	16.5
10.5	16.7	16.8
11.0	17.0	17.2
11.5	17.3	17.6
12.0	17.7	18
12.5	17.9	18.4
13.0	18.2	18.8
13.5	18.5	19.1
14.0	18.7	19.4
14.5	19.0	19.7
15.0	19.3	19.9
15.5	19.6	20.1
16.0	19.9	20.3
16.5	20.2	20.4
17.0	20.5	20.6
17.5	20.8	20.8
18.0	21.1	21.0

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Table 10.2: Carbohydrate requirements before and during exercise for children and adolescents with T1D in SMBG users[12]

	Expected blood glucose response during exercise	
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126-180 mg/dL	0.2-0.5 g/kg/30 minutes	0
90-124 mg/dL	0.5 g/kg/30 minutes	0.2 g/kg/30 minutes
70-89 mg/dL	Delay/stop exercise for 20 minutes	
	0.3 g/kg/30 minutes	0.3 g/kg/30 minutes

Do not exceed 60 kg when calculating carbohydrate amounts to prevent suggestions greater than the peak exogenous carbohydrate utilization of 1.0–1.2 g/minute. IBW) is used, if the BMI centile is ≥91st.

Table 10.3: Carbohydrate requirements before and during exercise for children and adolescents with T1D in CGM users[12]

CGM value	Trend arrows	Expected to fall during exercise	Expected to stay stable or increase during exercise
>270 mg/dL and ketones <0.6mmol/L	→ ↗ ↑	Give ½ correction dose, wait for BG to begin normalizing, then start exercise	
	↘ ↓	No carbohydrate supplementation	
181-270 mg/dL	↑ ↗ →	0	0
	↘	0.1 g/kg/BW/20 minutes	0
	↓	0.2 g/kg/BW/20 minutes	0
126-180 mg/dL	↑	0	0
	↗	0.1 g/kg/BW/20 minutes	0
	→	0.2 g/kg/BW/20 minutes	0
	↘	0.3 g/kg/BW/20 minutes	0.1 g/kg/BW/20 minutes
	↓	0.4 g/kg/BW/20 minutes	0.2 g/kg/BW/20 minutes
90-125 mg/dL	↑	0.1 g/kg/BW/20 minutes	0
	↗	0.2 g/kg/BW/20 minutes	0.1 g/kg/BW/20 minutes
	→	0.3 g/kg/BW/20 minutes	0.2 g/kg/BW/20 minutes
	↘	0.4 g/kg/BW/20 minutes	0.3 g/kg/BW/20 minutes
	↓	0.5 g/kg/BW/20 minutes	0.4 g/kg/BW/20 minutes
70-89 mg/dL	No need to delay exercise if ↑ ↗		
	↑[a]	0.2 g/kg/BW/20 minutes	0.1 g/kg/BW/20 minutes
	↗	0.3 g/kg/BW/20 minutes	0.2 g/kg/BW/20 minutes
	If there are horizontal or falling trend arrows; delay/ stop exercise for 20 minutes and give carbohydrates as per the trend arrows below		
	→	0.3 g/kg/BW/20 minutes	0.3 g/kg/BW/20 minutes
	↘[a]	0.4 g/kg/BW/20 minutes	0.4 g/kg/BW/20 minutes
	↓[a]	0.5 g/kg/BW/20 minutes	0.5 g/kg/BW/20 minutes

[a]*consider performing BG by SMBG, as CGM value may be lagging*
Do not exceed 60 kg when calculating carbohydrate amounts to prevent suggestions greater than the peak exogenous carbohydrate utilization of 1.0–1.2 g per minute. IBW is used if the BMI centile is ≥91st.

Table 10.4: 50th BMI percentile of Indian children for Ideal Body Weight calculation[29]

Age (in years)	Boys	Girls
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5.5	14.8	14.4
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6.5	15.0	14.7
7.0	15.1	14.9
7.5	15.3	15.1
8.0	15.5	15.3
8.5	15.7	15.6
9.0	15.9	15.8
9.5	16.2	16.1
10.0	16.4	16.5
10.5	16.7	16.8
11.0	17.0	17.2
11.5	17.3	17.6
12.0	17.7	18
12.5	17.9	18.4
13.0	18.2	18.8
13.5	18.5	19.1
14.0	18.7	19.4
14.5	19.0	19.7
15.0	19.3	19.9
15.5	19.6	20.1
16.0	19.9	20.3
16.5	20.2	20.4
17.0	20.5	20.6
17.5	20.8	20.8
18.0	21.1	21.0

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Chapter 11: Age Group-Specific Advice

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11.1. INTRODUCTION

There are several age-related issues in the care of Type 1 Diabetes Mellitus (T1D). These arise due to age-related differences in physiology and developmental stages, and they include practical issues such as diet, frequency of Blood Glucose Monitoring (BGM), types and doses of insulin used, and glycemic targets. In this chapter, we discuss specific issues in Medical Nutrition Therapy (MNT) in relation to various age groups, including toddlers/ infants, school-age children, adolescents, and preconception/ pregnant/ lactating women.

11.1.1. Infants and Toddlers

Infants are defined as children from birth to 1 year of age, and toddlers as 1-3 years of age. The period of life till three years is characterized by rapid physical and brain growth. The growing brain is particularly vulnerable to hypoglycemic insults as well as hyperglycemia, which can predispose to developmental problems. Hence, it is important to avoid hypoglycemia and marked hyperglycemia in toddlers and infants with diabetes by frequent BGM. A Continuous Glucose Monitoring (CGM) system would be particularly useful in this regard.[1]

11.1.2. Nutritional Needs and Developmental Issues

The requirements for energy and calories for children with diabetes are as per the Estimated Average Requirement (EAR) for age and gender recommended by the Indian Council for Medical Research-National Institute for Nutrition (ICMR-NIN) guidelines.[2] (Please see chapter 3.) Guidelines recommend that carbohydrates, fats, and proteins constitute 45-55%, 25-30%, and 15-20% of daily energy intake.[2,3] Exclusive breastfeeding is recommended in the first six months of life, followed by a gradual introduction of complementary feeds. The feeding pattern of infants (<6 months) is fairly regular, with frequent 2-3 hourly feeds.[4] Complementary feeding advice remains as per standard guidelines and should include a variety of locally available food, including rice-lentil *khichdi*, porridge (*dalia*/ *suji*/ rice) with milk/ dal, mashed *roti* in milk/ curd/ dal, with mashed or pureed vegetables (avoid potatoes)/ fruits, etc. A minimum amount of salt can be added to enhance the flavor but sugar/ honey/ jaggery must be avoided. It is best to use freshly made home products rather than commercial preparations. Food items should be introduced one at a time so the baby develops a taste for the particular item. Regular feeds at 3-4 hours help match insulin peaks with meals. Fruit juices offer little nutritional benefit, and lead to spikes in BG, so they should not be given. Breastfeeding should be continued and alternated with complementary feeds. Breastfeeding can be continued after one year of age; it fulfills more of an attachment need than a nutritional one. Too frequent breastfeeding may lead to fluctuations in BG and should be avoided.[5]

As the child grows and starts walking, appetite and physical activity may vary greatly from day to day. The toddler age group is characterized by an increasing sense of autonomy and a continued need for secure attachment to the parents/ caregivers. The child frequently says 'no' to assert independence and throws temper tantrums due to a lack of emotional regulation. Toddlers also develop fussiness in food matters, preferences for certain foods, and food refusal. One way to counter the variability in eating is to establish routines regarding play and meal times. Family-centered meals that avoid distractions help to form good eating habits.[5] The family should have a balanced, healthy diet and make sure the child is given whatever the family eats. It is advisable to use homemade products and avoid ultra-processed food, commercial breakfast cereals, and snacks. Children fuss less while imitating adults. The young child can also be involved in food-related activities like buying and handling food.[6]

11.1.3. Glycemic Targets

To avoid cognitive damage and long-term macro- and microvascular complications, the glycemic targets recommended by the International Society for Pediatric and Adolescent Diabetes (ISPAD) in under-5s with access to technology [CGM, Continuous Subcutaneous Insulin Infusion (CSII)], are similar to those in other age groups (HbA1c 6.5-7%).[5] However, in the absence of advanced diabetes technology, tight glycemic control could predispose to frequent episodes of hypoglycemia, which is especially important to avoid at this age for optimal brain development. Hypoglycemia may manifest as temper tantrums, irritability, and drowsiness – all of which also normally occur in toddlers. Small children are unable to express themselves if they experience symptoms of hypoglycemia, so it may be missed by the caregiver.[7] They may suffer from nocturnal hypoglycemia due to blunted counter-regulatory hormonal response.[8] Practically, a BG target of 6-11 mmol/L, i.e., 108-198 mg/dL, with bedtime targets of 120-180 mg/dL to avoid nocturnal hypoglycemia would help avoid hypoglycemia which could arise from higher insulin doses.[5] At the same time, hyperglycemia is also damaging at this age, and parents must be discouraged from giving inadequate doses of insulin due to the fear of hypoglycemia, which is a major impediment to good glycemic control in this age group.[9] Hence, there is a need for CGM as far as possible, and if not possible, very frequent BGM, especially if the child has eaten less or been very active physically. Apart from adjusting insulin type, doses, and timing, a bedtime snack can prevent frequent nocturnal hypoglycemia.

The treatment of mild hypoglycemia (BG <70 mg/dL) includes giving a fast-acting simple sugar (0.3 g/kg) orally and rechecking BG after 10-15 minutes.[5,10] This is approximately 5 g of sugar till age 5 years (and 10 g till age 10 years, 15 g thereafter). Honey should not be given to infants less than 1 year due to the risk of botulism. For severe hypoglycemia with neuroglycopenic features, a glucagon injection of 0.5 mg IM is recommended.[11] Parents should be taught how to administer glucagon injections by the diabetes educator/ nurse or doctor.

11.1.4. Choice of Insulin and Dose Modification

The ideal insulin regimen should mimic the physiological pattern of insulin secretion and consist of basal-bolus therapy with analog insulins, given as Multiple Daily Injections (MDI) or insulin pump. Insulin junior pens with half-unit increments, or insulin syringes 0.3 ml and 0.5 ml, which may be procured by parents from abroad, are very useful in titrating small insulin doses in younger children.[12] Conventional therapy with Neutral Protamine Hagedorn (NPH) and Regular insulin offers less flexibility and predisposes to glycemic variability. The insulin requirement at this age is 0.4-0.8 units/kg/day, with 20-40% as basal insulin and the rest as bolus insulin given before meals.[5]

11.1.5. Dietary Guidance

World Health Organization (WHO) recommends avoiding sugary foods and beverages for all children up to the age of 2 years to reduce the chances of developing a "sweet tooth" later.[13] This applies to the young child with diabetes as well.

Toddlers should have regular meals and between-meal snacks while avoiding grazing.[14] The ideal approach to meals and snacks consists of Carbohydrate Counting (CC) and bolus insulin dose adjustments accordingly. A snack can be offered if the child feels hungry before mealtime, and insulin can be administered based on the carbohydrate content. Alternatively, a free snack with low carbs can be given so that insulin is not needed. Such snacks include cucumber, apple slices, a small bowl of plain curd, unsweetened lassi, a piece of paneer, boiled egg, or crudites of cauliflower or broccoli stalks.[15] Sometimes, the child may confuse thirst with hunger or demand food simply out of boredom. Initially, offering some plain water and distraction and then judging if the hunger is genuine will reduce needless grazing, which can lead to obesity. Ideally, the gap between 2 meals/ snacks and, therefore, of insulin doses should be 3-4 hours to avoid the 'insulin stacking' effect.[16]

If the child refuses a particular food item after being given insulin, the caregiver can offer alternatives or exchanges of carbs, which should be kept available. Healthcare professionals should provide guidance on which foods can be substituted for others. If one is unsure of how much food the child will have, the insulin dose can be split, with part of the dose given before eating and the remaining dose given after the meal, based on the amount eaten. Similarly, if the child consumes more food than planned, an extra insulin dose can be given after the meal.[5] Swings in BG can be uncomfortable for the child and cause mood swings and temper tantrums. Since the needles currently available are 31G, parents can be given the first prick to realize they are almost painless; and encouraged to focus on good glycemic control rather than always trying to minimize the number of pricks.[17]

11.1.6. Behavioral Guidance

Toddlers develop an increasing sense of independence that can be used by the parents by involving them in meal planning and diabetes care. The child can be involved during the purchase of fruits and vegetables and the cooking process, and encouraged to feed himself/ herself to reduce the chances of temper tantrums and food refusal.[6,18,19] The parents can make a timetable with the child and refer to it to reduce grazing, initially offering water. Instead of saying an outright 'NO' to the toddler's demands, saying 'later' or 'at x time' may help reduce tantrums.[20] (Table 11.1)

Table 11.1: Salient points regarding feeding and insulin dosing in toddlers and infants

- Basal-Bolus therapy with analog insulins or an insulin pump would be ideal for mimicking the physiological pattern of insulin secretion.
- The use of CGM is strongly recommended. If that is not possible, BG should be monitored frequently—at least 6-10 times per day.
- The insulin requirement is 0.4-0.8 units/kg/day, with 20-40% as basal insulin and the rest as bolus insulin given before meals. Insulin should not be routinely given after meals.
- If it is difficult to maintain a gap between insulin and meals, ultra-rapid-acting insulin (Fiasp, Lyumjev) can be used just before or during meals.
- Establish meal routines. The ideal gap between meals should be 3-4 hours, avoiding grazing/ frequent snacking. Meal eating time should not be prolonged beyond 20 minutes.
- The dose of the rapid-acting analog insulin is based on the carbohydrate count of the meal or snack.
- If the child refuses a particular food item, an alternative with equivalent carbohydrate content can be offered, without panicking.
- Insulin dose splitting: If unsure of the amount of food the child will consume, the insulin dose can be split, with part given before the meal and the rest afterward, depending on the amount eaten.
- If the child has more carbohydrates than planned, extra insulin should be given after the meal or as per the post-meal BG.

11.2. SCHOOL-AGE CHILDREN

School-age children (5-18 years) have fairly stable daily meal times and activity routines. They spend the majority of their time in school and after-school activities. Hence, for the child with T1D, good diabetes management during school hours would greatly help optimize overall glycemic control. This would reduce hypoglycemia and hyperglycemia, optimize cognitive capacity and learning in school, and decrease macrovascular and microvascular complications in later years. In this section, we discuss the unique aspects of diet care as part of diabetes management in school.

11.2.1. BG Monitoring and Insulin Therapy

The child needs to monitor BG and inject bolus insulin before a snack or meal in school. The best place to do self-care activities may be in the classroom itself.[21] Various permutations and combinations of insulin doses before school are often tried to avoid an insulin dose in school. They are hardly ever successful. If the child is on rapid-acting analog bolus insulin, the BG check and shot can be done during the break time. If Regular (i.e., soluble) insulin is used for bolus dosing, the BG test and shot are best given one period before the break so there is a sufficient time gap before eating. Additional BG tests may be needed in case of suspected hypoglycemia, sickness, unexpected physical activity and/or food intake.[21] CGM is preferable for BGM, as without needing anyone to do a finger prick, it gives BG levels and trends, with alerts when BG is above or below target. This enables taking corrective or preemptive action. Parents can access BG logs remotely, which is reassuring for them and the teachers.

11.2.2. Dietary Guidance

Most schools give one or two breaks during the 6-7 hours of school time and provide separate time for physical activity (which could

vary from once a week to daily). Most schools expect the child to carry food from home, while some provide meals, which may be optional or compulsory. At school, the child needs to monitor BG and inject bolus insulin before the snack or meal in a dose based on the carbohydrate content of the food and the BG level. Sometimes, extra carbohydrates may be needed before physical activity if it is intensive or prolonged.[22] The principles of a healthy meal remain the same: balanced proportions of low Glycemic Index (GI) carbohydrates, fiber, protein, and healthy fats. If a tiffin is carried from home, the food should be easy to carry, avoiding too many items and items that may leak. This would enable the child to also play during this time. The family can be taught healthy tiffin recipes like whole wheat or millet wraps of vegetables with *paneer*/ egg/ chicken; rice or millet *khichri* with hung curd; sprouts/ *paneer*/ egg/ chicken salad; with an option of added nuts and seeds or fruits in various combinations. The carbohydrate count can be calculated to decide the insulin doses accordingly. If the school provides food, the parents can discuss the menu with the teachers and child to decide the approximate proportions of what to eat and calculate the carbohydrate count.[15] The school authorities can be requested to minimize unhealthy food in the school meal (or canteen), for example, fried dishes or snacks, rich salad dressings, and rich desserts.

11.2.3. Management in School

The parents, school authorities (especially the class teacher, principal, school doctor/ nurse, counselor), and child should work with the diabetes care team to prepare a Diabetes Management Plan (DMP). The DMP should have details of the Insulin-Carbohydrate Ratio (ICR) and Insulin Correction Factor (ICF); it should be updated at least annually, and copies should be available in the class, principal's room, medical room, and sports section.[23] Diabetes supplies in school (Table 11.2) must include glucose tablets/ powder or sugar/ gel and some snacks to prevent hypoglycemia. Such snacks include peanuts, roasted *chana*, peanut/ sesame/ *chana laddoos*, etc. Children often share tiffins in school. The child and family should be aware of healthy and unhealthy foods to keep the latter to a minimum. The teacher can discuss this to discourage other children from bringing unhealthy food to school, thus improving their health.

Physical activity levels may vary on different days and be quite prolonged in the run-up to events like sports day or annual day. The child should have access to additional snacks with rapid-acting or slow-release carbohydrates as needed. Sometimes, the children are given snacks on the day of the event or during the preparatory days; these often consist of unhealthy foods.[24] Parents can discuss this with school authorities and request them to give healthy snacks like roasted peanuts/ *chana* (gram)/ lentil-based *khakra*, or fruits, and healthy beverages like unsweetened lemonade or buttermilk/ lassi; they should also inform parents in advance of any events involving food so that BGM and insulin doses can be planned. (See Chapter 10.)

11.2.4. Other Forms of Support

Teachers must ensure that children with T1D are allowed to participate in all school activities and perform self-care activities without being made to feel different from their peers. Permission to have unhealthy food and beverages occasionally and in small portions, with adjustment of insulin doses, helps normalize situations. Teachers can praise healthy food items brought by the child (and other children) and promote him/ her as a role model.

Table 11.2: Checklist for school (ISPAE diabetes resources for schools, KiDS school pack)

• Diabetes ID card
• Diabetes Management Plan
• Emergency contact numbers of parents, diabetes care team
• Supplies:
1. Glucometer and Glucostrips (replace close to expiry date)
2. Insulin pens/ needles/ spirit swabs
3. Glucose tablets/ Glucose powder/ Sugar sachets
4. Glucagon injection
5. Extra snacks

11.3. ADOLESCENCE

Adolescence is the age of 10-19 years and is the transition period from childhood to adulthood, with several physical and psychological changes occurring. With the onset of puberty and the growth spurt, appetite increases, and serum levels of sex hormones and growth hormone start rising, leading to a physiological state of insulin resistance. Higher insulin doses, up to 1.5-2 units/kg/day, are required at this age. Girls may experience fluctuations in BG levels during their menstrual cycle due to cyclical changes in estrogen and progesterone levels. Typically, BG levels are higher just before the menstrual cycle due to high progesterone levels.

Dietary management is one of the most challenging aspects of treating an adolescent with T1D. Dietary prescription should be individualized - one eating pattern does not suit all. Meal planning should aim at adapting insulin therapy to the nutritional needs and lifestyle of the person, achieving growth and glycemic goals, preventing hypoglycemia, managing weight, and preventing disordered eating. The new insulin formulations and advances in diabetes technology help with better meal planning and lifestyle.

The following nutrition-specific issues need attention:

11.3.1. Reinforce Healthy Eating Habits

Adolescence is a challenging phase in life with increasing independence, an intense desire to conform to peers, and frequent high-risk behavior. This is also a period where diabetes control gets difficult due to many reasons – hormonal and psychosocial.[25] Adolescents may want to make their own food choices and decide what to eat, when, and how much. Food and exercise timings may become erratic due to academic and other pressures. All these factors can adversely affect glycemia, impacting their mood and study ability. They and their parents may need empathetic support in handling these issues and reducing conflict. Adolescents diagnosed during childhood usually need "re-education" for diabetes self-management as they take charge of their own lives and glycemia. They must be taught why and how to eat healthy, have nutritious, timely meals with portion control, and avoid excessive snacking.[25] They must learn the impact of macro-nutrients (carbohydrate, fat, protein, and fiber) and meal composition on BG levels, CC, and insulin dose adjustments.[26]

11.3.2. Role of Diabetes Self-management Education (DSME) in Food Preferences

Due to peer pressure, adolescents often eat inappropriately, especially calorie-dense, nutrient-poor foods, with a consequent decrease in

diet quality. They may indulge in staying up late to study or to party, meals missed or eaten at odd times, sleeping in, skipping insulin, and sometimes, consuming alcohol. Nutrition education is required for the individual and the family, addressing the myths and barriers to healthy eating, discussing problem-solving, and setting targets.[25] The adolescent must learn and practice CC as it is a key component to achieve glycemic goals. Making a list of the carbohydrate count per portion size of the 'junk foods' frequently eaten, such as college canteen '*samosa*', helps in accurate dosing and reducing miscalculation. The diabetes team has to teach him/ her how to adapt meal timing and insulin administration according to variable schedules, including school, exercise, and work commitments.[3]

Adolescents are attracted to technology and gadgets. Using technology for decision-making in diabetes care and promoting healthy behaviors may engage the otherwise reluctant young person. Using applications to help with counting carbohydrates, understanding how different foods impact their BG levels, and making food diaries on their phones help achieve goals.[27] Adolescents may not admit to risk-taking behaviors like alcohol consumption, so they should be informed of the legal age for drinking in their state, and given realistic advice on issues with the consumption of alcohol, including how to avoid prolonged hypoglycemia and nocturnal hypoglycemia.[28] Educating about frequent BGM, having carbohydrates while drinking and before sleeping, and having a buddy who is not drinking to keep an eye out, can be crucial. Adolescents should be cautioned against drug use by informing them about the ill effects; for example, cannabis may cause excessive snacking during use and later anorexia, apart from other side effects.[29]

The adolescent will need guidance to handle examinations, including general adjustments in diet and insulin regimen. Meals should be timely and preferably low GI to sustain BG, but sugar and high GI snacks should be available in case of need. They must be taught how to prevent or handle stress-related hyperglycemia, and to carry sugar and snacks to the exam hall to prevent or handle hypoglycemia. Glucometers, CGM, insulin pump, sugar, and snacks are permitted by the Central Board of Secondary Education (CBSE) (2017 and 2024) and other school boards, as per the 2023 directive of the National Commission for Protection of Child Rights (NCPCR) to all school boards.[30] It is best if the adolescent is encouraged to start following exam timings, adjusting food intake and insulin accordingly, at least 1-2 weeks in advance, so that the effects of glycemic variability on exam performance are minimized.

Adolescents may get temporary or permanent driving licenses. Since even mild hypoglycemia can affect the ability to drive safely, they must be taught to monitor BG before and during driving, eat meals/ snacks of slow-release carbohydrates with proteins and fats before driving, and have access to rapid-acting carbohydrates in case of need. Long-distance driving can predispose to hypoglycemia, which should be prevented by frequent BGM and appropriate food intake. This is especially important if hypoglycemia unawareness exists.[31]

Exercise for more than 30 minutes needs frequent BGM and insulin dose reduction if planned; for unplanned exercise, additional carbohydrates may be needed before/ during/ for several hours after the activity. The snack should be high in GI, carbohydrates, and protein; a bedtime snack may be necessary. At the same time, overzealous dietary adjustment should be avoided as it may result in increased calorie consumption, hyperglycemia, and obesity. Young adults need 1-1.5 g carbohydrates/kg body weight/hour during strenuous exercise.[9] (See also Chapter 10.)

11.3.3. Eating Disorders

Erratic meals and Eating Disorders (ED) are common in adolescents with diabetes and could be the cause of deterioration in metabolic control. Disordered Eating Behaviors (DEB) should be thought of in any adolescent with uncontrolled diabetes. DEB is a general term used to describe several disturbed eating behaviors and includes intentional over- and under-dosing of insulin, dietary restriction, and self-induced vomiting.[32] ED is a clinical diagnosis that includes insulin omission, reported in pre-teens, adolescents, and young adults, to reduce weight.[33] (refer to Chapter 14)

11.3.4. Optimal Weight Gain

If diabetes is well controlled, the child or adolescent should grow normally, including weight gain.[34,35] However, obesity is increasing among individuals with T1D, so interventions to promote weight loss, including changing dietary habits, may be needed. Weight loss or failure to gain weight may indicate an ED or DEB.

11.4. PRECONCEPTION, PREGNANCY & LACTATION

11.4.1. Preconception Nutrition Advice

Preconception care should involve DSME, revising CC, reinforcing healthy eating habits, promoting tight glycemic control, and weight optimization. These measures will help improve pregnancy outcomes.[36] Advice may be sought from a dietitian familiar with T1D. A supplement containing low-dose folic acid (400 µg) and potassium iodide (150 mg) should be started, and any micronutrient or macronutrient deficiencies should be corrected, initially with dietary adjustment.[37]

11.4.2. Individualized Nutrition Plan in Pregnancy

Pregnancy is a state of increased metabolic activity, with an increased need for macronutrients and micronutrients in the second and third trimesters. The goals of MNT are to achieve and maintain normoglycemia, provide adequate maternal and fetal health nutrition, and promote fetal and placental growth. Nutrition plans that are individualized, culturally sensitive, and viable socio-economically should be made with the help of an expert dietitian. The calorie requirement should factor in pre-pregnancy body weight and the desirable pattern of weight gain during pregnancy. The Dietary Reference Intakes (DRI) recommends at least 175 g of carbohydrates daily, with careful CC, regular exercise, and insulin dose adjustments.[37] Three major meals are needed, and if using Regular insulin for bolus doses, 2-3 adequately spaced snacks, with attention paid to the timing, content, and quality of meals and snacks. A balance of macronutrients and nutrient-dense, whole foods (fruits, vegetables, legumes, and whole grains) are recommended during pregnancy.[38] Processed foods and sweetened foods and beverages should be limited or avoided. (Table 11.3)

Table 11.3: Recommended calorie per trimester[2]

First trimester	Nutrient-rich balanced diet
Second trimester & Third trimester	An additional 350 kcal must be added to the nutrient-rich balanced diet. For malnourished pregnant women, an additional 100 kcal per day (350+100=450 kcal/ day) is recommended.

11.4.3. Gestational Weight Gain (GWG)

Optimizing GWG is important to reduce adverse pregnancy outcomes. The optimal targets for GWG, based on pre-pregnancy Body Mass Index (BMI) in women without T1D, apply to women with T1D: 11.5–16 kg for women with normal weight, 7–11.5 kg for women with overweight and <5kg for women with obesity. High GWG is associated with maternal hypertension and increased fetal weight gain, independent of glycemic control and pre-pregnancy BMI, with a higher risk for offspring to become overweight or obese adolescents.

11.4.4. Nutrition in Postpartum and Lactation

The insulin requirement, which slowly rises through pregnancy, drops sharply by 30-40% immediately after delivery, then gradually increases to return to pre-pregnancy levels in 2-4 months and remains 10% lower than the preconception requirement in those who are breastfeeding.[39] Lactation is when the woman needs extra calories (0-6 months- additional 600 kcals, protein 50 g + additional 13.6 g/day, and 7-12 months-additional 520 kcals, protein 47 g + additional 10.6 g/day).[2,40] An individualized meal plan to promote successful breastfeeding, restore body weight to normal, and maintain diabetes control is essential. Breastfeeding causes hypoglycemia, so a decrease in insulin doses and a protein+carbohydrate snack or meal with water before or during nursing are important, especially during night feeding.

11.5. SUMMARY & RECOMMENDATIONS

• MNT is an essential component of T1D care across each age and stage of life - infancy, school, adolescence, preconception, pregnancy, postpartum, and lactation - to achieve glycemic goals, promote health, and reduce long-term adverse outcomes. “One-size-fits-all” dietary advice is inappropriate: meal planning should be age-group specific and individualized.
• CGM or regular BG checks are crucial for infants and toddlers to prevent hypoglycemia and hyperglycemia, which can affect brain development and overall growth.
• Establishing consistent meal and snack routines for toddlers helps manage BG levels and prevent food fussiness. Family-centered meals and involving young children in food-related activities can promote healthy eating habits.
• Glycemic targets for infants and toddlers with t1D should avoid hypoglycemia and hyperglycemia. BG targets of 108-198 mg/dL (6-11 mmol/L) during the day and to prevent nocturnal hypoglycemia, 120-180 mg/dL at bedtime are recommended, if technology support (CGM, insulin pumps) is not possible.
• School-going children must be supported by staff in diabetes self-care activities in school, including checking BG and taking bolus before school meals, and preventing hypoglycemia. School tiffin should have a healthy balance of carbohydrates, proteins, fiber, and fat.
• For school-going children, a comprehensive DMP involving parents, teachers, and healthcare teams is essential to manage BG levels during school hours and physical activities, ensuring safety and optimal learning.
• Adolescents face challenges due to hormonal changes, peer pressure, and independence. Re-education on healthy eating, CC, and adjusting insulin doses to match varying schedules is critical for maintaining glycemic control.
• Adolescents and their families need support to address erratic eating behaviors and potential disordered eating, which may contribute to metabolic control issues. Education on healthy decision-making, including the impact of alcohol and drugs, is important.
• Preconception and pregnancy care should focus on achieving normoglycemia and providing balanced nutrition. Individualized, culturally appropriate meal plans help manage increased caloric and nutrient needs during pregnancy and lactation.
• Postpartum, insulin needs decrease significantly, especially during breastfeeding, which can cause hypoglycemia. Adjusting insulin doses and having protein+carbohydrate snacks before or during nursing can help manage BG levels and promote successful breastfeeding. Self Monitoring Blood Glucose (SMBG)/ CGM can be used for decision-making.

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Chapter 12: Nutritional Management of Type 2 Diabetes in Children and Adolescents/ Young People

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12.1. INTRODUCTION

Type 2 Diabetes Mellitus (T2D) is been increasingly recognized in children and adolescents in the last few years, and has become an important health concern in our country, as well as globally. South Asians have a high and rising prevalence of obesity. In 2011, a large multi-city study reported that 4.5% of urban Indian children (8–18 years) had central obesity.[1] This increases the risk for T2D, even at a lower Body Mass Index (BMI). The National Family Health Survey 5 (NFHS 5, 2019-2021) reported 3.4% of children (<5 years) to be overweight.[2] The onset of T2D in young persons is associated with hypertension, dyslipidemia, and early onset of microvasculopathy, resulting in chronic complications earlier than with adult onset. Weight management is an important element of the primary goal of diabetes care. Nutritional risk factors related to overweight/ obesity include suboptimal consumption of fruits and vegetables, and consumption of energy-rich unhealthy foods and Sugar-sweetened Beverages (SSB).[3] A study among the Asian population showed that compared to traditional food patterns, a diet containing meat, soda, fried food, and fast food, including instant noodles, was associated with increased prevalence of abdominal obesity, increased Low-Density Lipoprotein (LDL) cholesterol, decreased High-Density Lipoprotein (HDL) cholesterol, and high triglycerides.[4] Diet, therefore, plays a crucial role as a modifiable factor in T2D prevention and as a most important behavioral aspect of T2D management. However, clinicians and patients often misunderstand basic concepts of nutritional management. The guidelines for the role of Medical Nutrition Therapy (MNT) for a young individual with T2D are provided, with the best available scientific evidence from both childhood and adult studies and experience where possible.

12.2. INDIAN PERSPECTIVE

Guidelines suggest a dietary composition of 45-55% [low Glycemic Index (GI) and Glycemic Load (GL)] carbohydrates from sources like cereals, mixed grains, and whole pulses, soybeans; and salads 15-20% proteins derived from low-fat dairy, eggs, fish, and lean meats and plant-based sources (pulses and lentils); and 25-30% fats, with less than 10% from saturated fats (7% in those with raised blood lipid levels) and the remainder primarily from Monounsaturated Fatty Acids (MUFA) and Polyunsaturated Fatty Acids (PUFA) [MUFA: 10% energy + any calories left from carbohydrate portion; PUFA- 10% of energy].[5,6] The essential fatty acids such as omega 6 (n-6) are widely available from various food sources, whereas omega 3 (n-3) can be obtained from oily fish, nuts, and seeds.

It is important to understand variations and similarities of food consumption patterns across various regions among Asian Indians. Our diet patterns are mostly carbohydrate-based, with studies reporting carbohydrates comprising 65-70% of total dietary energy.[7–9] Over the years, influenced by several socio-economic and cultural factors, there has been an ongoing transition from the consumption of coarse grains to refined grains, and the consumption of Ultra-processed Foods (UPF) High in Fats, Sugars, and Salt (HFSS). This pattern is higher in urban populations but is rising even in rural populations, with decreased consumption of millet and whole cereals, and increased intake of UPF. Refined sugar intake is high and increasing exponentially.[8] Low consumption of dietary fiber has been reported across India, with intake as low as < 10 g/day of crude fiber.[10] A nationwide survey by the Centre for Science and Environment found that half the children consumed SSB, packaged salty and sweet foods twice a week, with every other child consuming packaged foods or SSB at least once daily.[11] These consumption patterns result in micronutrient deficiencies, increasing T2D, poor control of T2D, and related metabolic conditions.[12] Factors that promote unhealthy lifestyles include poverty, lack of awareness of healthy eating, myths and misconceptions about diet, easy access to unhealthy foods in school canteens and at home, food insecurity, use of food supplements, nuclear families with working parents, lack of safe play areas and neighborhood friends, digital toxicity, lack of healthy sleep and increasing evening tuitions.

12.3. MEDICAL NUTRITION THERAPY

MNT, along with behavior changes and increased physical activity, is one of the cardinal pillars of T2D management and diabetes self-management education.[13] Other modalities such as pharmacotherapy and bariatric surgery, which have gained popularity in recent years, are beyond the scope of this document. We focus here on MNT, ensuring caloric intake matches expenditure, maintaining consistent daily carbohydrate consumption in meals and snacks, focusing on the nutritional content and quality of foods, and timing meals and snacks effectively.

12.3.1. General Treatment Goals of Nutrition Intervention in Children and Adolescents with T2D

- Maintain Blood Glucose (BG) levels as close to normal as possible, by balancing food consumption with physical activity, and the appropriate use of medications or insulin.
- Provide appropriate calories for optimal growth and development and maintain a healthy body weight.
- Meet individual nutritional needs by taking into account personal and cultural preferences, willingness to change, and the enjoyment of eating, while restricting food choices only when necessary.
- Prevent/ manage risk factors and co-morbidities like hypertension and dyslipidemia, maintaining optimal Blood Pressure (BP) and lipid levels.
- Prevent both acute and long-term complications of diabetes.
- Educating and empowering the child and the family on optimal nutrition.
- The relative value of each nutritional goal varies with individual patient characteristics. Focusing on a gentle change in family and individual dietary habits is crucial to achieve better long-term goals.[14]

12.3.2. Timing of Intervention

The critical times for providers to discuss and review MNT are:

- At diagnosis
- Every 6-12 months
- When not meeting treatment targets.

12.3.3. Recommendations of MNT

Dietary counseling as a part of community health programs, resulting in dietary changes, can effectively prevent diabetes.[15,16] In individuals with T2D, Fasting Blood Glucose (FBG) drops within several days of calorie restriction[17], but long-term glycemic control depends upon weight loss. Trials such as Look AHEAD[18] (Action for Health in Diabetes) and DiRECT[19] (Diabetes Remission Clinical Trial) have shown that lifestyle intervention (increased physical activities and calorie restriction) achieved modest weight loss at one year, with remarkable improvements in FBG, glycemic management, BP, HDL-cholesterol, and triglyceride levels, and notable reductions in the need for medications for diabetes, hypertension, and dyslipidemia. They highlight the role of weight loss in achieving diabetes remission and metabolic control.

12.4. DIETARY MODIFICATION

The aims are to improve glycemia, facilitate weight loss if needed, promote effective weight maintenance, and reduce Cardiovascular (CV) risk factors. Nutritional strategies for weight loss may involve adjusting macronutrient goals and food choices to produce the required energy deficit. Graded reduction of calorie and fat intake is implemented, while maintaining standard proportions of macronutrients, and ensuring nutritional needs are met by meal planning strategies such as exchange systems and meal replacements.

12.5. BASELINE ASSESSMENT AND MANAGEMENT

The optimal BMI for adults in South Asia is 18.5-22.9 kg/m^2 (less than for other ethnicities).[20] According to the 2015 Indian Academy of Pediatrics (IAP) charts for BMI, overweight is defined as adult equivalent BMI of 23 kg/m², and obesity is defined as adult equivalent BMI of 27 kg/m².[21] In children and adolescents, normal BMI and BP increase with age: the child's BMI and BP should be assessed by comparing them with the normal for age using IAP charts. Estimating caloric intake and individualizing a plan depends on age, gender, BMI, BP, pubertal status, and physical activity levels (active/ sedentary).

12.6. WEIGHT LOSS GOALS

Achieving weight loss and optimal body composition with healthy body fat and muscle mass proportions are essential to management. For children and adolescents diagnosed with T2D and whose weight exceeds the healthy range, initial recommendations for weight loss and physical activities are outlined below:

- The ideal target is a reduction of 7-10% in body weight for those who have completed their growth phase, or achieving a BMI below the 85th percentile for their age and sex for those who are still growing.[22] It is wise to approach this goal stepwise, with an initial goal of weight maintenance, later intensified to achieve weight loss of 0.5-1 kg per month for youth still in the growing phase.
- Those who have completed puberty can aim for a weight loss of approximately 0.5-1 kg per week, as recommended for adults with T2D; this can be challenging for some adolescents.[23]
- For managing children with severe obesity and related comorbidities or complications, a gradual weight loss is advised: children aged 2-5 years should aim to lose 0.5 kg/month, while older children and adolescents should target a weight loss of 1 kg/week.[24] For a weight loss of 1 kg/week, 500-1000 calories are deducted from daily weight-maintenance calories, and at least 60 minutes per day of moderate to vigorous physical activity, with 20 minutes/3 days/week of strength training[25], i.e., a combination of aerobic and strength training exercises, is advised.
- A multidisciplinary approach is recommended, involving collaboration among physicians, diabetes nurse educators, dietitians, mental health professionals, and, if available, exercise physiologists. Consistent follow-ups are crucial to assess weight, glycemic control, and compliance with dietary recommendations.[24]
- Once initial weight-loss targets are achieved, subsequent goals should be set based on the effects of the weight reduction on BG levels and the individual's willingness to pursue further weight loss. Reaching the ideal body weight is not required to improve health status if exercise is regular.[26]
- Even a sustained weight loss of 5-10% of initial body weight can lead to significant long-term improvements in dysglycemia, dyslipidemia, and hypertension.[27–29] Adolescents with T2D treated with Very Low-calorie Diets (VLCD) for 1-4 months have shown reduced BMI and HbA1c, enabling discontinuation of pharmacologic agents.[30] However, such diets require very close medical supervision by an experienced team and may not be appropriate for children and adolescents in the long term.
- Educating on weight maintenance is needed, by imparting awareness on healthy eating using strategies like Traffic Light Diet or MyPlate concept adapted to local ethnicities and food cultures, with avoidance of JUNCS (Junk foods, Ultra-processed foods, Nutritionally inappropriate foods, Caffeinated/ Colored/ Carbonated foods/ Beverages, and SSB).[31] To combat childhood obesity, the American Academy of Pediatrics endorses the '5-2-1-0' guideline. This includes eating at least 5 servings of fruits and vegetables daily, limiting screen time to less than 2 hours daily, engaging in 1 hour of moderate to vigorous physical activity daily, and avoiding SSB entirely.[32]
- Eating late and inadequate sleep promote weight gain. The timing of meals and the composition of the diet (chrononutrition), play significant roles in managing circadian rhythms. This approach enhances metabolic health and also helps in reducing the risk of developing obesity and diabetes.[33]

12.7. DESIGNING NUTRITION CARE PLANS

Dietary counseling begins by assessing the present diet of the individuals with T2D and their family, their dietary choices and constraints; forms of physical activity, frequency and duration of sedentary behaviors (including screen time); family time; monetary constraints; cultural background; social support available, educational background, and level of motivation. Based on this information, the counselor guides the individual with T2D and the family toward a healthier diet with measurable and achievable dietary goals. The nutritional recommendations include teaching calorie and fat gram counting, Carbohydrate Counting (CC), the Plate method, choices using an exchange system, and meal replacements. Emphasis should be on the consumption of whole grains, millets (unpolished), nuts and seeds, non-starchy vegetables and whole fruits, legumes, low-fat dairy products, eggs, and lean meats; while curtailing consumption of UPF, SSB, sweets, refined grains, and red meats.[34] Additional advice will depend on whether the individual with T2D has hypertension or other comorbidities. Eventually, the care plan would be revised to a maintenance phase based on the willingness of the individual and the family to sustain glycemic management and prevent complications of diabetes.

In case of severe obesity and/or comorbidities, even in children, low-calorie diets (<1200 kcal/ day) and VLCD (<800 kcal/ day) may be initially considered for short periods of time. They require careful medical supervision.

12.7.1. Macronutrient Composition

Based on glycemic and weight loss goals, food preferences, and associated metabolic comorbidities, individualizing the optimal

macronutrient mix may improve the long-term ability to self-manage healthful eating patterns.

12.7.1.1. Dietary Carbohydrate

Consumption of nutrient-dense, high-fiber sources of carbohydrates such as vegetables, fruits, whole grains, legumes, and low-fat dairy are recommended. The quantity consumed is adjusted to control postprandial and overall glycemia. Moderate sucrose intake (up to 5-10% of total calories) is acceptable; excess amounts lead to poor dietary quality, increased postprandial BG levels, and excess weight gain.[35] As per the World Health Organization (WHO), a stricter target of sugar intake <5% of daily energy intake gives additional health benefits.[36]

12.7.1.1.1. Carbohydrate Consistency

Maintaining carbohydrate quantity and quality improves glycemic management since there is a direct effect on postprandial BG levels. Carbohydrate consistency can be especially beneficial for individuals experiencing fluctuating BG patterns, including those prone to hypoglycemia. Pre- and post-meal BG monitoring helps to analyze if the changes in carbohydrate intake at meals and snacks are effective. There are several meal-planning approaches to achieving carbohydrate consistency.

- **Basic CC:** With this training, predetermined, proportionate amounts of carbohydrates are recommended for consumption in meals and snacks to meet nutrition goals.
- **The Plate method:** A simple 9-inch plate graphic illustrates food portioning — one-quarter of the plate is allocated for lean proteins, another quarter for carbohydrates such as starches or grains, and half the plate for non-starchy vegetables. This method is an effective alternative for individuals unable to perform basic CC. (refer to Figure 17.1 for Indian Healthy Plate)
- **Advanced CC:** This approach involves adjusting food intake, insulin doses, and physical activity based on analyzing detailed logs that track BG levels and carbohydrate consumption.[37,38] (refer to Chapter 5)

12.7.1.1.2. Low-carbohydrate Diet

Various dietary approaches focus on adjusting the macronutrient composition, improving the quality of carbohydrates, or implementing calorie restrictions like VLCD, protein-sparing modified fast, or a low-carbohydrate diet. As discussed above, short-term interventions such as VLCD (<800 kcals/day with variable carbohydrate and protein content) and keto diets improve glycemia, lower lipids, and help weight loss, but they have challenges of long-term sustainability and nutritional inadequacy, resulting in growth failure.[39] Sufficient evidence supports the safety of energy-restricted diets, but only under close medical supervision.

12.7.1.2. Dietary Protein

In most Indian diets, protein sources are predominantly pulses, contributing 10% and 11% of protein intake in rural and urban areas respectively, and milk and dairy products, accounting for 10% and 12%, respectively. The remaining protein intake comes from cereals.[40] The recommended daily allowance of protein of 1.2-1.4 g/kg/day in infancy, decreasing to 0.8 g/kg/day in adults, is unmet in many Indians.[41] Suboptimal protein intake causes poor growth, poor muscle mass and function (sarcopenia), and poor bone density accrual. Sarcopenia is higher in South Asians and is independently associated with T2D. Preferred protein sources are pulses, soy products, nuts, seeds, low-fat dairy, eggs, fish, and lean meats. Plant-based proteins, which contain lower levels of saturated fat, may contribute to modest improvements in HbA1c and FBG levels in individuals with T2D when used as a substitute for animal proteins.[42] Unrestricted protein intake, i.e., >1.3 g/kg/day or >20% of calories, should be avoided, as it is associated with albuminuria, loss of kidney function, and Cardiovascular Disorders (CVD) and mortality.[43]

12.7.1.3. Dietary Fat

Fat quality and quantity are both important. Generally, Trans-fats (hydrogenated fats) such as vanaspati, and processed, ready-to-eat baked foods like puffs, *khari*, pastries, biscuits, and cookies are atherogenic and advised to be avoided. However, in 2021, an Indian survey released by FSSAI (Food Safety and Standards Authority of India) on Trans-fat in different categories showed >90% of food products achieved <2% of trans-fat as mandated by FSSAI. Individuals with T2D and their families must be encouraged to get skilled in reading labels to identify trans-fat content. Saturated fats (margarine, red meat, butter, ghee, etc.) should be less than 10% of total fat consumed, while MUFA and PUFA (e.g., fish, olive oil, nuts, flax seeds, sunflower, corn, and soybean oils) are relatively cardiovascular protective (particularly n-3 fatty acids).[44] Substituting saturated fats with polyunsaturated fats can help reduce FBG, HbA1c, and insulin resistance. Moreover, replacing carbohydrates, saturated fats, or monounsaturated fats with polyunsaturated fats may improve insulin secretion.[45] In the obese child, the daily cholesterol intake should be limited to 300 mg if lipid levels are normal, and restricted to less than 200 mg for those with dyslipidemia or risk of CVD (one egg has 180 mg cholesterol, so a maximum of 2 eggs a day is safe). Indian diets are high in n-6 PUFA, resulting in a higher n-6 to n-3 fatty acid ratio than is ideal. The recommended intake of n-3 fatty acids is between 0.6% and 1% of total dietary energy. The suggested n-6 to n-3 ratio for optimal health is 5:1 to 10:1. It is advised to consume 200 mg of n-3 PUFAs daily; however, Indian cuisines typically provide only 20-50 mg of n-3 PUFAs. This highlights the need to increase n-3 intake in Indian diets.[46]

12.7.1.4. Dietary Fiber

Higher fiber intake may improve glycemia; at least 15 g/1000 calories daily, with whole grains providing at least 50% fiber, is recommended. The Indian Council of Medical Research - National Institute of Nutrition (ICMR-NIN) 2024 guidelines recommend a daily fiber intake of 15-30 g/day.[41] Recommended fiber intake can be calculated as age in years +5 = g/day of fiber. Wheat- or millet-based diets generally have higher fiber than rice-based diets. Children can achieve adequate dietary fiber intake by consuming a variety of vegetables (raw or cooked, in meals, 2-3 times a day), whole fruits, legumes, and whole-grain products.

12.7.2. Glycemic Index (GI) and Glycemic Load (GL)

GI and GL are discussed in Chapter 7. Low GI diets with high fiber content (as above) may improve postprandial hyperglycemia.[47]

12.7.3. Exchange System Approach

This approach provides steadiness in meal planning and allows diverse food choices to achieve calorie, fat, and carbohydrate goals. The exchange lists give several options in each group that provide similar nutritional value in terms of calories, carbohydrates, protein, and fat. (refer to Chapter 8)

12.7.4. Meal Replacement

Replacing part/ full meals with low-calorie diet items such as soups or healthy shakes may be useful in the initial phase. The extent of weight loss depends on the number of meal replacements per week for a given duration of time.[48]

12.7.5. Important Targets for Counseling Include

- Moderate portion sizes.
- Substitute a carbohydrate-rich food with a whole fruit or non-starchy vegetable.
- Decrease or avoid high-caloric SSB (e.g., soft drinks, energy drinks, juices - replace with water or low-calorie/ calorie-free beverages).
- Reduce the frequency of eating out/ ordering in.
- Increase home-cooked family meals.

12.8. PSYCHOLOGICAL SUPPORT AND FACILITATING DIETARY SELF-MANAGEMENT

Expecting long-term commitment to dietary changes to achieve and maintain glycemic control and optimal or best possible weight is usually challenging for adults with T2D, more so for children and adolescents, who are also dependent on their families' willingness to change. The entire family must make the changes – trying to do so only for the child/ adolescent is counter-productive.[23] The important factor that determines optimal management is the ability to self-manage eating and activity habits, which is enhanced by understanding the benefits of even modest weight loss, person-centric care, individualized planning, shared decision-making guided by various lifestyle treatment options, and revisiting the progress of nutrition goals during follow up visits. The addition of a mental health clinician familiar with diabetes and psychosocial challenges during adolescence to the team caring for youth-onset T2D is important to support healthy behavioral change strategies.[49] Using appropriate language, avoiding body shaming and fear of complications, providing adequate psychological support, helping overcome social stigma, and looking for socially acceptable solutions for the growing child/ adolescent and family are vital.

12.9. ADVOCACY (POLICY CHANGES)

Rational solutions are needed across many domains to ensure dietary modifiable risk factors for postprandial hyperglycemia and chronic lifestyle disorders; they involve collective efforts at different levels by the food industry, policymakers, clinical researchers, population, and individuals. School canteens serving energy-dense foods, commercial advertisements in media[50], inadequate policymaker involvement, lack of societal awareness, and unwillingness for behavioral change are among the challenges that need urgent focus to prevent obesity and T2D.

12.10. SOLUTIONS AND APPROACHES (SOCIAL AND BEHAVIORAL) TOWARDS PREVENTION AND MANAGEMENT OF T2D

- Social and behavioral change by promoting awareness of relevant food choices and avoiding unhealthy food, at home, in schools, and social gatherings.[51]
- Adopt and promote healthy lifestyles and physical activity at home, schools, colleges and workplaces, and provide safe, easily accessible green spaces.
- Promote optimal maternal nutrition, maintaining a healthy weight during the reproductive age and pregnancy, and implementing proper infant feeding practices.
- Appropriate use of educational resources such as digital apps, visual models (e.g., Plate model), and color-coded materials to assist in wise choices of common foods.
- Education about faulty cooking practices, e.g., high-heat-treatment and frying in leftover oils, which generate Trans Fatty Acids.[52]
- Implement research, training, and mass educational programs about locally available staple foods and nutritional shortfalls to facilitate community behavioral interventions with region-specific strategies.
- Encourage locally grown and seasonal food consumption to meet micronutrient requirements and encourage food diversity.
- Push the 'Eat Right Movement' launched by FSSAI to address nutrition safety, planned along the Indian National Health Policy, 2017, focusing on preventive and promotive healthcare.[53]
- A simplified system of identification of healthy and unhealthy processed foods based on GI, GL, energy density, salt, and fat content, with a mandatory display of accurate, easily understood information on packaged food labels. Increased awareness of such food labels.
- High government taxation on unhealthy foods (HFSS).[54]
- Tough regulations on media and celebrities to ensure they behave responsibly and avoid endorsement of unhealthy and non-nutritive food products.
- Regulatory bodies could promote the selling of healthier food products.
- Establish clinics with professional care teams for easier access and earlier treatment.
- Design and implement a national obesity/ diabetes preventive program for children, using the best local evidence available. The program should be robust, realistic, accessible, and sustainable and include all stakeholders (child, family, school, community).

12.11. SUMMARY & RECOMMENDATIONS

- To manage youth-onset T2D, knowledge and individualized application of basic principles of nutrition are needed, rather than advising any specific calorie or "diabetic" diet.
- A balance of macro- and micro-nutrients is needed, aiming for glycemic control, improved metabolic profile, reduction and later maintenance of weight, good quality of life, normal growth and development, and ultimately prevention of long-term complications.
- The diabetes care team has to educate and motivate the person with diabetes and family members to implement a family-based, individualized program for the best outcomes.
- Achieve near-normal BG levels by balancing food intake with physical activity and medication or insulin use while ensuring appropriate calorie intake to achieve optimal growth, and maintaining a healthy body weight.
- Customize nutritional plans to suit individual needs, taking into account personal and cultural preferences, willingness to change, and the enjoyment of eating. Limit food choices only when necessary and appropriate to do so.
- Lifestyle intervention (physical activities and calorie restriction) to improve glycemic status and metabolic parameters. Avoid 'JUNCS' foods (Junk foods, Ultra-processed foods, Nutritionally inappropriate foods, Caffeinated/ Colored/ Carbonated foods/ Beverages, and SSB).
- The recommended weight loss goal is to reduce body weight by 7-10% for those who have completed linear growth or to achieve a BMI below the 85th percentile for age and sex for those still growing.
- It is important to engage in at least 60 minutes of moderate to vigorous physical activity daily, including strength training sessions for 20 minutes, three times a week.
- Nutrition counseling should emphasize the consumption of whole grains, pulses, nuts and seeds, non-starchy vegetables and whole fruits, and low-fat dairy products; while minimizing the consumption of ultra-processed foods, sugar-sweetened beverages, sweets, refined grains, and red meats; to reduce postprandial BG.

• Consumption of nutrient-dense, fiber-rich carbohydrates, with the quantity adjusted to control postprandial and overall glycemia.
• Protein sources such as pulses, soy products, nuts, seeds, low-fat dairy, eggs, fish, and lean meats are recommended to meet the Recommended Dietary Allowance (RDA) for each age group.
• Mono- and polyunsaturated fats are relatively protective. Saturated Fatty Acids (SFA), MUFA, and PUFA in the ratio of 1:1.5:1, with SFA consumption within the range of 7-10% of the individual total energy consumption, is recommended.
• Fiber intake of at least 15 g/1000 calories daily, with whole grains providing at least 50% fiber.

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Chapter 13: Handling Nutrition During Sick Days, Hypoglycemia in Type 1 Diabetes Mellitus

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13.1. SICK DAYS

13.1.1. Introduction – Why Sick Days Need Extra Special Care

Illnesses require special attention in a child with Type 1 Diabetes Mellitus (T1D). Both physical and emotional sickness can increase the stress levels in the body, resulting in increased counter-regulatory (stress) hormones such as epinephrine and cortisol.[1] In People with Diabetes (PwD), since insulin secretion is compromised, unopposed action of these hormones will increase the Blood Glucose (BG) levels and tend to increase blood ketones, increasing the risk of Diabetes Ketoacidosis (DKA). This may require hospitalization. Such episodes affect the family in multiple ways – worsened glycemic control, school absenteeism, increased expenses, and deleterious effect on the child's and family's emotional well-being - and are best avoided.[2,3]

While most illnesses can be managed at home, adequate nutrition during sick days can be tricky.

13.1.2. Effect of Illness on Nutrition and BG Levels

• Most viral illnesses start with fever, which may be high-grade, sometimes reaching 104-105°F on days 1-3. This causes rapid hyperglycemia and ketosis, sometimes severe enough to need control with Intravenous (IV) insulin.
• Many viral fevers have gastrointestinal symptoms like nausea, vomiting, diarrhea, and intestinal mucosal edema. These symptoms can affect food intake and glucose absorption and increase the risk of hypoglycemia.[4]
• A sore throat can make it difficult for the child to swallow solids and liquids, thus challenging the child's normoglycemia and good nutrition maintenance.
• Longer-lasting bacterial illnesses, such as typhoid, tuberculosis, etc., can significantly affect the child's appetite. Parents sometimes give 'unhealthy food' to ensure "at least something is going in." They should be discouraged from giving poor-quality-nutrient foods, such as foods high in sugar, salt and fats, as they will cause satiety without providing the nutrients required for recovery.
• Illnesses requiring hospitalization pose a special challenge in selecting IV fluids and maintaining nutrition.
• Water can be lost in multiple ways, which puts the child at increased risk of dehydration.[5]
i. Polyuria due to hyperglycemia
ii. Vomiting
iii. Poor intake due to sore throat or vomiting
iv. Fever causing sweating and higher losses from the skin
v. Diarrhea.
• Dehydration and sepsis can lead to lactic acidosis, which worsens the ketoacidosis.[6]
• *Vomiting is a very important symptom.* While it can be a sign of illness, vomiting in PwD should be considered due to ketosis unless proven otherwise.[7,8] Often, parents omit insulin during vomiting, considering the child's poor intake. In fact, the need for insulin is more due to stress, leading to worsening of vomiting and increased risk of DKA.
• Children with poor glycemic control are already in a catabolic state, with limited liver glycogen stores. They are more likely to get infections, and any acute illness can precipitate DKA or hypoglycemia quickly in them. Such children are also at higher risk of worsening infection or multisystem involvement, making things worse.[9]
• Illnesses requiring surgery require special attention post-operatively: the diet needs to be managed according to the type of surgery.
• During recovery from illness, the body tries to make up for losses. This often increases the child's appetite. Insulin doses and meals during recovery need to be carefully planned and grazing avoided, so that severe hyperglycemia can be prevented.

13.1.3. Managing Nutrition During Sick Days

Management starts by educating the family about sick days and equipping them with clear, written instructions on handling them.[10] During any illness, they should have adequate support systems and access to Healthcare Professionals (HCPs), including doctor, diabetes educator, and nutritionist. The underlying condition should be treated as for any other child.

Four main rules for sick day management should be followed simultaneously[11]

i. *Never omit insulin:* basal insulin needs to be continued during illness and the dose needed may rise; in addition, food needs bolus dosing. Adequate insulin must be given according to the BG and ketone levels.
ii Check BG 1-3 hourly or review Continuous Glucose Monitoring (CGM) frequently.
iii Check blood/ urine ketones 2-6 hourly, as needed.
iv *Provide plenty of liquids orally:* these liquids should be salty if the BG is high and contain both sugar and salt if the BG is drifting low.

Prevent Dehydration: this is one of the most important aspects during an illness. Children who cannot eat meals should be offered plenty of liquids.
• *What fluids to give?*
–*For BG >180 mg/dL*, low-carbohydrate fluids, e.g., plain water, salty buttermilk, vegetable soup, coconut water (around 10 g carbohydrate per 250 mL cup), salted lemon water, *jal jeera*, etc., can be given. Oral Rehydration Salt (ORS) (14 g dextrose per liter) is important only if diarrhea is present as well. A soup made with vegetables and moong dal, pressure cooked with a small amount of oil, and blenderized, with some cumin powder and salt added, is an example of a nutritious liquid.
–*For BG <180 mg/dL*, sweetened liquids such as homemade lemonade or buttermilk with sugar and salt can be given.
• *How much to give:*
–Fluids should be given at 4-6 mL/kg/hour; e.g., for a 20 kg child, around 100 mL (i.e., half a glass) should be given every hour.
• If the child cannot take orally or is vomiting, fluids should be given in small sips. Cold fluids may be preferred because they reduce the tendency to vomit.[11]

• The child should be offered easy-to-digest carbohydrates such as curd rice, bananas, *khichdi*, etc. Adequate nutrients facilitate recovery from illnesses, particularly gastrointestinal illnesses. Fruit juices, whether fresh or packaged, and particularly fruit-based beverages, which are sugar-rich, should not be given.
• In gastrointestinal illnesses, replace meals with small amounts of sugar-containing liquids, given in sips, with insulin coverage. The total daily insulin dose may be reduced by 10-50% in gastrointestinal infections with associated hypoglycemia. If the appetite is reduced and the child's intake is unpredictable, or if the child is vomiting, the correction insulin dose for high BG and ketones can be given before the meal, and the dose for the meal itself can be given after it is consumed, depending on how much is consumed and retained. If hypoglycemia does not improve, then mini-dose glucagon or intravenous fluids are needed.[12]
• Any child who has (a) persistent vomiting (especially age <5 years), (b) continuously high or rising BG and ketone levels despite additional insulin doses and hydration, (c) exhaustion, (d) hyperventilation, or (e) a change in neurological status, should be urgently hospitalized.

13.1.4. Recovery

• Typically, a febrile illness significantly increases the insulin requirement during peak illness, with a rapid drop in insulin needs during recovery. On the contrary, insulin doses may have been reduced during gastrointestinal illnesses and would rise during recovery. There may be weight and nutrient losses during the illness; the appetite may increase significantly after the illness to compensate. As a result, the daily dose may be higher than the routine requirement for a few days during recovery. Careful and frequent BG monitoring and insulin dose adjustments are needed during this time.
• The child should be given a nutrient-rich, balanced diet during this phase. Fruits, vegetables, pulses, and low-fat dairy products should be included in sufficient amounts, with adequate insulin cover, without force-feeding.
• It is not advisable to use very-low-carbohydrate meals during an illness since that can increase the risk of ketoacidosis.
• Carbonated and other sugar-sweetened beverages should be avoided as much as possible at all times.

13.2. HYPOGLYCEMIA

13.2.1. Introduction

It is rare to find a person living with T1D who has not experienced hypoglycemia, which is one of the major limiting factors for achieving optimal glycemic control.[13,14] It can cause morbidity; and may set off a vicious cycle of repeated hypoglycemia, as one episode can predispose to further episodes.[15,16] Even a single episode of severe hypoglycemia can also lead to marked fear of hypoglycemia (FOH) in the minds of the PwD and caregivers.[17] Hypoglycemia is also responsible for 6-10% mortality in PwD.[18–21] FOH results in caregivers/ clinicians setting undesirably high BG targets. An analysis of 1441 Diabetes Control and Complication Trial (DCCT) participants found recurrent hypoglycemia to be a risk factor for weight gain in PwD.[22]

13.2.2. Definition

The International Society for Pediatric and Adolescent Diabetes (ISPAD)[23], Indian Society for Pediatric and Adolescent Endocrinology (ISPAE)[8], and American Diabetes Association (ADA)[24] Guidelines state a BG value of 70 mg/dL as the level below which treatment for hypoglycemia should be initiated, and a value of <54 mg/dL as clinically significant hypoglycemia. It is important to check the BG with a finger prick when hypoglycemia is suspected or seen on CGM, in order to confirm and assess severity.

• **Clinical hypoglycemia alert:** A BG value of <70 mg/dL is called *Level 1 hypoglycemia* and is considered a threshold or alert value that should be identified and treated to prevent more serious hypoglycemia. Treatment consists of giving simple sugar like glucose (powder, tablet or gel), table sugar, *shakkar, gur, khand*, or honey. The amount depends on the age of the PwD: 5 g for children up to age 5 years; 10 g for children ages 5-10 years; and 15 g for those older than 15 years. This is followed, after waiting for 15 minutes, by a snack/ meal if BG has normalized. PwD should ideally spend <4% of their time below 70 mg/dL.
• **Clinically Important or Serious Hypoglycemia:** A BG value of <54 mg/dL is considered clinically serious: below this level, hormonal counter-regulation is defective, and there is impaired hypoglycemia awareness. The person starts experiencing neurogenic symptoms like headache, drowsiness, confusion, etc., and sometimes also cognitive decline, with a high risk of developing severe hypoglycemia. This is considered *Level 2 hypoglycemia*. PwD should spend <1% of the time in this range.
• **Severe Hypoglycemia:** It is an event associated with severe cognitive decline (including coma or convulsions) such that the PwD requires assistance from another person to administer carbohydrates, glucagon, or IV dextrose. Any episode of hypoglycemia where such assistance is required, is considered *level 3 hypoglycemia* or severe hypoglycemia, irrespective of the BG level. In small children, assistance is required even with mild hypoglycemia.[25]
• **Pseudohypoglycemia** is an event during which a PwD experiences typical symptoms of hypoglycemia but a BG >70 mg/dL, although it could be approaching that level.[26] It may be seen when BG drops rapidly. This should be distinguished from situations when the PwD says symptoms of hypoglycemia are occurring (due to stress or a subconscious desire to get a "treat" or seek attention), but the BG is and remains normal.
• **Nocturnal Hypoglycemia:** PwD are at risk of developing hypoglycemia at night due to increased insulin sensitivity and suppressed sympathoadrenal responses, which slows down the body's own ability to normalize BG. Nocturnal hypoglycemia is worrisome as it may be missed and not be treated in time, which may lead to brain damage or even mortality.[27] Nocturnal hypoglycemia should be suspected if there is recurrent high fasting BG, which may be due to a rebound (Somogyi effect). CGM devices are useful in detecting nocturnal hypoglycemia.[28–30]

13.2.3. Management

• The management of hypoglycemia can be divided into acute management and prevention: both should be carefully taught to every PwD and all caregivers. Hypoglycemia level and duration need to be assessed and accordingly prevented/ managed.
• The aim of acute treatment is to bring BG up, preferably above 100 mg/dL, with complete recovery of symptoms. The acute management can be explained in Figure 1 as follows.

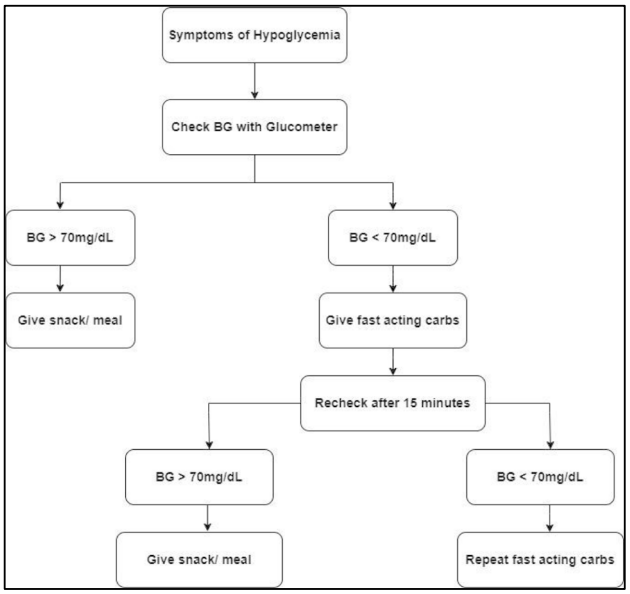

Figure 13.1: Acute management of hypoglycemia

• For the initial correction of hypoglycemia, fast-acting carbohydrates, i.e., simple sugars (glucose, glucose tablets, sugar in any form like table sugar/ *gur*/ *khaand*/ candy, juice or sugar-sweetened beverage) are required in a 0.3 mg/kg dose.[23,28] To simplify matters, the dose is 5 g, 10 g, and 15 g for PwD who are 5 years, 5-10 years, and >10 years, respectively. For adolescents and adults, the rule of 15 is followed:

give 15 g of fast-acting carbohydrate
after 15 minutes, recheck BG,
if >70 mg/dL, give 15 g complex carbohydrate snack;
if still < 70 mg/dL, repeat 15 g fast-acting carbohydrate.

Waiting for 15 minutes after giving fast-acting carbohydrates is important at all ages, to allow time for absorption and thus avoid over-correction and marked hyperglycemia.

•A meta-analysis showed that glucose tablets corrected BG faster than dietary sugars like sucrose, fructose, orange juice, milk, or jelly beans.[31] Sucrose and glucose were found to be more effective than fructose.[32] Fruit juice and honey are also effective,[23,33] but the proportion of fructose and sucrose in honey is variable; hence, it may be less reliable. Packaged juices should be discouraged as it is difficult to stop at the right amount, and over-correction is common. Some juices may contain non-nutritive sweetners and would be ineffective. Diet drinks are also ineffective. It is important to teach that foods high in fat or protein should be avoided for initial management, as they take longer to absorb and may impair the absorption of simple sugars. Hence, chocolates, cakes, biscuits, *mithai,* etc., are not appropriate for acute management of hypoglycemia. It is also important to discourage caregivers from offering "treats" to correct hypoglycemia; otherwise, the child may subconsciously invite hypoglycemia to get such food items. "Treats" are permitted occasionally in a planned way rather than at times of crisis.

• Once the BG is >70 mg/dL, a 5-15 g (amount based on age) slow-acting carbohydrate snack (milk, nuts, chapati, fruit, sandwich, etc.) is given to prevent recurrence. If the time is close to meal time, the child can consume a normal meal with a negative correction of insulin dose. It is important to educate caregivers not to miss the pre-meal insulin dose in such a situation, as this can result in hyperglycemia.

Table 13. 1: List of fast-acting carbohydrates or simple sugars

List of fast-acting carbohydrates or simple sugars	
Preferred choices for management	*To be used only if preferred choices are not available*
• Glucose powder/ tablets	• Fruit juice
• Sugar (powdered/ crystal)	• Sugar drinks (not diet drinks)
• Glucose gels	• Sugar candies
• Jaggery/ *boora*/ *khaand*	• honey
Examples of post-hypoglycemia snacks (15-20 g carbohydrate exchanges)	
• One fruit like an apple or a small banana	
• One chapati with butter or peanut butter	
• Sandwich or one slice of bread	
• A handful of roasted chana	
• One glass of milk	
• 2-4 dates	

• For PwD who are on insulin pump therapy, the treatment remains the same, with minor differences. The pump need not be suspended unless BG drops <54 mg/dL and should be reconnected after correction of the hypoglycemia. The post-hypoglycemia snack should be taken only if active insulin is present to neutralize it. PwD who are on hybrid closed loop or sensor-augmented pumps need much less fast-acting carbohydrates: hence, only half of the calculated amount should be given. If the PwD wants a snack, an appropriate bolus should be given.[23]

• Management of hypoglycemia also involves preventing further episodes and preventing the development of FOH. CGM devices are very helpful in preventing hypoglycemia; however, it is important that low CGM values are confirmed with a finger prick before corrective action is taken. A finger prick test is also needed to check for recovery.

• PwD on Regular (soluble) insulin should take a bedtime snack daily, unless the bedtime BG level is >180 mg/dl. Examples of bedtime snacks are milk or curd, with/ without fruit or nuts; sesame or peanuts or other nuts and seeds (plain or as a *ladoo*); date nut roll; or a small *chapati* with (homemade) peanut butter or *paneer*. Dietary changes are helpful if hypoglycemia occurs around 2-3 am with a rise in BG by early morning: a snack of nuts and seeds before sleeping would help to prevent hypoglycemia and rebound hyperglycemia. CGM devices are useful for managing and preventing nocturnal hypoglycemia.[23,34]

13.2.4. Prevention

• Education for prevention, treatment, and risk factors of hypoglycemia should be taught at diagnosis and repeatedly reinforced.

• Timely meals and regular BG monitoring 4-10 times daily are needed to adjust insulin doses, especially during Physical Activity (PA). As discussed above, CGM devices are very effective in identifying BG trends and preventing hypoglycemia. If flash glucose monitoring (FGM) is used, i.e., alarms are not available, it may be more practical to keep the threshold for action at 80 mg/dL. For those experiencing recurrent hypoglycemia, and in children under five years of age, a target of >90 mg/dL may be safer.[8,35]

• Foods high in fat or protein can raise postprandial BG levels for several hours. This may be useful to prevent hypoglycemia during prolonged sports and other strenuous activities.[36] Such foods are needed as bedtime snacks by those on Neutral Protamine Hagedorn (NPH) and Regular insulin regimens, to prevent nocturnal hypoglycemia, especially after unusually strenuous PA during the evening. Examples of bedtime snacks are given above.

• Foods high in fat may not allow a rise in BG in the first two hours postprandially, and give a delayed spike; hence, appropriate adjustment of insulin doses is needed.[36]
• A sudden change in carbohydrate amount or quality without an appropriate change in insulin dose is a common cause of hypoglycemia; hence, properly matching the insulin dose to food is important.
• Exercise is an important risk factor for hypoglycemia, with increased risk during, immediately after, and for up to 12 hours after strenuous exercise. If the pre-exercise BG is normal, a 0.2-0.5 g/kg complex carbohydrate snack should be given for every 30-40 minutes of exercise. If exercise is to take place two hours after a meal, including fat in the meal may help prevent hypoglycemia during exercise.[37]
• Maintaining meal timings and not skipping meals is important for PwD on multiple daily injections, especially those taking Regular and NPH insulin.
• For PwD taking Regular insulin, which peaks much later than the postprandial BG peak, the importance of mid-meal and bedtime snacks should be emphasized to prevent hypoglycemia.
• An important risk factor in adolescents and adults is consumption of alcohol, which can also mask the symptoms of hypoglycemia. It is important to educate PwD to consume alcohol only with or after a meal, in moderation, along with BG monitoring.[38]
• Lipohypertrophy is an important cause to look for in patients with recurrent unexplained hypoglycemia with fluctuating BG. Injecting into a lipohypertrophic site will cause hyperglycemia and increased insulin requirement, while injecting the same dose in a normal site injection may cause hypoglycemia.[39,40]
• PwD should always carry with them simple sugars and a snack (peanuts, dates, roasted *chana,* fruit, etc.), for use in a crisis. They should also carry a medical identity card that states their name, medical condition, contact details, emergency contact, and a note on the back explaining the treatment of hypoglycemia.

13.3. SUMMARY & RECOMMENDATIONS

• Illnesses need special care in PwD. They increase the risk of DKA and pose a challenge to maintaining good glycemic control. Clear written instructions about sick day management and access to HCP during illnesses are necessary for PwD.
• Different illnesses affect BG differently. Frequent BG and ketone monitoring, and meticulous adjustment of insulin doses are needed.
• Hydration must be maintained with salty/ sugary liquids, depending on the BG; since the child is at increased risk of dehydration due to polyuria, vomiting, diarrhea, fever, etc.
• Vomiting in PwD should be considered as Ketosis unless proved otherwise.
• Any child with persistent vomiting, continuously high or rising BG and ketone, hyperventilation, or a change in neurological status (increasing drowsiness, coma, seizures) should be urgently hospitalized.
• BG value < 70 mg/dL is considered Clinical Hypoglycemia Alert or Level 1 Hypoglycemia, and requires treatment.
• BG value of <54 mg/dL is Clinically Important or Serious Hypoglycemia or Level 2 Hypoglycemia. PwD should ideally spend <4% of their time below 70 mg/dL and <1% of their time below 54 mg/dL.
•Any hypoglycemia with cognitive decline is Severe Hypoglycemia or Level 3 hypoglycemia, regardless of the BG level.
• Acute management of hypoglycemia and its prevention should be taught to PwD and their caregivers at home and in school/ college, and reinforced whenever possible, with clear written instructions about management and prevention, and access to HCP during an episode of hypoglycemia.
• Only fast-acting carbohydrates should be used for acute treatment - in a 0.3 mg/kg dose for children. For adolescents and adults, the rule of 15 is followed, i.e., give 15 g of fast-acting carbohydrates, recheck BG after 15 minutes, if >70 mg/dL, give a 15 g carbohydrate snack, and if <70 mg/dL, repeat fast-acting carbohydrate.
• Prevention includes regular monitoring of BG or using CGM devices, managing delayed hypoglycemia following exercise, matching the food to insulin, consistent carbohydrate intake, and maintaining meal timings.
• All PwD should carry a medical identity card that states their name, medical condition, contact details, emergency contact, and a note on the back explaining the treatment of hypoglycemia. They should also always carry simple sugars and snack for emergency use.

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Chapter 14: Management of Comorbidities, Psychological Aspects

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14.1. INTRODUCTION

Type 1 Diabetes Mellitus (T1D) can present with a variety of comorbidities and complications, making it a multifaceted health challenge. As worldwide obesity rates rise, this affects people with diabetes (PwD) as well; thus, they need to not only manage their Blood Glucose (BG) levels but may also have to control obesity and comorbidities like hypertension, dyslipidemia, or fatty liver; or micro- and macrovascular complications. PwD are also more likely to have other autoimmune disorders like hypothyroidism or Celiac Disease (CD). These associated conditions significantly affect overall health and increase the need for individualized management. For instance, CD requires a gluten-free diet, while hypertension or dyslipidemia may necessitate specific dietary adjustments to manage blood pressure or cholesterol levels, respectively. Addressing the unique nutritional needs arising from these comorbidities with effective dietary strategies tailored to individual needs is essential for optimizing health outcomes and preventing further complications.

14.2. MANAGEMENT OF COMORBIDITIES

14.2.1. Screening for Complications and Comorbidities

T1D is associated with other autoimmune disorders (such as hypothyroidism and CD), hypertension, dyslipidemia, and chronic complications, both microvascular and macrovascular. The risk of vascular complications rises with increased disease duration and poor glycemic control.[1] PwD must focus on prevention, with regular assessment and screening done to detect these comorbidities or complications early. (Table 14.1) The diabetes care team should communicate the importance of such monitoring and the benefits of prompt and appropriate intervention.[2] The intensity of monitoring or regular screening increases during and after the peripubertal period as the risk of vascular complications rises with puberty. Autoimmune thyroid diseases (Hashimoto's thyroiditis, Graves' disease) affect 17–30% of PwD; CD occurs in about 8%.[3] Other autoimmune disorders PwD are at increased risk for include Addison's disease (primary adrenal insufficiency), autoimmune hepatitis, autoimmune gastritis, dermatomyositis, and myasthenia gravis, though these conditions are rarely encountered.[4] Autoimmune gastritis can occur in ~ 5–10%, Addison's disease in 0.2%, rheumatoid arthritis in 1.2%, and systemic lupus erythematosus at 1.15% PwD.[3]

In this chapter, we shall discuss obesity, dyslipidemia, hypertension, CD, thyroid disorders, as well as psychological aspects of nutrition in PwD.

Table 14.1: Screening recommendations for microvascular complications

Microvascular complication	When to screen	Screening recommendations
Retinopathy	Begin at puberty or age 11 years, or T1D duration 2-5 years: whichever is earlier. Repeat every 2 years.	Fundus examination - ophthalmoscopy or photography (may be difficult in children)
Neuropathy	Begin at puberty or age 11 years, or T1D duration 2-5 years: whichever is earlier. Repeat annually.	History and examination are performed to check temperature, vibration, touch, and ankle reflexes.
Nephropathy	Begin at puberty or age 11 years, or T1D duration 2-5 years: whichever is earlier. Repeat annually.	First-morning urine sample to estimate Albumin to Creatinine Ratio (ACR).
Macrovascular complications - Coronary Artery Disease (CAD), stroke and Peripheral Arterial Disease (PAD)	Begin at puberty or age 11 years, or T1D duration 2-5 years: whichever is earlier.	Blood pressure at every clinic visit, or at least annually. Lipid profile every 2 years.
Thyroid disorders	At the time of diagnosis of T1D. Repeat every 1-2 years (earlier if symptomatic).	Thyroid-stimulating Hormone (TSH).
Celiac disease	At the time of diagnosis of T1D. Repeat at 2 years & 5 years (earlier if symptomatic).	Serum transglutaminase (IgA-tTG). Duodenal biopsy if tTG positive

14.2.2. Obesity

Obesity is defined as an increase in body fat content, which is most easily measured as an increase in weight or Body Mass Index [BMI = weight (kg)/ height $(m)^2$]. BMI has served as the most easily measurable and widely studied tool. It varies with age in childhood and adolescence, and should be interpreted accordingly. Age-based, gender-wise BMI charts from 5-18 years of age by the Indian Academy of Pediatrics (IAP) are available. [https://iapindia.org/iap-growth-charts/].

The pathophysiology of TID suggests an affected child is likely to be lean at diagnosis since weight loss is common. However, with the global increase in the prevalence of obesity, the child or adolescent may not be lean even at diagnosis, despite a history of weight loss.[5] Moreover, PwD, caregivers, and the diabetes care team need to take care to prevent obesity, which is likely in today's obesogenic environment. The prevalence of obesity in children and youth with T1D is increasing

and is reported between 2.8-37.1%.[6] The risk factors are nutrient-poor, high-calorie diets, high doses of insulin (promotes hunger), recurrent hypoglycemia and over-treatment of hypoglycemia, inadequate/ no physical activity, excess carbohydrates consumed for exercise, and binge-eating behaviors.[7]

The management of obesity associated with T1D begins with a preventive lifestyle and timely identification. The height and weight should be measured and plotted at each visit. Any rapid increase in weight/ BMI is an alert that should be discussed with the PwD and family to emphasize prevention.[8] The main challenge is the choice of the right foods in terms of quantity, quality [Glycemic Index (GI)], nutrient density, and diet diversity. Fear of hypoglycemia may prevent PwD from getting adequate exercise or choosing portion-controlled meals. The entire family has to be motivated to adopt a healthier eating pattern, instead of singling out the PwD for a so-called 'diabetic' diet or a 'low-fat' diet.

14.2.2.1. Nutritional Guidelines

- Children who are overweight should not be advised to lose weight, but rather not to gain further weight while their height is increasing. For those with significant obesity, gradual weight loss of 0.5g-1 kg/ month should be targeted by reducing 500-1000 kcal daily or 25-30% of daily caloric intake, and reduction of processed and refined foods. Drastic dietary reductions should be avoided in the growing child/ adolescent.
- For obese PwD, a calorie-restricted, customized diet plan is recommended.[9]
- Portion control must be emphasized.
- Excessive eating to avoid or treat hypoglycemia must be avoided.
- Consumption of foods with low GI (complex) carbohydrates and plenty of fiber, like vegetables, legumes, fruits, and whole grains, must be encouraged.[10]
- Refined carbohydrates (e.g., *maida*, including bread and other products; polished white rice, semolina), sugars, and highly processed and packaged foods must be avoided.
- Low carbohydrate diets (<130 g carbohydrates/day) and ketogenic diets (<55 g carbohydrates/day) must be avoided in T1D.[11] They interfere with glycemic control, and also impact growth and pubertal development as they can be nutritionally inadequate (low in calcium, B vitamins, iron, and fiber) due to the elimination of certain food groups.
- Low GI carbohydrates should make up 45-55% of the total energy, with high fiber content (>25-30 g/1000kcal). Protein should provide 15-20% of the total energy, and fats 25-30% [preferably Monounsaturated Fatty Acids (MUFA) and low in saturated fat, with little/no trans-fat].[7,12]
- Insulin requirements should be reviewed regularly as children grow. Intake of large snacks between meals or at bedtime to prevent hypoglycemia should be minimized.
- Similarly, reduction of insulin doses should be preferred instead of additional carbohydrate intake, to prevent hypoglycemia during physical activity.[7]

14.2.3. Dyslipidemia

Dyslipidemia is characterized by consistently high levels of plasma cholesterol and/or triglycerides (TG). PwD have a significant prevalence of dyslipidemia, which increases the risk of Cardiovascular Disorders (CVD) by 4-10 times.[13,14] Both over-insulinization when aiming for intense glycemic control or insulin insufficiency and poor glycemic control can contribute to dyslipidemia (with obesity as a potential cause).[15]

14.2.3.1. Nutritional Guidelines

Changes in diet and physical activity are the mainstay of treatment with dyslipidemia. The Cardiovascular Health Integrated Lifestyle Diet, or CHILD-1 diet, is the initial step toward assisting children over the age of one year and adolescents to achieve the aim of a healthy lifestyle. After a three-month trial, individuals on a CHILD-1 diet who are unable to meet their desired goals should be moved on to a CHILD-2 diet.[16] Table 14.2 shows CHILD-1 and CHILD-2 diet.

Table 14.2: CHILD-1 and CHILD-2 diet

CHILD-1	CHILD-2
It has been shown to decrease Total Cholesterol (TC) and Low-density Lipoprotein (LDL) cholesterol and lower obesity and insulin resistance.[17]	It is recommended if high LDL cholesterol and non-high-density lipoprotein (non-HDL) cholesterol levels persist after adequate compliance with the CHILD-1 diet for three months.[18]
• Total fat: 25-30% of daily calorie intake. • Saturated fat: ≤10% of daily calories. • Cholesterol intake ≤300 mg/ day. • Polyunsaturated Fatty Acids (PUFA): 10% of daily calories. • MUFA: 10-15% of daily calories. • Trans-fats and Sugar-Sweetened Beverages (SSBs) to be avoided • Dietary Fiber: 2-10 years = Age + 5 g of fiber/ day 11-21 years = 14 g/1000 kcals/ day	• Total fat: 25-30% of daily calorie intake. • Saturated fat intake: ≤7% of daily calories • Cholesterol intake is <200 mg/ day • MUFA: ~ 10% of daily calorie intake. • Plant sterol and stanol esters can be up to 2 g/day. • Water-soluble psyllium: 6 g/ day for children 2-12 years of age and 12 g/day for those >12 years. • Avoid trans-fats and SSBs. • Increase intake of fatty fish or add Omega-3 fatty acid supplements at 1-4 g/day for TG >200-499 mg/dL. • Moderate to vigorous physical activity – at least one hour daily. • Screen time – Less than two hours/day.

14.2.4. Hypertension

Hypertension in PwD may occur as a result of obesity/ insulin resistance or Diabetic Kidney Disease (DKD). Hypertension is defined as Blood Pressure (BP) ≥90th percentile for age, sex, and height or, in adolescents aged ≥13 years, BP ≥120/80 mmHg.[19] Hyperglycemia may also have a role in the pathogenesis of hypertension. In the SEARCH for Diabetes in Youth study, of PwD aged 3-17 years, hypertension was observed in about 6%, primarily adolescents, primarily adolescents with obesity and poor glycemic control.[20]

14.2.4.1. Nutritional Guidelines

Strategies for hypertension prevention and management include maintenance of a normal BMI, avoidance of excessive sodium consumption, and 60 minutes or more of regular physical activity. Processed foods often contain high sodium levels and should be avoided; switching to home-cooked food is helpful.[21] Nutritional strategies include following a Dietary Approaches to Stop Hypertension (DASH) dietary pattern.[22] The DASH diet includes

- Intake of whole grains, fruits & vegetables, legumes, unsalted nuts and seeds
- Moderate intake of low-fat dairy
- Limited intake of red meats, processed meats, full-fat dairy, desserts and SSBs
- Low salt intake. Restrict sodium intake to less than 2300 mg/day.[23]

14.2.5. Celiac Disease (CD)

CD is an autoimmune disorder that results from intolerance to gluten, a form of storage protein found in the endosperm of certain cereals like wheat and related grains (barley, spelt, and rye). It chiefly manifests as abdominal complaints but may be associated with widespread systemic manifestations like poor growth and development, skin rash, micronutrient deficiencies, or increased episodes of hypoglycemia.[24] Tissue Transglutaminase IgA (TTG-IgA) antibodies are an effective screening test, as they are raised, except in individuals with IgA deficiency; therefore, total IgA levels should be checked once initially. TTG should be tested at the time of diagnosis, annually for the first 2 years, after 5 years, and then if there are suggestive symptoms. IgA-deficient PwD should be referred to a pediatric gastroenterologist/ gastroenterologist for further evaluation with IgG-based assays. If TTG is positive, confirmation with upper gastrointestinal endoscopy and duodenal biopsy is a must. The prevalence of CD among children and adolescents with T1D ranges from 1-16.4%.[25–27]

14.2.5.1. Nutritional Guidelines

- Dietary management with lifelong Gluten-free Diet (GFD) is the cornerstone of therapy.[28]
- The aim is to remove all gluten sources from the diet while ensuring that all macronutrient and micronutrient demands are met, especially during childhood and adolescence.[29]
- Foods containing wheat, barley, spelt, or rye in any amount or form - refined flour (*maida)*, semolina (*sooji)*, couscous, vermicelli, malt extract (beers, ale), rye bread, food flavoring (coloring and thickening agents) have to be avoided. Gluten-free carbohydrate options include rice; maize; all millets including pearl millet *(bajra),* sorghum *(jowar),* finger millet *(ragi),* barnyard millet (*savaan*), foxtail millet (*kangni*), little millet (*kutki*), quinoa; amaranth, buckwheat, jackfruit flour, plantain flour, and all pulses.[30]
- Rather than using corn and rice (low in micronutrients) alone, incorporating unpolished millets is beneficial as they are rich in fiber, protein, and micronutrients (calcium, zinc, iron, manganese, and phosphorus), justifying their name "Nutri-cereals." Millets improve nutrient density and lipid profile.[31] However, they contain several anti-nutrient factors like oxalates and phytates, whose content can be reduced by soaking, debranning, germinating, fermenting, prior kneading with curd, and cooking. The gluten-free grains can be consumed as crepes (*chilla*), idlis, dosas, *daliya*, *khichri*, *mudde* (ragi balls), etc.
- These grains can be purchased, washed, dried, and ground at home: this reduces the chances of cross-contamination and lowers expenses considerably.
- Cookware used to cook gluten-free food should be kept separate to avoid contamination.[32]
- Oats are naturally gluten-free but contain avenin, a protein similar to gluten. While most people with CD can tolerate oats, some may show an adverse reaction. Also, oats are often contaminated by gluten during processing in factories that also process wheat, so only oats that specifically state "gluten-free" are safe for consumption in moderate amounts (20-25 g/day of dry rolled oats for children and 50-70 g/day for adults) for most but not all people with CD.[7]
- Asafoetida (*hing*) and soy sauce may contain gluten if wheat is used as a base. Look for gluten-free varieties which use rice as the base.
- In most countries, including India, foods containing less than 20 parts per million (20 mg/kg) gluten are considered suitable for a GFD.[33]
- All packaged products should be checked for gluten content and avoided if there is any doubt. The food label with the ingredient list must be looked at - foods with any mention of flour, *atta*, refined flour, all-purpose flour, malt, cereal additives, hydrolyzed wheat starch, wheat germ oil, and durum, should be avoided.[34]
- The sources of protein, fat, fiber, and micronutrients remain the same. Safe food groups in a GFD include pulses and legumes, milk and milk products, vegetables and fruits, tubers, nuts, dry fruits, seeds, fats, and oils.[7]
- CD can be associated with poor growth and nutrient deficiencies. So, there should be an emphasis on the nutritional quality of GFD, particularly the intake of micronutrients like folate, iron, magnesium, calcium, zinc, iodine, fiber, and B vitamins. All food groups should be included in the diet, including gluten-free whole grains, fruits, vegetables, milk and milk products, plant and animal-derived protein foods, fats and oils, nuts, and seeds.
- Processed and packaged foods High in Fat, Sugar, and Salt (HFSS), must be avoided.
- There is no role in the routine use of probiotics to prevent CD or improve control.[35]

14.2.6. Thyroid Disorders

Autoimmune thyroid disorders are the most commonly associated autoimmune disorders with T1D.[36,37] TSH should be tested at the time of diagnosis, and annually thereafter. There is no specific advantage in testing thyroid antibodies. Hypothyroidism can lead to poor growth, delayed puberty, increased episodes of hypoglycemia, and dyslipidemia, and is easily treated with thyroxine replacement.[38] Hyperthyroidism, seen in Graves' disease or the hyperactive phase of Hashimoto's thyroiditis (Hashitoxicosis), leads to heightened glucose demand due to increased metabolic rate.[39] This worsens glycemic control and increases the risk of acute complications [Diabetic Ketoacidosis (DKA), hypoglycemia] and hypertension.

14.2.6.1. Nutritional Guidelines:

- Avoiding processed foods, refined sugars, and saturated fats, and incorporating foods with iodine (iodized salt, milk, cheese, cottage cheese, prunes, egg yolk, cod fish), zinc (almonds, pumpkin seeds, pulses like chickpeas, kidney beans, soybean, seafood), and selenium (brazil nuts, green gram, dry peas, amaranth leaves, egg) supports normal thyroid function.
- Cooking neutralizes goitrogens in cruciferous vegetables (e.g., cabbage, cauliflower, and broccoli) and soy. Hence, these foods can be consumed in cooked form.[40]
- Thyroid medication should be taken regularly, at the same time every morning, with water, 15-30 minutes before eating food.[40]
- Iron or calcium supplements should not be taken within 3-4 hours of taking thyroid medication. It is best if coffee (caffeine), milk (calcium), walnuts, soybean flour, pearl millet, multivitamins, or other supplements, are avoided around the same time.[40]
- Individuals with autoimmune thyroid disorders may face the risk of vitamin B12 deficiency. B12-rich foods like fermented foods, dairy,

eggs, fortified cereals, nutritional yeast, organ meats, and muscle meats should be included in the diet.[41]

The mainstay for detecting comorbidities remains periodic screening. To reduce the risk of short- and long-term complications, optimal glucose control is crucial, along with regular physical activity, cessation of smoking, and none to minimal alcohol consumption (if applicable: the age at which alcohol can be legally consumed differs from state to state). Active participation in meal preparation and cooking should be encouraged from early childhood to promote healthy eating habits. Families should receive counseling on healthy eating practices, strategies for maintaining appropriate portion sizes, and reducing the consumption of HFSS foods.

14.3. PSYCHOLOGICAL ASPECTS OF NUTRITION IN T1D

14.3.1. Diagnosis and Breaking the News

The HCP should be considerate in disclosing and discussing the diagnosis of T1D with the PwD and family. It is best if the disclosure is done using a team approach, to ensure better care delivery, rapport building, and trust in the health services. The ideal Diabetes Care Team (DCT) comprises a pediatric endocrinologist, diabetes educator, dietitian, nurse, social worker, and psychologist, all experienced in pediatric diabetes care.[19] However, in most situations, such teams are not available; fortunately, online support of peers and professionals is increasingly becoming possible. The DCT/ HCP needs to assess the response of the PwD and key caregivers, to restructure their routine along with modifications in the lifestyle of the PwD.[42] The SPIKES model[43] helps structure this conversation with the family. (Table 14.3)

Table 14.3: SPIKES model

Setting	Choose a comfortable, non-threatening environment
Perception	Elicit the perceptions of the PwD and family
Invitation	Ask the PwD and family what they want to know
Knowledge	Explain the condition and the therapy
Emotion	Respect their emotions Respond with empathy
Summarize	Recap the essence of the session

This approach can be used to initiate the conversation and handle the initial grief and anxiety of the family. Non-verbal communication, like body language, tone of voice, and eye contact, is as important as the factual content during the conversation. These communication skills should be imbibed by the HCP. Ideally, a mental health specialist should be in touch with the family from the beginning. In addition, the team can involve a psychologist or psychiatrist later if they feel that the family requires more hand-holding.

14.3.1.1. Diabetes Education and Counseling at Diagnosis and During Follow-up

Diabetes Self-management Education (DSME) and counseling are the foundation on which the four pillars of diabetes management (insulin, Medical Nutrition Therapy (MNT), physical activity, and home BG monitoring) stand.[44] The HCP provides education during all visits/ points of contact. The initial sessions after the diagnosis should be immersive, non-threatening, and slow-paced, with a gradual increase in the content and complexity of issues of diabetes management. Motivational interviewing techniques are helpful, as are cross-checks to assess what the PwD and family members have learned at the end of each session using simple charts, quizzes, or diagrams.[45]

14.3.1.2. Educating Individuals and Families

- PwD and caregivers should be informed about how disordered eating behaviors can negatively affect BG levels, diabetes management, and overall health. Providing them with information on healthy ways to cope with diabetes-related stress, such as relaxation techniques, physical activity, and mindfulness practices is needed.
- Encourage their making small, gradual changes toward healthier eating and diabetes management, instead of drastic adjustments.
- Collaborate with the individual and their family to set realistic and achievable goals, such as establishing regular meal patterns, consistently monitoring BG levels, and using insulin as prescribed. Celebrate even small improvements and acknowledge milestones to boost motivation.[46]
- Family members should be encouraged to support the PwD by participating in assisting with diabetes management, including meal planning, and attending therapy sessions.
- Address any family dynamics that may contribute to disordered eating, such as an overemphasis on weight or strict food rules.
- Acknowledge that disordered eating may be a coping mechanism for emotional distress, and provide support through therapy, counseling, or peer support groups.[47]
- Work with a comprehensive care team that includes dietitians, endocrinologists, mental health professionals, and diabetes educators to ensure a holistic approach to treatment.

14.3.1.3. Care at School

A child spends more than half of the waking day at school, where food is eaten, physical activity occurs, and friendships, socialization, and habits of discipline develop. Children often share tiffins. Therefore, taking care of T1D in school, including testing BG, taking an insulin dose as per the expected carbohydrate count of the food to be eaten, and taking a snack in case hypoglycemia occurs or is anticipated (e.g., extra physical activity), become integral components of care.[48] Parents, PwD, and school staff may be reluctant to allow diabetes self-care activities in school, thereby compromising studies, glycemic control, and mental well-being.[49] Often, the psychosocial issues associated with school get ignored, and if not actively enquired and addressed, lead to poor academic performance and frequent school absenteeism.[50] Problems increase if the child is forced to hide diabetes, adding guilt and fear to the psychological issues, or is compelled to eat food in school that is very different from peers, mistakenly following a "diabetic diet" or some special diet, or trying to avoid taking insulin in school. The common issues include:

- Stigma and bullying
- Anxiety about checking BG and taking insulin in school
- Lack of support from school staff
- Logistic issues of insulin storage and administration at school
- Decreased academic performance because of hypoglycemia and hyperglycemia
- Decreased opportunity to participate in extracurricular activities.

The family and PwD should be counseled to involve the school staff, including teachers, in the day-to-day self-care of diabetes. The DCT should encourage parents to send sensible tiffin items, modify unhealthy foods to make them healthy, and allow the child occasional unhealthy food; and equip them to adjust insulin doses accordingly. This will imbue the child with confidence, build self-esteem, and improve quality of life, school performance, and productivity.[49]

14.3.2. Psychological Issues Related to Eating

14.3.2.1. Force Feeding by Parents in Young Children

Hypoglycemia is a life-threatening complication that can be distressing for the PwD, family, and school staff/ associates. Risk factors include unsupervised or overdose of insulin, missed or delayed meals, irregular meal frequency, excessive physical activity, and acute illness. There can be more than one risk factor associated with an episode of hypoglycemia. Parents may try to force-feed a young child to avoid hypoglycemia.[51] This has repercussions on the long-term management of T1D in terms of poor glycemic control and adaptation to unhealthy snacking by the child for fear of hypoglycemia, and must be discouraged.[52]

14.3.2.2. Excessive Dietary Restrictions in Children and Adolescents

Attempts to minimize glucose variability may prompt parents to adopt coercive feeding behaviors.[53] Common examples of this include restricting all sweet items, all fruits, or milk/ milk products, or initiating a special diet (e.g., ketogenic or low-carbohydrate diet), or forcing the child to have functional foods like bitter gourd juice. As the nutritional needs of PwD are similar to those of any child or adolescent without T1D, the family must be educated that they consume the same balanced diet, with adequate macronutrients and micronutrients.[11] Dietary restrictions on unhealthy food and foods with high glycemic index should also be followed by all members of the family. The extra calories, calcium, and iron requirement during periods of rapid growth should be met through suitable and locally available dietary choices. Such a balanced approach towards food helps normalize situations and makes it easier for the PwD and family to cope well, reducing distress and rebellion, and improving compliance with the more important behavior changes.

14.3.2.3. Diabetes Distress, Sneaking in Foods

The diagnosis of T1D usually comes as a huge shock to the child and the family. It is important for the Healthcare Professional (HCP) to handhold the family and support them during the initial period. This increases the family's confidence in managing the condition and lays the groundwork for good compliance later.[54]

Quality of Life

The management of T1D should focus on more than just minimizing glycemic variability or achieving a HbA1c below 7%. Life-skills education should be provided to help set and achieve goals that are important for overall mental and physical well-being, develop self-awareness, and cultivate problem-solving skills, as all these are directly and indirectly linked with glycemic control. The HCP has to communicate well and establish a rapport with the family to help them set SMARTEST goals - Specific, Measurable, Achievable, Reliable, Time-bound, Evidence-based, Strategic, and Tailored to the individual.[55] The entire family should agree to behavior changes ensuring an overall healthier lifestyle, instead of focusing on and discriminating against the child with special diet or restrictions. This is possible only as a team effort of the HCP (supervisory role), PwD, family, and school/ place of work. Improvement in the quality of life is, in turn, reflected in better compliance and improved diabetes control.[19]

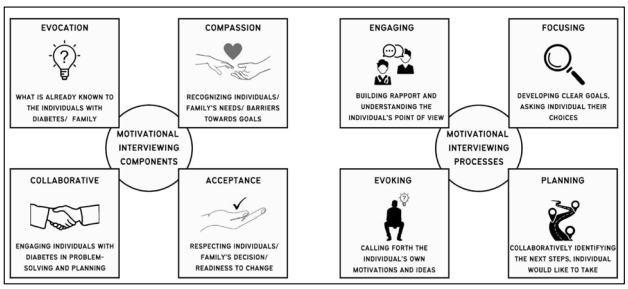
14.3.2.4. Diabetes Distress Scale

T1D demands intensive and continued care. Anxiety and fear of the disorder, needles, and complications, along with myths and stigma, all add to the distress for the family.[56] The distress can worsen in situations of poor social support, limited healthcare access, poverty, illiteracy, and food insecurity. It is important to identify factors that can increase anxiety and reduce compliance. The Diabetes Distress Scale (DDS) is a simple tool that addresses eight core areas, scored on a 5-point Likert Scale, to estimate the presence and degree of distress. A second part of the DDS focuses on specific aspects of living and managing diabetes to evaluate the likely source of the distress and serve as a rough guide to help the HCP focus and counsel regarding the highlighted factors.[23,52] The complete scale is available at https://www.diabetesed.net/page/_files/diabetes-distress.pdf and may be used after necessary permissions.

14.3.2.5. Providing Care

The presence of negative emotions should be flagged by the HCP, who should ensure the child's/ caregiver's frequent and intensive counseling with a multidisciplinary team that includes a doctor, diabetes educator, dietitian, and psychologist. A few supportive strategies are discussed below. Motivational interviewing is a collaborative conversation style that strengthens a person's motivation and commitment to change. (Figure 14.1)

Figure 14.1: Motivational Interviewing: Components and Processes



Support Groups

Support groups of T1D families can be supportive in day-to-day management, education about MNT, navigating social situations (e.g., adolescence), increasing awareness, and promoting advocacy. A list of support groups is available on the ISPAE website.[57]

Technology Support for Mental Health

Technology has been harnessed to manage different aspects of diabetes. The diagnosis and management of mental health and psychological disorders remain challenging. Online chatbots and online questionnaires can be used to screen for these conditions. A simple WhatsApp or social media group can assist families in problem-solving and decision-making. Technology can also be used to store reminders for insulin doses and follow-up appointments to the HCP. Teleconsultation can be provided for mental health disorders detected with pervasive and significant emotional and psychological issues.[58] (Refer to Chapter 16)

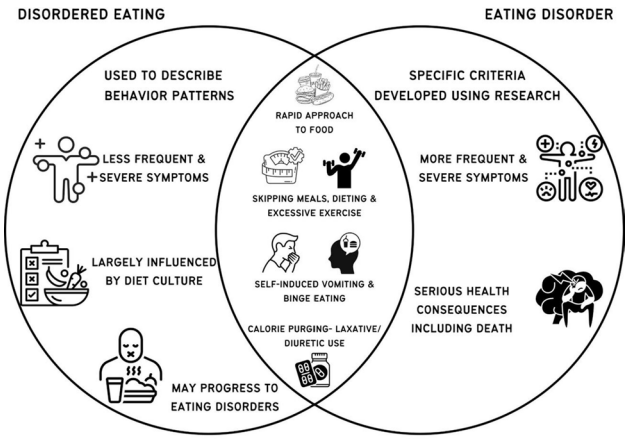
14.3.3. Disordered Eating Behavior and Eating Disorders

A major challenge in optimizing nutrition in T1D is a coexistent eating disorder, which may be difficult to diagnose unless a detailed nutritional history is incorporated into the follow-up plan.[59] Such disorders are more common in PwD with underlying sociodemographic

risk factors like broken family, substance abuse, change of environment - school/ family, lack of motivation, and poor life skills.[60] Figure 14.2 shows disordered eating and eating disorders.[47] The disorders may be:

• *Bulimia*- eating in excess (binge eating) is followed by purging behaviors like vomiting or laxative use.
• *Anorexia nervosa*– the person is afraid of eating or gaining weight. He/ she may eat very little, may diet, or exercise excessively to lose weight, even if not overweight.
• *Disordered eating behavior*- is similar to an eating disorder, with lesser intensity or severity in symptoms.
• *Diabulimia*- This manifests as the intentional administration of inadequate insulin doses to lose weight.[61]

Figure 14.2: Disordered eating and eating disorders.[62] (Adapted from Dziewa et al.)



To facilitate early detection, intervention, and prevention of eating disorders, routine screening for disordered eating is recommended for children and adolescents with T1D. Screening should begin for children aged 10–12 years using a diabetes-specific tool, such as the Diabetes Eating Problems Survey-Revised (DEPS-R).[19] Other validated tools, including the modified Sick, Control, One, Fat, Food (mSCOFF) and Eating Disorder Screen for Primary Care (ESP), are also suitable for use in the T1D population.[63,64] Mental health professionals experienced in T1D should evaluate children and adolescents with T1D for psychosocial issues, including eating disorders.[19]

14.3.4. Psychological Disorders

The HCP should be able to suspect, identify, and refer a PwD and caregiver with any significant psychological or emotional issues, including anxiety, depression, burnout or mood disorders.[52] Anxiety is normal; it is distressful when it is persistent and excessive, such that it limits the routine daily functioning of the individual. Depression is when a person feels low constantly or has displeasure or lack of interest in normal activities, causing significant distress or impairment in functioning. Mood disorders are diagnosed if inappropriate and sustained feelings disrupt normal emotions. These can make the person feel low/ depressed or high (hypomania or mania).[65] These feelings are common during the initial period of diagnosis as part of distress. However, if these emotions are sustained and excessive, an assessment by a trained mental health care professional is required for a likely mental health disorder. The likelihood of these disorders developing even years after diagnosis is higher in the presence of risk factors.

The usual symptoms of a psychological disorder include insomnia, hypersomnia, fatigue, palpitations, or problems in relationships, but often the presentation may not be obvious. A disorder should be suspected in the presence of subtle cues, as follows[65]:

• A PwD who had well-controlled diabetes but now has poor control.
• A PwD/ family begins to miss follow-up visits.
• There is an unexplained change in the pattern of glucose logs- frequent hypoglycemia, BG swings, or episodes of DKA.
• The child/ adolescent manifests a behavior change, e.g., appears withdrawn or overactive, talks less, or has poor eye contact.
• There is recent, unexplained weight gain or loss.
• There is a fall in grades at school, concerns flagged by teachers.

14.3.4.1. Referral

The HCP should suspect and screen for psychological disorders and refer if detected.[65] If a team familiar with T1D is unavailable locally, the HCP may try to organize online consultations with experts elsewhere. Missed referral opportunities can be associated with more adverse outcomes like hypoglycemia, hospitalization with DKA, school drop-out, or even suicide. A few commonly available screening scales are mentioned below.[66]

• Screen for Child Anxiety Related Disorders (SCARED) (global anxiety and any anxiety disorder) for 8-18-year-old individuals.
• Patient Health Questionnaire and General Anxiety Disorder (PHQ-9 and GAD-7).
• Patient Health Questionnaire–Adolescent (GAD and panic disorder) for 8-18 year old individuals.
• Beck Depression Inventory (BDI).

14.4. SUMMARY & RECOMMENDATIONS

• Overweight children should be guided to maintain their weight as they gain height, rather than aiming for weight loss.
• For those with significant obesity, gradual weight loss of 0.5-1 kg/ month can be targeted by reducing caloric intake from processed foods, and regular physical activity.
• For obese PwDs, a calorie-restricted, customized diet plan focusing on portion control, high fiber, and low GI carbohydrates is recommended. Refined carbohydrates and highly processed foods should be avoided. Regular review of insulin requirements, with insulin dose adjustments, is essential.
• For PwD with hypertension, processed foods, usually high in sodium, should be avoided, and home-cooked meals preferred.
• PwD with celiac disease have to be on gluten gluten-free diet lifelong. Gluten-free flours are becoming available, but many families may find it easier to wash, dry, and grind gluten-free grains at home. Packaged foods should be carefully scrutinized.
• To support normal thyroid function, processed foods, refined sugars, and saturated fats are best avoided, while including iodine-rich, zinc-rich, and selenium-rich foods in the diet. Cooking cruciferous vegetables and soy helps to neutralize goitrogens.
• PwD, especially children, may face psychological issues related to eating, such as being force-fed to prevent hypoglycemia or experiencing excessive, needless, dietary restrictions. These practices can negatively impact long-term diabetes management, leading to unhealthy eating habits and poor glycemic control.
• Regular screening for psychological disorders, including anxiety, depression, and eating disorders, is crucial for PwD and caregivers. Care should involve a multidisciplinary team and focus on integrating diabetes self-care activities into daily routines, including at school, to prevent negative outcomes.

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Chapter 15: Nutritional Management for Limited Resource Settings

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15.1. BACKGROUND

Type 1 Diabetes Mellitus (T1D) is a chronic condition caused by insulin deficiency leading to persistent hyperglycemia, which has implications for the quality of life in affected persons. The International Diabetes Federation (IDF) and T1D Index (2022) estimated that 8.75 million people were living with T1D globally, of whom 1.52 million were below 20 years of age, and ~1.9 million were living in Low-and Middle-Income Countries (LMIC), i.e., a significant proportion of individuals with T1D live in resource-constrained settings. A large proportion of this population lives in India, which has the largest population of People with Diabetes (PwD) under the age of 20 in the world, and also the highest estimated number of "missing" persons with T1D (dying undiagnosed or soon after diagnosis).[1,2]

Management of T1D includes insulin therapy, Blood Glucose (BG) monitoring, dietary modifications, exercise, and diabetes education for self-management. In this context, food choices advised should be easily available, affordable, and culturally acceptable, to make them sustainable. In most regions of India, people consume diets higher in carbohydrates (60-70%) and lower in protein (~10%) than the recommended intakes.[3] On the other hand, traditional Indian food choices have the goodness of fewer processed foods and the availability of a wide variety of locally available complex carbohydrate options, which are micronutrient-rich and contain modest amounts of proteins. These foods must be incorporated more often to compensate for the disproportionate distribution of macronutrients and improve diet diversity and nutrient density.

In this chapter, we shall explore food options that are easily available, affordable, culturally acceptable, and can be sustainably incorporated into the diet of PwD to achieve the recommended macronutrient proportions and help fulfill daily micronutrient requirements, with a positive impact on glycemic control.

15.2. RATIONALE

International Society for Pediatric and Adolescent Diabetes (ISPAD) and Indian Council of Medical Research - National Institute of Nutrition (ICMR-NIN) guidelines suggest that carbohydrates should contribute to 45-55% of total energy, with 25-30% of energy from fat (<10% from saturated fat and trans-fat) and 15-20% from protein.[4,5] Families are often swayed by misinformation into opting for low carbohydrate, ketogenic diets; other fad diets or "superfoods," which are not evidence-based, can be expensive, culturally inappropriate, and with the potential to cause physical and/or emotional harm to the young PwD. A diet balanced in terms of nutritional composition, based on traditional patterns, appropriate to the region, climate, seasonal variation, and cultural and culinary diversity, with an additional effort to decrease Glycemic Index (GI) and Glycemic Load (GL), and improve the protein content, would suit the needs of the PwD in India.[6] For PwD, the diet must be personalized, aimed to suit the individual's lifestyle, as well as local and seasonal availability of ingredients.

Our traditional meals are mostly plant-based, consisting of whole grains, pulses, locally available vegetables, and fruits, with various herbs and spices, which meet macro- and micro-nutrient needs. Besides providing nutrients, they contain fiber and good phytochemicals, which bestow several benefits, including antioxidant, anti-inflammatory, anti-cancer, and anti-bacterial properties.[7] Liberal use of low-fat dairy products (such as *chaas*) provides calcium and protein.[8] Cold-pressed oils and ghee provide energy, increase palatability, facilitate the absorption of fat-soluble vitamins, lower the GI, and achieve satiety. These oils are notable for containing Monounsaturated Fatty acids (MUFA). Additionally, cold-pressed oils contain beneficial phytochemicals. Food processing (sprouting, malting, fermentation) and preservation techniques improve the quality, bioavailability of nutrients, and palatability. Traditionally, local and seasonal foods were preferred; whole unpolished millets, which grow even in arid soils, were staples, all greens and peels of vegetables were utilized, and high-calorie/ high-fat dishes were reserved only for festivals, served in small portions, so even the poor could afford a reasonable diet. The modified version of the traditional "Indian *Thali*," replacing some carbohydrates with protein and plenty of vegetables, is a perfect example of a healthy, affordable, balanced Indian diet.[6,9] In India, regional preferences for cooking oils vary, with mustard oil commonly used in the East, groundnut oil in the West, and sesame oil in certain parts of the country; a mixture of fats was achieved because different dishes were preferably cooked in different oils or in ghee.[10]

However, much of this changed with poverty inflicted by colonial rule and subsequent industrialization and globalization. Currently, hyperpalatable, highly processed, packaged foods and beverages High in Fat, Sugar, and Salt (HFSS) dominate the kitchen and dining table.[11] Refined, cheaper, often subsidized carbohydrates (white rice, *maida*, polished millets, and their products), which have low fiber and high GI, provide 65-70% of the total energy of the Indian diet. Protein is expensive and is reduced to around 10%. Refined oils and trans fats have replaced traditional plant-based filtered oils and clarified butter.[12] Local greens are often unavailable, expensive, or spurned. For these reasons, many growing children and adolescents face micronutrient deficiencies ("hidden hunger").[13] So, it is time to revive the ancient wisdom of Indian cuisines and opt for local, seasonal, and cost-effective foods to suit our cultural heritage and economy. In almost every region of India, especially rural India, seasonally, numerous green leafy vegetables, which are very good for health, can be accessed. Efforts must be made to identify and popularise these beyond the popular spinach (*palak*) and fenugreek leaves (*methi*). Leaves of radish, beet, drumstick, etc should be incorporated in numerous ways. Similarly, whole pulses with skin should be encouraged rather than relying on polished *dals*. We should explore and advise options to optimize the quality of carbohydrates and fats, including fiber liberally, increasing protein content, and ensuring adequate micronutrient intake to suit the needs of growing children and adolescents, especially PwD.

15.3. RECOMMENDATIONS

15.3.1. Optimizing Carbohydrate and Fiber

High-GI carbohydrates should be replaced by low-GI alternatives, i.e., preparations made of whole grains like whole wheat (*atta*), unpolished

rice, and millet. This would ensure more dietary fiber and micronutrients and reduce glycemic excursions.[14,15]

Pulses do have significant carbohydrate content. Using unpolished pulses in different forms in each meal would ensure lente carbohydrate while adding protein and fiber and thus control of the post-meal glycemic excursions.[16] Combining cereals with pulses, as done traditionally, would ensure high-quality protein. Subsidized pulses are now gradually becoming more available.[17]

Fiber intake has an important role to play in glycemic control. Leafy greens often discarded (e.g., leaves of cauliflower, radish, pumpkin, etc.) can be used in cooking, singly or combined with pulses or other dishes.[18] They add to the taste, fiber, and micronutrients, without additional cost. Most rural areas can access green vegetables grown on the edges of farmland. The combination of cereal, pulses, and vegetables provides balanced nutrition. Encouraging consumption of *roti* with cooked lentil *(dal/* whole pulse preparations, e.g., *rajma, chole, masur,* dry peas, cowpeas*)* and vegetable curry or salad across north and west India, or other traditional foods having a rational combination of carbohydrate and fiber-based cereal and protein-based side dish, e.g., *Dalbati* in Rajasthan and Madhya Pradesh, *Litti-Chokha* in Uttar Pradesh and Bihar, *Khichadi* in almost all parts of the country, *idli/ dosa* made with unpolished rice and whole lentil in the southern states, along with small amounts of low-fat dairy like buttermilk/ *raita*/ plain curd, is culturally appropriate and financially sustainable. The combination of *idli* with *podi* or *sambar* is also worthwhile. A few other tweaks can be suggested to increase protein and fiber (which improve nutrient content and reduce post-meal glycemia) - e.g., use any flour with bran and/ or add 10-30% locally available cheap grain (barley, barnyard millet, foxtail millet, porso millet, kodo millet, little millet) or soya or black chickpeas to wheat at the time of grinding (home-based/ local grinding whenever feasible), use thicker *dal* and higher portion of locally available seasonal vegetable preparations.[6,9]

White rice can be replaced by parboiled rice/ brown rice or locally grown rice without extensive milling or other unpolished cereals/ millets with higher amounts of complex carbohydrates (barley, jowar, bajra, barnyard millet, foxtail millet, porso millet, kodo millet, little millet) to reduce the GI.[19] These options are cheaper and nutritionally superior. Refrigerating boiled rice or potatoes for 24 hours and consuming after gentle reheating reduces GI due to the increased amount of resistant starch.[20] Using roasted black chickpea flour (*sattu*) in flour/ stuffing *roti* for major meals or as a drink to substitute for snacks increases good carbohydrates and protein. Other inexpensive ways of reducing GI are discussed in Chapter 7.

15.3.2. Optimizing Protein Intake

Recommended protein intake in children varies from 1.5-2 g/kg/day in early infancy to 1 g/kg/day for a 10-year-old and to 0.8–0.9 g/kg/day in later adolescence and adulthood. ICMR-NIN suggests ~8.5 g/day in infancy to 37 and 45 g/day in adolescent girls and boys, respectively.[21] ISPAD guidelines (2022) advise the consumption of vegetable protein (such as pulses) and animal protein (including fish, lean cuts of meat, and low-fat dairy products).[4] In LMIC settings, several adjustments in food options can be suggested to meet the desired amount of protein.

As already discussed, the beauty of the traditional Indian diet is combining a protein source with a carbohydrate source in every staple food. Locally available foods rich in protein can be added to enhance protein content, e.g., by adding pulse or soybean flour to wheat/ cereal flour, adding sprouted or boiled pulses to meals and snacks, including *sattu*-based preparations as discussed above, or gram (*besan*)-based preparations. In most parts of South India, many chutneys are pulse-based, increasing flavor and protein content. Popular snacks with cereal-pulse combinations like *dosa, idli*, *vada*, and *puttu* are preferable to commercial snacks.[6,9] When eating *vadas* from commercial vendors, it's important to consider the portion size and ingredients used. Some establishments may incorporate rice into *medu vada* recipes, potentially impacting glucose levels. In rural areas, low fat dairy like *chaas* (after fat has been removed for making butter/ ghee) may be available inexpensively. Adding whole eggs (the yolk should not be discarded): an egg daily, adds high-quality protein.[22,23] The family can breed hens for eggs and meat whenever possible in rural or semi-urban areas. Fish preparations are popular in all coastal areas and are good sources of essential fatty acids and protein; fish pastes and dried fish from discarded small fish are inexpensive. The practice of fish breeding in local ditches or personal ponds is prevalent in many eastern states and is an economical way to have a fresh and sustainable fish supply.

15.3.3. Optimizing Dairy Intake

Consumption of ~400 ml of low-fat milk/curd daily helps fulfill calcium requirements and adds to the daily protein quota.[24] Dairy products also contain modest amounts of fat, which makes them great bedtime snacks for those using conventional insulins [(Regular and Neutral Protamine Hagedorn (NPH)] or on days of extra activity to prevent late-night hypoglycemia.[25] Buttermilk is a tasty, low-calorie carbohydrate snack that adds to the daily calcium quota (~100 mg/100 ml) and hydration. It is advisable not to encourage the addition of excess salt. Cumin powder, pepper powder, and mint could be added to enhance flavor.[26]

15.3.4. Optimizing Fat Intake

In order to reduce the risk of obesity and Cardiovascular Disorders (CVD), total fat intake should not exceed 30-35% of total energy.[27] However, low-fat diets should be avoided, as fats provide energy and essential fatty acids, increase palatability, and reduce GI. Traditional fat sources in Indian diets are plant-derived oils, ghee, dairy products, and, to some extent, fish and meat for non-vegetarians.[28] Locally available and affordable oils like sesame, peanut, and mustard oil are rich sources of unsaturated fatty acids. Using cold-pressed, filtered oils instead of refined ones retains essential fatty acids and increases flavor; such oils should be encouraged for cooking and pickling.[29] Coconut oil, commonly used in Kerala, coastal and hilly areas of Karnataka, and ghee, used extensively across the country, can be used in moderation wherever culturally and regionally appropriate. They are less atherogenic than vanaspati. Marine fishes like salmon, sardines, Indian mackerel (*bangda*), and hilsa are particularly rich in Eicosapentaenoic Acid (EPA) and Docosahexaenoic Acid (DHA) and should be encouraged in moderation - once or twice a week (80-120 g/day), where available.[4] A variety of unsalted nuts and seeds like peanuts, sesame (black or white), flax seeds that are a good source of omega-3 fatty acids, melon/ pumpkin/ watermelon/ cucumber seeds, cashews, almonds, walnuts, and pistachio are rich sources of MUFA, fiber, and antioxidants.[30] Peanuts are widely available throughout India, inexpensive, and used in a variety of ways: roasted as snack preparation, added to vegetables, curries, salads, *chutney*, or as topping for *poha*; or as sweet (*chikki/ gajak*, *holige*, *ladoos*) with moderate jaggery or sugar. Coconut (dry or raw), also used extensively in many forms, adds fiber and satiety.[6,9] All these nuts and seeds make excellent snack options for PwD, especially during exercise and to prevent nocturnal hypoglycemia.

15.3.5. Optimizing Micronutrients

Micronutrient deficiency, often called 'hidden hunger,' is a huge problem, especially among growing children and adolescents, more so

in those with T1D. Consumption of wholesome food, as discussed above, with locally available green leafy vegetables, seasonal fruits, whole grains, pulses, sprouts, and low-fat dairy products, can solve the problem. Traditional food processing techniques like soaking grains (reduces phytates), fermentation (increases B12 content and digestibility), and germination (reduces tannins) increase micronutrient availability and improve the digestibility of protein and starch, the latter having implications for the effect of starchy foods like *dosas*, etc., on blood glucose levels.[31] Different ways of combining these food items, e.g., making *raita* (curd with different vegetables or green leaves, with salt and spices), *kosambari* (mixture of carrot, cucumber, soaked green gram, lime, chilly, peanut) improve taste, and add to nutritive value. Adequate intake of calcium can be ensured by a liberal intake of dairy products, cereals, pulses, nuts, millets, and seeds, whereas an adequate quantity of magnesium can be obtained by consumption of legumes, grains, nuts, and leafy greens. Cooking in iron vessels increases iron content, especially with the addition of acidic compounds like tamarind, lemon, *kokum* (Garcinia Indica), or gooseberry (*amla*).[32] Zinc, an important micronutrient for health and prevention of disease, is found in meat, seafood, grains, and eggs. Wide varieties of colored vegetables and fruits provide antioxidants, B complex vitamins, and fiber; raw mango, gooseberry, and citrus fruits are sources of vitamin C. A good general guide is to ensure that all rainbow colors are represented in the day's diet.[33] All families (regardless of financial status) should be encouraged to use leaves and peels in broths/ soups/ curries/ chutneys/ dals. As mentioned above, families can use greens that are often discarded (e.g., use of preparations including leaves of radish, cauliflower, pumpkin, and pea shells). They can grow vegetables on the edges of fields in rural areas or balconies/ backyards using pots, even in crowded cities, using composted kitchen waste and egg shells. Cultivation and consumption of microgreens can also be taught and encouraged wherever possible.

15.3.6. Traditional Beverages

Beverages contribute to fluid intake, increase satiety, and add to the nutritional value of food when chosen wisely. Locally available home-made beverages like *sattu*, *mattha*, *lassi*, *jal-jeera*, *kanji*, *kokum* extract, lemon water, *rasam*, and *aam panna,* with little to no added sugar, can be encouraged.[5] One can use creative skills to make beverages from by-products of home-made foods, e.g., residual whey from cottage cheese (*paneer*) or water used to cook vegetables/ dals or boil black chickpeas can be used as a drink, with the addition of home-made spice-mix. These options are tasty, easily made at home, and add to satiety without increasing costs or the calorie burden. Home-made drinks can be used effectively during play/ exercise/ sick days to avoid dehydration. Awareness can be increased by serving them during diabetes camps and get-togethers. The help of celebrities can be taken to spread awareness regarding available options and their benefits. Sugar-sweetened commercial drinks, usually in plastic bottles, which have now penetrated the remotest places of the country, should be actively discouraged.

15.3.7. Millets

India is the largest producer of millets in the world. Known as the 'cereals of the poor,' they are cheaper and nutritionally superior to other common cereals (wheat and rice), as they are rich in protein, vitamins, and minerals (iron, zinc, and calcium) and have low GI.[34] They are also gluten-free, making them more suitable and affordable for people with Celiac Disease (CD). Pearl millet (*bajra*) and sorghum (*jowar*) are common examples that can be used to make various tasty dishes. Millet flour is coarser than wheat and tends to make harder rotis, which can be difficult to eat unless freshly made. This can be reduced by kneading millet or mixed flour with curd/ paneer and resting for some time before cooking: the fermentation reduces anti-nutrient factors, adds nutritional value, and improves taste and softness. Millets can also partially replace rice, or be used to prepare various preparations like *dosa/ idli/ upma* alone or with other cereal/ pulses.[21,34]

Ragi is a millet popular in south India; it has a higher GI than other millets, therefore, it must be used in moderation and in combination with other cereals/ pulses and consumed with moderate amounts of fat. (refer to Table 15.1 for recipes)

Table 15.1: Millet recipes[35]

*1.*Sorghum *Khichdi (Jowar khichdi)*
Ingredients:
Sorghum *khichdi rawa:* 1 cup, *moong dal:* ½ cup; mustard seeds, chopped onions, green chillies, tomato, curry leaves, ginger-garlic paste, turmeric powder, salt, and water as required.

Preparation Method:
Soak green *moong dal* and sorghum *rawa* for 15 min.
Season with mustard seeds, onion, green chillies, ginger-garlic paste, tomatoes, curry leaves, and turmeric powder.
Add sufficient water and salt, cook on low flame until cooked properly, and serve hot.
*2.*Pearl Millet *Upma (Bajra Upma):*
Ingredients:

Pearl millet rawa: 1 cup; 2.5 cups water; oil 2 tsp, 1 medium onion chopped; 1 medium-sized carrot chopped, ¼ cup French beans chopped, ¼ cup shelled peas, 1 tsp urad dal, 1 tsp soaked chana dal, ½ inch piece ginger minced, 1-2 green chillies chopped, ½ tsp mustard seeds, ½ tsp cumin seeds, 1 pinch asafoetida, 1-2 stalks curry leaves, coriander leaves to garnish; peanuts and cashew nuts to garnish; ½ - 1 tsp salt (as per taste), a pinch of sugar; ½ tsp ghee.
Preparation Method:
Roast pearl millet *rawa* till it turns brown.
Add urad dal and chana dal and cook for a few minutes.
In a separate pan, heat oil, add carrots, beans, and peas, chopped onions, green chillies, mustard seeds, cumin seeds, and saute until cooked (a few minutes).
Add water and roasted *rawa.* Cook well until it becomes soft.
Season with curry leaves, roasted peanuts and cashew seeds.
Serve hot.

Recipe based on: Indian Institute of Millet Research: https://apeda.gov.in/milletportal/files/Millets_Indian_RecipesA_Healthy_choice

15.4. OTHER CHALLENGES

A holistic approach to successfully managing T1D on an ongoing basis requires an assessment of the family's socioeconomic background, literacy levels, food insecurity, housing stability, parental support and availability, extended family support, and financial resources. This assessment should be done at diagnosis, and any changes in the circumstances should be updated in the hospital records, like death or major illness or job change of a parent or other key family member, etc. Factors such as socioeconomic status, beliefs about nutrition, and awareness of diabetes care and complications, influence good practices.

15.4.1. Celiac Disease (CD)

Persons with T1D are more prone to develop CD, which requires a gluten-free diet.[36] This adds to management and financial difficulties, as commercial gluten-free foods are expensive and not widely available. Fortunately, the wide range of millets, pseudo-cereals, and raw plantain and jackfruit flour used in traditional Indian diets, especially during religious fasts, as well as rice and starchy vegetables, are not expensive and may even be cheaper than rice and wheat. A practical solution to significantly reduce costs is to acquire a home grinding machine so that millet and other grains can be washed, dried, and ground at home. (refer to Chapter 14)

15.4.2. Technology to Help Accessibility to Dietary Advice

Experienced dietitians may not be available in many areas; however, mobile phones are now ubiquitous, and technology can be creatively used to overcome this problem through virtual individual/ group consultations, YouTube videos, and phone messages of authentic health education material shared in relevant groups.[37] These educational sessions can be made in local languages, with locally appropriate content, to break myths about diabetes and teach about a healthy diet. Official and authentic mobile apps prepared by professional societies with desired information regarding nutrition are of great help in reaching more people and avoiding false information. Formal training programs conducted by professional bodies like the Indian Society of Pediatric and Adolescent Endocrinology (ISPAE) e.g. IDEAL (ISPAE Diabetes Education and Learning)[38] program for diabetes educators and BEST (Basic Education Series in Type 1 Diabetes)[39] for families with T1D, can go a long way in filling the knowledge gap.

15.4.3. Illiteracy, Poor Numeracy, and Language Barriers

Basic numeracy skills are needed to understand and apply fractions, percentages, ratios, and proportions, handle data, and interpret and calculate nutrients from food labels. Poor numeracy skills adversely and significantly influence glycated hemoglobin (HbA1c). The relationship between both can be independent of socio-economic factors.[40] Extra effort would be needed if there are numeracy difficulties: practice and reinforcement by members of the peer group may be useful.

There is a lot of internal migration of people between states within India, for many reasons, including employment, education, professional development, etc. This can pose challenges of language and cultural barriers to residents in different states, specifically pertaining to ongoing diabetes education. Limited resource settings worsen these difficulties. Limited access to diabetes education materials in regional languages hinders understanding and adherence to dietary recommendations.[41] Illiteracy is a major barrier to diabetes education and spreading the right information to the appropriate audience. Liberal translation of authentic and simplified education material with good illustrations in local/ hyperlocal languages and dialects, and preparation of audio-visual education material in local languages may help circumvent this issue. Social media and mass media, reaching even the last person in society, can be used as effective tools for knowledge transfer. Families should be given information about and helped to access websites like ISPAE[42] and the British Diabetes Association[43], which have information about various topics in different Indian languages.

Low-cost food options for PwD include cereals combined with pulses, creating nutrient-rich meals that help maintain stable BG levels. (refer to Table 15.2)

Table 15.2: Low-cost food options that are suitable for PwD[6]

15.2.1: Cereal-based preparation

Food item	Remarks
Bisibelebath	It's a good mixture of cereal with a pulse. Can decrease GI further by adding more vegetables, serving with some ghee and vegetable *raita*.
Pulao	It can include more vegetables and green leaves, served with curd or vegetable *raita*.
Upma	Mostly made with rava *(sooji)*, vegetables, oil, lentils (dal), and peanut/ cashew. May use broken wheat/ millets instead of sooji.
Poha	Made of beaten rice, onions, and peanuts. May add vegetables like carrots, beans, and peas. It can be served with chutney or curd, which reduces GI. Use red poha rather than the white one made with polished rice. Can use corn flakes instead of rice flakes.
Stuffed *paratha*	Made of whole wheat flour with vegetables or onions, pulses like rajma, i.e., dal parathas or cottage cheese (paneer), or minced meat.
Mattha ke aloo	Potato, curd-based spicy curry to be served with *roti*.

15.2.2: Pulses based preparation:

Preparation	Remarks
Dal	A variety of pulses can be used alone or in combination. Adding green leafy vegetables or other vegetables increases their nutritive value and decreases GI.
Sambhar	Popular south Indian pulse and vegetable-based curry served with rice or *dosa/ idli*. Better than *rasam* in terms of GI and nutritive value.
Dahi Kadhi, gatte ki sabji	Vegetable curry made with gram flour and curd gravy.
Kootu	Made of pulses, vegetables (bottle gourd, pumpkin, cabbage), and raw coconut-based curry.
Channa chaat	Boiled dried channa, lemon, onion, tomato, and raw mango.

Khaman	Savoury made with *channa dal* flour, semolina, curd and lemon.
Panki	Steamed moong dal on green leaves with added chilli coriander leaves, spices, lemon, curd, and salt.
Metkut/chutney powder	Various dals are roasted and grounded with added spices, tamarind, and salt to make fine powder sprinkled generously on hot rice with ghee.

15.2.3: Preparations based on Cereal pulse combinations:

Preparation	Remarks
Pongal/vegetable *khichdi*	Rice and pulses are cooked with vegetables, chilly, and seasoned with ghee. Millets can replace rice. Lime can be added.
Idli	Steamed cake made with fermented batter [cereal and pulses (3:1)]. Various millets can replace rice to reduce GI. Served with sambhar or chutney.
Dosa	Crepes made with fermented batter [cereal and pulses (3:1)]. Served with *sambhar* or *chutney.*
Thalipeet	Flatbread made from whole grain flour, pulses, and onion.
Dal baati	Pulse curry consumed with roasted whole flour balls.
Vada	Combination of rice with *urad dal*, deep fried served with vegetable *sambhar*. Use in moderation is advised as it is deep fried.

15.6. SUMMARY & RECOMMENDATIONS

• Globally, there are approximately 8.75 million people with T1D, with a significant portion living in LMICs, including India.
• Resource-limited settings pose an additional challenge in the management of nutrition in T1D. A significant proportion of PwD live in such settings globally and must be helped to improve their lives for better outcomes.
• Globalization and modernization have replaced healthy food with hyper-palatable ultra-processed foods HFSS. Current Indian diets are higher in carbohydrates (60-70%) and lower in protein (~10%) than recommended.
• Traditional Indian diets offer locally available, inexpensive, complex carbohydrate options that are micronutrient-rich and contain modest amounts of proteins. These diets can be more sustainable and culturally acceptable for individuals with T1D in India.
• Like other family members, PwD should eat nutritious food that contains enough macro- and micronutrients to support normal growth and development. Harnessing the ancient wisdom and social acceptability of traditional Indian diets to increase protein, fiber, and micronutrient intake, using locally available low-cost options, can help overcome this challenge and enable PwD to achieve good glycemic control, reduce short-term and long-term complications, and enjoy good physical and emotional health.
• A balanced diet is imperative: suggestions can be advised to incorporate locally available, cost-effective, and nutritionally rich foods, with a few modifications to improve the quality of carbohydrates and the quantity of protein, drawing on ancient Indian practices.
• To get more fiber and micronutrients, high-GI carbohydrates can be replaced with low-GI options like whole grains (e.g., whole wheat, unpolished rice, and millets).
• Unpolished whole pulses are preferred: to add fiber and protein and thus control post-meal glycemia.
• Protein and carbohydrate sources can be combined in staple foods.
• Aiming for ~400 ml of milk/ milk product per day ensures adequate calcium and protein:
• Consuming dairy products containing modest amounts of fat is suitable for bedtime snacks.
• Use of traditional plant-derived, cold-pressed oils (e.g., sesame, peanut, mustard) and small amounts of ghee should be encouraged, while avoiding refined and hydrogenated oils.
• Consuming wholesome foods with locally available green leafy vegetables, seasonal fruits, whole grains, pulses, and low-fat dairy should be encouraged.
• Utilizing traditional processing and preservation techniques helps to increase micronutrient availability and palatability.
• Millets are cheaper and nutritionally superior, rich in protein, fiber, vitamins, and minerals, and have low GI, and should be included as part of a mixed diet.
• Sugar-sweetened and commercial beverages should be avoided, instead using locally available homemade beverages like buttermilk (*mattha*), lassi, *nimbu pani, rasam, sattu* drink, etc., without added sugar.

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Chapter 16: Integrating Technology with Medical Nutrition Therapy in Type 1 Diabetes Mellitus

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16.1. INTRODUCTION

Diabetes technology refers to the devices (hardware as well as the software) used for the management of diabetes, including, monitoring Blood Glucose (BG), maintaining BG logs, calculating insulin doses, delivering insulin accurately, eliminating hypoglycemia and hyperglycemia, quantifying nutrition intake, setting reminders, monitoring therapy responses, or assisting with lifestyle modifications.[1]

Food has the most important impact on the glycemic status of a person with Type 1 Diabetes Mellitus (T1D). With the advancement of technology, it has become feasible and simple to get information on the food to be eaten [e.g., calories, carbohydrate/ protein/ fat content, Glycemic Index (GI)] and calculate the insulin dose accordingly, along with caring for other aspects of diabetes like monitoring and sharing BG changes, administering insulin doses accurately, and keeping track of BG logs. Telecommunication helps make the dissemination of information and communication between People with Diabetes (PwD) and their families and the diabetes care team easier, at little or no cost.[2]

However, the costs of devices and the complexity of their use, the rapid evolution of technology, the unevenness of the accuracy of the information available, and reluctance on the part of Healthcare Professionals (HCPs) as well as of the families to adopt technology, are barriers to widespread use. These must be addressed on an individual basis. This chapter sheds light on integrating advanced diabetes technology with diabetes care, especially regarding nutrition, to encourage HCPs to help PwD and their families achieve better glycemic control and a better quality of life.[3]

Disclaimer: This chapter does not endorse any brands mentioned in the text: it only gives examples of some available options. These examples may not be all-inclusive and may change from time to time, as this is a dynamic field.

16.2. CARBOHYDRATE COUNTING (CC)

Indian food – the variety, ingredients, cooking styles, eating patterns, and food behavior - can differ greatly from that in the West and elsewhere. Moreover, the carbohydrate content (grams and quality) and other ingredients in the same food item can vary across different households. Individualized meal plans based on cultural, regional, socioeconomic, and seasonal preferences help achieve compliance and optimal glycemia.[4] Synchronizing insulin with carbohydrates in the meal and adjusting insulin for high or low pre-meal BG is essential in T1D management, whether the PwD is on Multiple Daily Injections (MDI) or Continuous Subcutaneous Insulin Infusion (CSII or insulin pump).[5,6] Accurate calculation of insulin doses based on the carbohydrate content of meals and snacks empowers PwD to make informed food choices while maintaining glycemic control. The CC approach may positively impact HbA1c; its safety has been established in many studies, with hypoglycemia, weight gain, and insulin doses similar to those of control groups.[7,8] If the food contains large amounts of protein and fat, that also has to be taken into consideration.

16.2.1. Carbohydrate Counting Applications

Though CC and Insulin-Carbohydrate Ratio (ICR) should be taught to all PwD from the time of diagnosis, CC is perceived as burdensome, is often inaccurate, and often ignored. Fortunately, CC mobile phone applications show better results than manual CC in reducing HbA1c.[9] Some functionalities of the applications include:

- Recognizing the food/s, estimating macronutrients and micronutrients.
- Tracking the history of food consumption.
- Food recommendation system.

Such technology can also help prevent obesity and chronic complications like cardiovascular disease since it is possible to analyze food intake behavior (e.g., eating habits, intake of calories, macro- and micronutrients) and suggest modifications.[10]

Example:

***mySugr* Application:** The *mySugr* application is a widely used diabetes management tool, with over 5 million downloads worldwide, reflecting its reliability and effectiveness. It simplifies daily diabetes care by assisting with CC, allowing users to log meals, track carbohydrate intake, and correlate this information with glucose levels. The application integrates seamlessly with Continuous Glucose Monitors (CGMs) and BG meters, providing personalized insights to optimize glycemic control. Additional features include logging of insulin doses, physical activity, and medications, as well as reminders for testing or insulin administration. The application also generates detailed reports for sharing with HCPs and gamifies diabetes management through challenges and rewards to keep users engaged. With its user-friendly interface and robust analytics, *mySugr* empowers individuals to take greater control of their diabetes, earning high user ratings and widespread adoption.[11]

Though many m-health applications are available, most of them are not validated, and when recommending any of them, physicians can make their own smart choices. Similarly, numerous carbohydrate-counting applications are available globally, but their effectiveness for Indian diets is often limited due to the lack of extensive databases featuring Indian cuisine; many of them may require manual adjustments for precise tracking of Indian diets.

Challenges with Carbohydrate-Counting Applications

- Many applications do not comprehensively cover Indian regional dishes, reducing their accuracy and reliability.
- While custom recipe options exist, these applications often overlook changes in nutrient content based on cooking methods, such as frying or boiling.
- The predominance of English in application interfaces can make them less user-friendly for non-English speakers.

• Not all users, particularly older adults, are comfortable navigating applications or using smartphones effectively.
• Advanced features like bolus and correction dose calculators often require paid subscriptions, which may not be affordable for everyone.

Many caregivers and PwD find applications useful as adjunct tools to support patient education and dietary management. Others, especially older adults, find it difficult to use them effectively, necessitating additional guidance from the HCP or the peer group. There may be noted discrepancies between application-generated data and real-life dietary practices, which can hinder precision in insulin dosing. Encouraging PwD to consistently log their meals can be a significant challenge, as people often lose interest over time.

16.2.2. Plate Image Capturing Applications: Analysing Meal Composition Through Artificial Intelligence (AI)

These applications use food images or videos sent by the user to estimate nutrient content. Caution is needed as very few are tailored to Indian foods; moreover, these applications may be prone to errors if the user is not properly trained or the image quality is inconsistent.[12]

Example:

NutriAIDE mobile application is an innovative tool designed to empower users toward healthier and more sustainable nutrition choices. Recently launched by the Indian Council of Medical Research - National Institute of Nutrition (ICMR-NIN) in collaboration with German institutions, *NutriAIDE* enables users to track both micro- and macronutrient intake. Utilizing an AI-based photo recognition tool, the application can identify foods through photographs, and provide nutritional values. Additionally, it dynamically calculates the carbon footprint of individual food choices, promoting environmental consciousness alongside personal health. Beyond mere calorie counting, *NutriAIDE* encourages users to reflect on their eating habits, engage in adequate physical activity, and evaluate their food environments, providing a holistic approach to nutrition and well-being.[13]

Users find these applications convenient for meal tracking and nutritional analysis, but their effectiveness depends heavily on accurate image quality and proper training. Many appreciate the innovation but note the need for manual corrections to ensure accuracy.

16.3. BLOOD GLUCOSE MONITORING TECHNOLOGY

BG monitoring is essential for T1D management and can be done by capillary BG monitoring by finger pricks ('self-monitoring of blood glucose': SMBG) as well as by interstitial fluid glucose monitoring by sensors placed on the skin (CGM). Ideally, CGM should be available for all those with T1D from the time of diagnosis, because it tracks not only real-time glucose levels but also provides data on patterns, glycemic variability, and the impact of diet, exercise, stress, etc., which helps titrate insulin doses, assess responses, and achieve glycemic targets safely and effectively.[14]

16.3.1. Self-Monitoring of Blood Glucose (SMBG)

Testing BG 6-10 times per day (before and 2 hours after all major meals, bedtime, and 2 am) has been advocated if CGM is not available for any reason, with PwD encouraged to do the maximum SMBG possible.[15] PwD with recurrent hypoglycemia, brittle diabetes, and suboptimal glycemic control require more frequent monitoring, but the frequency is often also dependent on resources available and the caregivers' willingness. If daily pre- and post-prandial checks cannot be afforded, at least the pre-meal BGs to titrate insulin doses and bedtime BGs to avoid nocturnal hypoglycemia should be done. If even this cannot be afforded, doing the full SMBG profile 1-2 days a week gives more information than isolated random BGs.[15] BG should be recorded in columns along with food eaten and physical activity for the PwD to understand patterns and for review with HCP. Targets for reasonable control are 80-130 mg/dL pre-meal, and 80-180 mg/dL post-meal. The following functions of glucometers should be kept in mind:

• BG monitoring devices with a memory function to record previous BG values are needed for confirmation of BG logs. Those without a memory function should be avoided.
• *Connected (or Smart) glucose monitoring devices:* Some glucose meters can be connected to online applications via Bluetooth. Apart from BG values, meals, insulin doses, physical activity, and sleep can also be recorded. This enables more informed understanding as well as decision-making. The use of glucometers connected to mobile applications has shown sustained improvement in maintaining BG within range and in HCP satisfaction.[16]

Some connected glucometers include *OneTouch Verio Flex, Accuchek Guide, Accuchek Instant, and Contour Plus One.* (Please see Appendix 1 for details of some Connected Glucometers)

16.3.2. Continuous Glucose Monitoring (CGM) and Nutrition Planning

CGM provides immediate and continuous feedback on the glycemic response of food(s) consumed, activities, and nocturnal patterns. This enables accurate insulin dose calculations, initiating corrective strategies including correction bolus, planning and doing physical activity, and preventive measures.[17] CGM use definitively improves HbA1c, decreases glycemic variability and, therefore, acute complications (hypoglycemia, ketoacidosis), reduces and delays chronic complications, and greatly enhances the quality of life.[18–20] Therefore, all individuals with T1D should use personal (not retrospective) CGM from the onset, using real-time values for informed decisions. Even intermittent use (every 1-3 months) may provide an understanding of BG patterns, especially during illnesses and periods of transition (e.g., exams, travel).[15] Readings are divided into Time In Range (TIR, defined as the time during which sensor glucose, i.e., SG values are 70-180 mg/dL), Time Above Range (TAR, i.e., time with SG >180 mg/dL), and Time Below Range (TBR, time with SG <70 mg/dL).[21] The recommended targets are TIR >70%, and TBR <4%.

Some examples of available CGMs include FreeStyle Libre 1, 2, 2 plus, 3, 3 plus (Abbott); LinX, Tracky, Guardian 3 and 4 (Medtronic); and Dexcom G6 and G7. Currently (2025), FreeStyle Libre 2 Plus, LinX, Tracky, and Guardian 4 Smart CGM System are available across India.

A recent innovation is the Accu-Chek SmartGuide CGM, paired with the Accu-Chek SmartGuide Predict application. This application leverages AI technology by using algorithms that analyze CGM data in combination with user-provided inputs, such as insulin doses and carbohydrate intake. It predicts BG trends and thereby offers actionable recommendations. This supports proactive diabetes management while reducing the daily burden of care, and reducing alarms. The predictive algorithms deliver several key functionalities:

• *30-minute Hypoglycemia Prediction:* The application provides a timely alert when there is a risk of hypoglycemia within the next 30 minutes, enabling users to take preventive actions.

• *2-hour Glucose Trend Forecasting:* Users can view easy-to-read graphs that project glucose level trends over the next two hours, helping them stay ahead of potential fluctuations.
• *Overnight Hypoglycemia Risk Assessment:* Evaluating the likelihood of nocturnal hypoglycemia enables the taking of preventive measures.[22]
The advantages of CGM in nutrition planning are:
• Features like glucose values and trends, trend arrows, line graphs of earlier days, and alarms give a real-time perspective of the glycemic profile and help make better food choices. The trend arrows can help predict and therefore prevent hyperglycemia and hypoglycemia.
• *Insights into effect of food items and meal composition*: CGM provides information about postprandial glucose excursions, helping PwD understand how different food items and meals affect their BG levels, and thus effectively adjust food and insulin to optimize glycemic control.[23]
• *Carbohydrate counting:* CGM makes understanding CC much simpler, enabling PwD to adjust carbohydrate intake, insulin, and/or activity levels.
• *Optimizing carbohydrate intake*: CGM studies have shown that both lower and higher carbohydrate intake reduces TIR.[24] A randomized, multicentre, open-label, crossover trial over 12 weeks with 69 individuals with T1D found that compared with a traditional diet, a moderate carbohydrate diet decreases mean glucose levels and TAR and increases TIR without increased risk of hypoglycemia or ketoacidosis.[25]
• *Timing of carbohydrate intake* also affects the glycemic response. Independent of its GI effect, a carbohydrate-rich meal causes higher BG spikes after breakfast than when consumed at dinner time.
• *Adjusting insulin doses for the fat and protein:* CGM data reveals patterns in glucose responses to meals containing differing amounts of fat and protein. By analyzing these patterns, PwD can fine-tune their insulin-dosing strategies to manage fat and protein intake. Appropriate dosing, duration, and timing of dual wave or other extended boluses (or correction dose for those on MDI) can be decided based on CGM readings.[26]
• *Individualizing nutrition therapy*: CGM data, combined with information on insulin dosing, physical activity, and lifestyle factors, allows personalized nutrition therapy tailored to individual needs and preferences. This may involve optimizing meal timing, portion sizes, and macronutrient distribution to achieve optimal glycemic control.[27,28]

16.4. INSULIN DELIVERY TECHNOLOGY

Technological advancements in insulin delivery techniques like connected (smart) insulin pens and insulin pumps offer more precise insulin dosing and greater flexibility in matching the insulin administration to the food intake.

16.4.1. Connected Insulin Pens and Algorithms

Connected insulin pens, also known as smart insulin pens, have features like dose reminder alerts and assessment of active Insulin On Board (IOB). They help streamline insulin therapy with better timing and dosing of insulin meal boluses, avoiding insulin stacking, missed doses, and insulin running out unexpectedly.[29] Along with CGM, they are useful education tools. Pens with wireless pairing capabilities have been introduced following the widespread adoption of smartphones, Bluetooth, and Near-Field Connectivity (NFC). (Please see Appendix 2 for some Connected Pens).

These pens are not officially available in India, but families may acquire them through friends and relatives, so HCPs should be aware of their working and usefulness. These are some features:

• *Dosing memory*: At times, insulin boluses may be taken during or after a meal, leading to higher post-prandial glycemia. The pen's built-in memory capabilities record the time and dose of each insulin injection, which helps keep track of insulin doses and adherence to the treatment regimen; it also helps analyze glycemic patterns and correct them appropriately.
• *Reminders and alerts*: Connected insulin pens usually have dose reminders, notifications for missed doses, and low insulin alerts, which are very helpful for users to stay on track with their insulin therapy.
• *Digital connectivity*: Connected insulin pens may be equipped with Bluetooth or other wireless connectivity features that allow them to sync with smartphone applications or other compatible devices. This connectivity enables real-time data transmission and tracking of insulin doses, which can be useful for tracking when the child is away from caretakers (school, friend's place, sleepover, picnic, camp, excursions).
• *Dose recommendation (Bolus calculator)*: Some connected insulin pens offer dose recommendation algorithms based on individual insulin sensitivity, carbohydrate intake, and BG levels.
• *Integration with CGM*: they can integrate with CGM systems, allowing users to correlate insulin doses with real-time glucose data.
• *Data logging and analysis*: The data collected by connected insulin pens can be stored in smartphone applications or cloud-based platforms, where users can access detailed logs and the analysis of their insulin usage patterns over time.

16.4.2. Bolus Calculator Applications: Personalized Insulin Dose Adjustment

Automated correction bolus calculators were introduced as a feature of insulin pumps, but are now available for use by PwD on SMBG and MDI as well. Bolus calculators are useful for assessing the Insulin Correction Factor (i.e., ICF, also known as the Insulin Sensitivity Factor, i.e., ISF).[30] They generally factor in target glucose level, current glucose level, ICR, ICF, duration of insulin action, and, therefore, active IOB into their calculations. *mySugr*, *Bolus Calculator, and GlucoLog RapidCalc* are examples of bolus insulin dose calculator applications. **Personalized dosing grids/ charts,** along with SMBG/ CGM, are also useful for adjusting insulin doses at a basic level, especially for those with low literacy or low numeracy.

16.4.3. Insulin Pumps & Automated Insulin Delivery System (AID)

Insulin pumps offer variable basal insulin rates and precise prandial insulin dosing, including even for small snacks.[31] They may also offer bolus calculator functions based on the BG levels, CC, ICR, ISF (ICF), and IOB. Taking IOB into account prevents insulin stacking and subsequent hypoglycemia.

High fat (>35 g) and high protein (>40 g) or very high protein (>75 g) in a meal can lead to significant hyperglycemia 3-6 hours after a meal. CSII offers different types of extended bolus systems like 'dual wave' bolus and 'square wave' bolus to manage high-fat and/or high-protein meals.[32] Increasing the insulin dose with 10-20% of the ICR, followed by combination bolus delivery (60-40%, 70-30%) over 2-3 hours have been variably used. CSII and CGM work well to optimize correction doses and achieve optimal glycemia with mixed meals. Correction dose boluses are also easier to administer and are more precise.[33]

In addition, bolusing for fasting and feasting (as in Ramadan) is easier to titrate.[34] During sick days, nutritional choices and insulin dosing based on the sickness and the BG levels are easier to titrate closely.

Role of CC in Enhancing the Efficacy of Advanced Hybrid Closed Loop (AHCL) Systems

Advanced Hybrid Closed Loop (AHCL) systems or AIDs primarily automate basal insulin delivery based on the sensor glucose readings. The basal insulin delivery automatically changes every 5 minutes and if the BG levels remain high despite reaching maximum basal rates, it can even auto-bolus. AID devices such as MiniMed™ 780G, while in auto-mode, can prevent both hypoglycemia and hyperglycemia to a large extent.

They also include features to assist with mealtime bolus insulin dosing.[35] They work best with accurate CC, but some errors in CC (e.g. bolus forgotten or carbohydrate underestimated) can be partially mitigated as the AHCL system corrects postprandial hyperglycemia. Since the 780G system adjusts insulin delivery in response to BG levels every 5 minutes, the hyperglycemia caused by CC errors and omissions does get covered, though not as precisely as accurate CC, due to delays in subcutaneous insulin absorption. Simplified meal announcements using a preset of three different personalized fixed-carbohydrate meals and unannounced snacks of up to 30 g carbohydrates, have also been shown to achieve fair post-meal glycemic control and reasonable HbA1c.[36] However, TIR was significantly better when precise CC was used.[35,36,37,38] However, AHCL systems cannot mitigate excessive boluses delivered for overestimated carbohydrates.

Do It Yourself Artificial Pancreas (DIYAP): also called Open-source Automated Insulin Dosing (OS-AID) algorithms offer transparency by providing access to the exact code for their interoperable automated glycemic controllers, that govern their functionality. In contrast to commercial entities, OS-AID algorithms are primarily created, managed, and refined by PwD and their support networks. Currently, thousands of PwD rely on these algorithms in combination with approved CGM systems and insulin pump components. Detailed guidance on setting up and maintaining these systems is freely accessible online, promoting widespread adoption and use.[37]

Different bolus patterns are an important feature of AID and DIY systems. 'Dual wave' boluses' are useful for low GI meals, especially with higher protein and/ or fat content. 'Super' boluses can be used for high-GI meals. 'Super' bolus is where the user gives extra insulin before a meal, more than what the carbohydrate count would call for, by "borrowing" from the basal insulin due to be delivered over the next few hours.[38] Adding insulin to the bolus and then "low temping" for a few hours "front shifts" some part of the insulin activity.[39] Essentially, small "Super-micro-boluses" (SMB) of insulin are given at mealtime to quickly (but safely) respond to the rapid BG spike expected after a meal rich in carbohydrates. Real-world studies have shown this avoids hypoglycemia and prevents post-meal hyperglycemia.[38,40]

Advancements in technology are reducing the need for CC and manual entry into the pump by PwD; with the insulin pumps of the future, no CC or meal announcement may be needed. This would make mealtimes easier.

16.5. WEARABLE HEALTH DEVICES IN DIABETES MANAGEMENT

Although wearable technology has been around for a while, its application for managing diabetes was not successful. These early devices had simple sensors and could not read or predict BG accurately.

Currently, popularly accepted wearables include smartwatches, which can potentially significantly improve the quality of life for PwD. Smartwatches can be used to set medication reminders and alarms, with timely doses and avoidance of missed doses improving glycemic control.[41] Other benefits include measuring heart rate or blood oxygen and managing nutrition and calorie intake. For instance, a smartwatch application, *Klue*, uses proprietary AI trained to detect eating behaviors and promptly delivers reminders for insulin doses. The consequent reduction in missed or delayed boluses has been shown to reduce HbA1c significantly.[42,43]

Though smartwatches cannot measure BG accurately, some of them integrate with CGM systems, so PwD can view real-time glucose data directly on their wrists. *Apple Watch*, *Fitbit Versa* and *Fitbit Sense*, *Galaxy Watch 4,* and *Galaxy Watch Active 2* integrate with certain CGM systems, such as Dexcom G6 and G7. *Garmin Venu* and *Garmin Fenix* series support integration with certain CGM systems, including Dexcom G6.

Smartwatches typically include features for tracking physical activity, sleep, including calories spent, step count, and distance covered. Given the importance of regular physical activity for managing diabetes, smartwatches help PwD set activity goals, monitor progress, and stay motivated to stay active.

16.6. EDUCATION AND COMMUNICATION

16.6.1. Telemedicine and Telehealth in Diabetes Management

Telemedicine provides clinical support across geographical barriers, connecting users who are not in the same physical location to improve health outcomes. Efficacy can be enhanced by using Information and Communication Technology (ICT) applications.[44] Telemedicine has been documented to be useful in T1D care, especially during the Coronavirus disease (COVID-19) lockdowns.[45,46]

Experiences with the application of telemedicine in diabetes management have been reported since the 1980s. The first of its kind was the DIACRONO system, designed to evaluate and interpret glucose monitoring data.[47] DIABTel was the second telemedicine application-based system developed by the Gomez group, which used telemonitoring and telecare services to enhance daily diabetes care and ensure intensive management.[48] Further advancements in telecommunication enabled PwD to be advised over the telephone on insulin doses, diet, exercise, etc. after the clinic had received data. The Diabeto project was a telemedicine application for PwD with diet-related educational programs. The SESAM–DIABETE was a sophisticated approach using French videotext telecommunication, which PwD could access from home for advice on diet and nutrition, physical exercise, ketonuria, hypoglycemia, and hyperglycemia.[49] Another application, HealthyR-Hearts, successfully translated a telehealth Medical Nutrition Therapy (MNT) intervention for Cardiovascular Disorders (CVD) prevention in rural and remote primary care settings.[50] Telehealth is proving to be a beneficial tool for dietary counseling and has been shown to reduce HbA1c in a low-income ethnic minority community.[51,52]

16.6.2. Virtual Support and Community Engagement

Social networks can impact all aspects of our lives, including health and well-being. Social media platforms such as websites, media, and internet-based tools like Facebook, WhatsApp, Skype, YouTube, Instagram, X (Twitter), Pinterest, Foursquare, LinkedIn, Viber, blogging sites, online forums, etc., offer PwD, their caregivers, and HCP better

communication platforms to procure and exchange necessary information.[53] The scientific community thus strongly advocates using social media platforms that convey correct information to introduce a healthy lifestyle and behavioral patterns among the public as a part of various disease prevention and management programs.[54] Certain social media platforms allow PwD to interact with HCP and share experiences with peers, thereby enabling more productive health management virtually. However, much misinformation abounds; social media influencers and quacks may misguide as well. PwD and caregivers need to be watchful and cross-check with their HCP. Some popular social networking websites include www.diabetessupport.co.uk, www.patientslikeme.com, www.diabetesmine.com, and https://community.diabetes.org/home.

The Diabetes Tele Management System (DTMS®), a telemedicine-based intervention designed to provide comprehensive diabetes care remotely, is a successful model from India. Established in Kerala in 1997, DTMS® leverages a multidisciplinary team comprising doctors, nurses, dietitians, diabetes educators, pharmacists, and psychologists. Customized software integrated with Electronic Medical Records (EMRs) and secure telecommunication platforms, including phone, email, and dedicated web portals, is used to deliver individualized care continuously and proactively. Real-time insulin titration, dietary guidance, and patient education are offered. DTMS® has resulted in better medication adherence, better quality of life, fewer hospital visits, lower HbA1c and lipids, and decreased incidence of microvascular and macrovascular complications.[55,56]

16.6.3. Educational Tools and Resources

Developing and utilizing authentic educational models and digital resources for PwD and HCP are important. Web-based educational tools (such as a nutrition handbook) are good choices for practical patient recommendations for planning MNT as long as they are based on evidence-based guidelines and provide relevant references. The Health Educator's Nutrition Toolkit offers several resources for making healthy food choices, including practical tips on how to shop for and prepare food and order food when eating out. The nutrition facts and the information provided by the Toolkit can help health educators, dietitians, physicians, other health care and nutrition professionals, social workers, youth counselors, and program directors educate PwD and families. Health Educator's Nutrition Toolkit: Setting the Table for Healthy Eating (https://www.fda.gov/food/nutrition-education-resources-materials/health-educators-nutrition-toolkit-setting-table-healthy-eating)

16.7. DATA MANAGEMENT

Electronic Medical Records (EMR)

EMRs are a digital version of conventional paper records and include a comprehensive medical history of the individual, including laboratory and imaging reports, past medical events, and dietary history. EMR benefits HCPs as it allows them to monitor the medical data of individuals over extended periods of time, helps to identify when preventive visits and screenings are due, and improves overall quality and precision of care. EMR may also have automated facilities such as prescription ordering, reminders, and therapeutic prompts, and by linking to evidence-based guidelines, compute individual-specific recommendations at the point of care.[57]

16.8. CONTEXTUALIZING TECHNOLOGY INTEGRATION IN THE INDIAN SCENARIO

In India, diabetes management becomes arduous due to various reasons, including unawareness, myths, poor or no literacy, poor numeracy, poor socioeconomic background, and inaccessibility to quality specialized care, along with wide variability of food availability and eating habits. Additional barriers exist to using advanced digital platforms, technology, or devices.[2] Upgradation and customization of existing practices/ protocols/ hardware cost money: since most medical expenses are out-of-pocket, families may be unwilling or unable to pay for such facilities. Resisting the adoption of digital care and preferring traditional methods may be due to a lack of awareness or improper understanding of technology on the part of the PwD, caregivers, or HCP. The use of accurate, low/ no cost resources of information about nutrition and glycemic control should be encouraged to improve management. Since considerable personal identifiable data about medical conditions and well-being is collected and stored in interconnectable networks, there are increasing ethical concerns over cybersecurity, data privacy, and ownership. Users have to ensure the authenticity and ongoing reliability of the providers so that there is faith in the new user interface between doctors and patients. Small and standalone clinics simply may not have access to EMRs.[3]

Wider and better availability of connectivity is reducing the digital divide between rural and urban India, though access to high-speed broadband Internet and telecommunication infrastructure is still limited. Ideally, telehealth programs should be able to ensure live-video real-time connections between PwD and HCPs.

Role of a Multidisciplinary Team

The ideal multidisciplinary diabetes care team should include one or more physicians, diabetes nurses, diabetes educators, psychologists, and nutritionists. The team is pivotal in empowering PwD and caregivers through educational programs and social media platforms, helping titrate insulin doses, and providing ongoing advice on diet, lifestyle, and other aspects to achieve better control and quality of life. Families can obtain specialized services virtually in areas where the complete team is unavailable. Registered MNT professionals can provide advice via telemedicine to families coming to the clinic and those in remote areas.[58,59] Alternative methods like group sessions or guided self-study can efficiently and effectively supplement individualized counseling sessions for clinical nutrition advice and management. Whatever the setting, the basic aim of nutrition counseling is to ensure food is balanced and healthy, is a source of joy, and facilitates glycemic and metabolic control.

16.9. SUMMARY & RECOMMENDATIONS

- T1D management is challenging and needs a comprehensive approach, including MNT aiming to normalize Blood Pressure (BP), BG, and lipids, achieve normal weight and height, and overall development, with sustainable healthy eating habits. Innovative research leading to cutting-edge transformations in digital technology is helping HCPs achieve these goals.
- CGM has been transformative for those who can afford it, and non-invasive real-time glucose monitoring devices are eagerly awaited.
- Wearables such as body-mounted biosensors, on-body cameras, and wrist-worn wearables provide data on eating and drinking habits.
- Developments to simplify life for PwD and caregivers vary from simple applications to calculate the bolus dose or estimate carbohydrates, to complex advanced hybrid closed-loop insulin pumps like MiniMed 780G.
- HCPs must stay abreast with technological advances since they continue to transform practice. This could be as simple as teaching nutrition changes to calculate carbohydrate quantity and quality, to achieve euglycemia; to as complex as customizing MDI and pump settings; the aim is to maintain the best possible control while accommodating individual

dietary needs and preferences, including exercise and daily routines, and specific situations like festivities and fasting.
• Technology can allow novel approaches for comprehensive solutions for handling a broad spectrum of dietary options and combinations. Capabilities, once considered beyond the reach of PwD, are now attainable to improve outcomes and enhance the quality of life.
• A wide spectrum of software and hardware integrating with MNT can ease the burden of insulin dose adjustments, CC, bolus calculations, composing balanced meals, etc., to aid PwD in managing diabetes without stress.
• Though advancements are improving the quality of life of PwD, many applications still lack precision. Future research continues towards developing cost-effective, error-free technology that can be tailored with MNT for optimal glycemic management.

Appendix 1: Some Connected (Smart) Glucometers and Their Features

Connected glucometers: Glucometers are connected to applications via Bluetooth, which allows recording data points like meals, insulin dosage, activities, sleep, etc., along with BG values, enabling more informed decision-making. Some of the currently available connected glucometers include OneTouch®Verio®, CONTOUR®PLUS ONE, and Accu-Chek® Instant. The applications and meters provide users with excellent integrated information for improving glycemic control.

• OneTouch Reveal® mobile application with One Touch meters supports meal tagging, which is applied to readings in the meter. Once readings are synced to the application with meal tagging on, 'Before Meal and After Meal target range limits' can determine if the BG readings should trigger a message.
• The CONTOUR™DIABETES application is a cloud-enabled mobile application that operates on smartphones or tablets (whether running on Apple iOS or Android operating systems) to sync BG monitoring with the CONTOUR®NEXT ONE meter. The application provides a Meal Marker option to view the readings marked Fasting, Before Meal, or After Meal and a Day Divider to mark periods for Breakfast, Lunch, Dinner, and Overnight (changed by the user to fit their schedule). The application can detect patterns more easily with frequent glucose tests and markings of BG readings with meal markers and meals.
• Another application that has gained popularity globally is the MySugr application from AccuChek, which syncs with AccuChek Instant and AccuChek Guide. Users can manually create log entries with data about insulin therapy, current and target BG levels, carbohydrate intake, and details of activities.
• With regard to diet support, tools like the Photo Function, Plus, Tags, and the Smart Search Function and Notes allow users to add valuable details about dietary details, which aid them in reducing glycemic variability.
• In addition, applications such as MyFitnessPal, Fooducate, Carb Manager, and Glucose Buddy have been proven beneficial in managing dietary habits to maintain BG in the target range.

Appendix 2: Some Connected (Smart) Insulin Pens and Their Features.

Commonly used Smart Insulin pens include InPen, Novopen 6, Echo Plus, Emperra ESYSTA Pen, and Pendiq 2.0.

InPen (formerly Companion Medical, now Medtronics), the first FDA-approved insulin pen with a bolus calculator, pairs with a companion smartphone application. It has a comprehensive automated insulin dose record, data connection with CGM, and an insulin dose calculator (Automated Bolus Calculator, i.e., ABC), enabling accurate insulin dose calculation. It shows active Insulin On Board (IOB) to help plan correction doses and prevent insulin stacking. For PwD who are not on insulin pump therapy, this technology can be useful. The FDA later approved the InPen for additional bolus calculation modes after it was first released: (1) fixed dosing (the static dose is advised before each meal), and (2) meal estimation (the dose is based on meal size, which is classified as small, medium, and large). The InPen can give 0.5 U insulin increments.

NovoPen 6 and Echo Plus are Bluetooth-enabled insulin pens compatible with Novo Nordisk insulin cartridges. They record and store the last 800 doses, including flow check doses, recording the time since the last injection, and the amount of each insulin dose. The pen cap contains a dose memory function, allowing users to check the last dose without using the application. It provides reminders for mealtime and basal insulin doses. The Echo Plus can give 0.5 U insulin increments.

Bigfoot Unity system (Bigfoot Biomedical, California): another insulin pen for Multiple Daily Injections (MDI) users, which was FDA-approved in 2021. The system has a connected insulin pen cap with a simplified ABC, which suggests a mealtime dose according to whether the meal is small, medium, or large. The PwD and HCPs preprogram the doses for each meal size. If the BG is high, the ABC adds an additional correction dose.

Pendiq 2 (Pendiq; Moers, Germany): a digital insulin pen is Conformité Européene (CE)-marked and used in Europe. It can give insulin increments of 0.1 U, is Bluetooth compatible, and stores details of 1000 injections.

ESYSTA BT Pen (Emperra; Potsdam, Germany) is also available in Europe and is CE-marked. It has memory and has Bluetooth connectivity.

Note: As of January 2025, these are not available in the Indian market.

Appendix 3:

For individuals with limited financial resources, it is essential to highlight affordable and subsidized options. Government schemes such as Ayushman Bharat, Mittayi (Kerala), and Non-governmental Organization (NGO) initiatives like the Research Society for the Study of Diabetes in India (RSSDI) Hope project, type 1 foundation of India, Nityaasha Foundation, Udaan, P Kesavadev Trust, etc. provide access to glucometers and test strips at reduced costs or even free of charge in some cases. Community health programs and local diabetes clinics often offer similar support, especially in rural areas. These should be leveraged to enhance SMBG accessibility.

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Chapter 17: TEACHING TOOLS AND RESOURCES TO USE FOR NUTRITION EDUCATION FOR TYPE 1 DIABETES

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17.1. INTRODUCTION

Medical Nutrition Therapy (MNT) is central to maintaining optimal growth, development, and glycemic control in children and adolescents with Type 1 Diabetes Mellitus (T1D). Therefore, children diagnosed with T1D and their caregivers must receive comprehensive nutrition education tailored to their cultural practices, family traditions, socioeconomic status, and educational background.[1,2] Knowledge-based, patient or caregiver-centered nutrition education is essential for good glycemic control, which can prevent the development and/or progression of long-term diabetes-related complications.[3,4]

Presently, diverse teaching tools and resources are intended explicitly for the dietary education of individuals with T1D. Apart from conventional resources such as printed reading material, including books, modules, and pamphlets, technological advances have resulted in the development of interactive resources, including mobile applications, websites, and online platforms, which provide personalized guidance, meal or 'carbohydrate' tracking, and other educational content. Technology has also made sharing educational material from anywhere in the world easier and virtually costless.[5]

17.2. CHALLENGES AND RATIONALE

Despite being home to the largest number of children and adolescents with T1D in the world[6], nutrition education remains largely underexplored in India. The variability of traditional meal practices, regional cuisines, and cultural preferences across the country pose significant challenges to developing universally acceptable nutritional guidelines.[7] Moreover, language barriers, economic disparities, and varying levels of technology adoption and literacy rates across different regions hinder the widespread dissemination of nutrition education.[1,8] Nutritional counseling for food-insecure families should consider their incomes and living standards[8], keeping in mind that "food insecurity" due to erratic meal timings may not be only in low socioeconomic status families, but in anyone with erratic lifestyle and meal timings. Managing T1D is complex, and nutrition is best handled by offering a comprehensive approach that includes various resources, such as measurement tools, educational materials, and technological aids. However, the breadth and depth of information ideally required could potentially overwhelm the People with Diabetes (PwD) and caregivers, particularly the newly diagnosed, those who have limited health literacy or indeed literacy, or have misconceptions about diabetes and its management. The complexity of topics, the numerous tools and resources available, and the learning curve associated with acquiring new skills like Carbohydrate Counting (CC) and interpreting Continuous Glucose Monitoring (CGM) data may contribute to feelings of confusion and stress.

To mitigate these challenges, Healthcare Professionals (HCPs) and educators should adopt a patient-centered approach, providing tailored support, breaking down information into manageable chunks, and fostering a supportive environment where the PwD and caregivers feel comfortable seeking guidance and asking questions. By having their individual needs addressed, and being offered ongoing encouragement, they can feel more confident and empowered in managing diabetes effectively, using the abundance of available resources.

17.3. GENERAL PRINCIPLES OF NUTRITION EDUCATION FOR T1D

- *When to start?*
  The ideal time to start nutrition education is at the time of diagnosis of T1D.[8] Early dietary education enables caregivers to implement dietary strategies to maintain normoglycemia, learn about meal planning, understand CC, and foster positive dietary behaviors right from the beginning, which can improve glycemic control and quality of life.[9]
- *Who should deliver and whom to address?*
  It is advisable to include, wherever feasible, a pediatric diabetes educator and a specialist dietitian as part of the multidisciplinary team caring for children, adolescents, and adults with T1D. Where this is not possible, the HCP can take the help of experts via telemedicine and online sessions. Nutrition education sessions should involve all key family members involved in dietary decisions, e.g., grandparents, siblings, aunts, and uncles, especially in joint families. Encouraging children and adolescents with T1D to attend these discussions can enhance their understanding of the condition, give them flexibility in food choices, and help improve overall dietary adherence. The education should be tailored to the developmental age and receptivity of the PwD and caregivers, and should be provided in a manner that is simple, engaging, and easy to understand.[10]
  • *How to teach?*
  The education sessions can be conducted for individual, one-on-one; or in groups, as needed. Caregivers with poor literacy or comprehension may benefit initially from one-on-one sessions. Virtual platforms can target a wider audience, particularly in regions with limited access to healthcare facilities. Peer support can play a vital role in nutritional education. T1D support groups for various age groups and peer-led workshops focusing on nutrition and lifestyle management can provide PwD and their caregivers a platform to share their experiences and practical tips, providing valuable emotional and psychosocial support.[11]
  • *What to cover?*
  The initial sessions should assess the family's existing dietary habits, beliefs, and traditions and evaluate the PwD's dietary intake and activity patterns, while also building rapport. In subsequent sessions, the broad principles of MNT can be introduced, gradually moving to specific aspects such as taking care of macro- and micronutritional requirements, concepts of Glycemic Index (GI) and Glycemic Load (GL), CC, calculating Insulin-carbohydrate Ratio (ICR) and Insulin Correction Factor (ICF) to make dose adjustments to avoid post-meal glucose excursions. The sessions should be interactive, with caregivers encouraged to freely ask questions and discuss practical issues, such as family taboos, myths, or challenges faced at school, when eating out, etc.[12]
  • *Frequency of education sessions*
  Nutrition education is an ongoing process, with periodic reassessments to ensure that the PwD and caregivers are confident about various aspects of dietary management. The frequency of educa-

tion sessions and reassessments vary, based on individual needs and preferences; however, at least 3-4 follow-up visits a year with the dietitian are recommended.[13] These sessions can be clubbed with the physician visits to minimize additional visits and expenses.

• *Assessment and feedback*

Various assessment tools can be integrated into nutrition education programs for T1D to improve program effectiveness. Pre- and post-education questionnaires or surveys can be used to objectively assess changes in knowledge and confidence levels of the family.[14–16] Feedback sessions where the PwD and caregivers can provide suggestions for improvement, are useful. Blood Glucose (BG) records available through Self-monitoring of Blood Glucose (SMBG) by finger-prick or CGM can be analyzed to evaluate dietary adherence, provide constructive feedback to the family, appreciate positive behavior, and offer suggestions for improvement in a manner that is supportive and non-judgmental.

17.4. TEACHING TOOLS AND RESOURCES

17.4.1. Managing Diabetes with Traditional Indian Diets: Simple Guidelines

It is recommended that managing diabetes be taught with minimal changes to the pre-existing, likely traditional Indian diet, incorporating the Healthy Plate Model.

• **The Healthy Plate Model Method and Traditional Indian *Thali*:** Utilize the "Healthy Plate Model" for balanced eating for the entire family, using the traditional Indian *Thali* concept, with pulses, cooked and/ or salad vegetables, and cereal (wheat/ rice/ millets/ starchy vegetables), along with other components such as curd/ condiments/ beverage. (Figure 17.1) Divide the plate: half for veggies and fruit, one-quarter for protein, and one-quarter for carbohydrates, as described in the "Joslin Diabetes Center Healthy Plate".[17] This needs some modification because of overlapping categories since a significant source of proteins in the Indian diet, i.e., lentils, also have 50% carbohydrates. Apply the model to meal planning, shopping, and dining out. Emphasize *Thali* benefits, promoting balanced nutrition and portion control. Encouraging pride in their own culture, as it helps people feel connected, the HCP can help design "plates" based on the local cuisine, explaining using measuring cups and spoons.

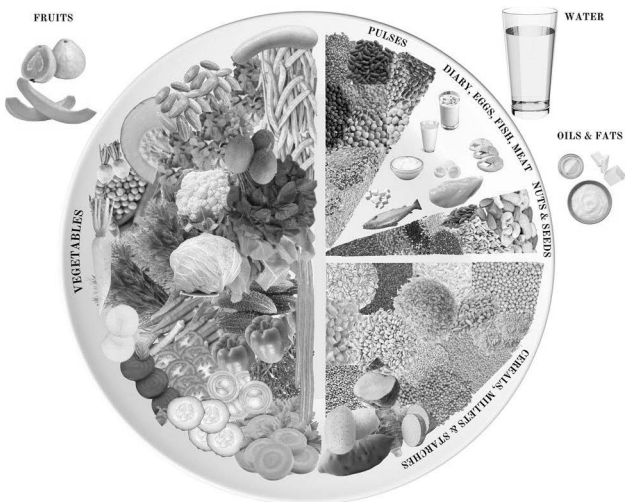


Figure 17.1: RSSDI: Indian Healthy Plate

17.4.2. Measurement Tools

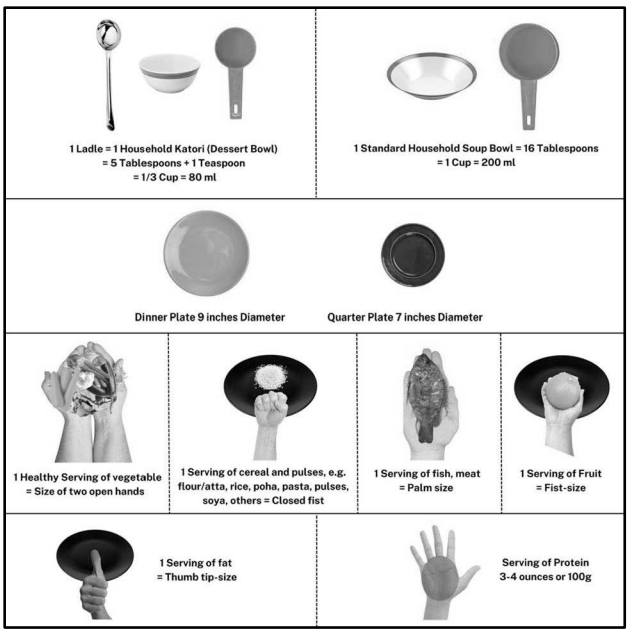
Accurate measurement aids in calculating carbohydrate content accurately, boosts adherence to dietary plans, ensures more stable BG levels, and optimizes T1D management.
Measurement Tools can be:

• **Common Household Measures:** Using everyday tools like food scales, measuring spoons, cups, and bowls helps measure food ingredients accurately, improving the precision of CC. This is particularly important in the first few months after diagnosis to get an idea of portion sizes in that household. Accuracy enables estimation of carbohydrate intake vs. carbohydrate goals.[18] Beyond counting carbohydrates, it is useful to estimate the protein and fat content in meals, which makes calculating insulin doses more accurate. (Figure 17.2 A & 17.2 B)

Figure 17.2 A: Common Household Measures

• **Hand Size Measures:** If measuring cups and spoons are not available, using simple hand measurements like a fist for carbohydrates, palm for proteins, and thumb for fats helps estimate and balance portion sizes approximately; this may give some help in managing BG and sticking to a healthy diet. (Figure 17.2 B)

Figure 17.2 B: Hand Measures

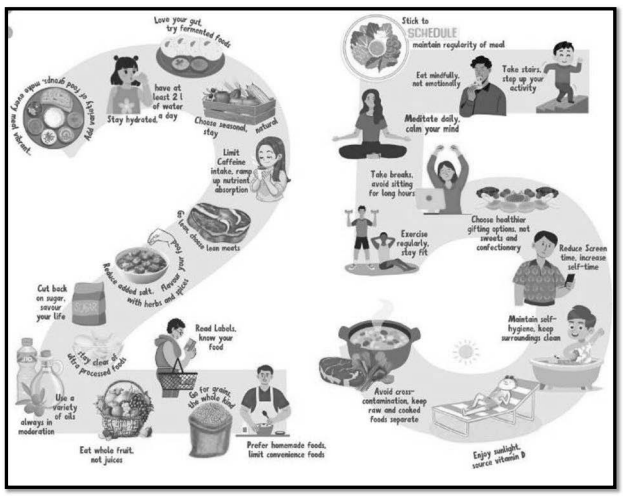


17.4.3. Triple Approach to T1D Education - Visual, Written, Audio

T1D education and management are enhanced using visuals, written materials, and audio aids.

• *Visual Illustrations/ Pictorial Representations:* Visual representations such as infographics, charts, videos, and digital tools simplify complex concepts related to T1D management. They also give a better understanding of dietary guidelines, portion control, and meal planning, especially for the uninitiated.[19] (refer to Figure 17.3 for the visual representation of healthy habits by ICMR-NIN)

Figure 17.3: Healthy Habits for the Body and Mind (picture credits: ICMR-NIN)



• *Handbooks/ Leaflets/ Brochures:* Written materials provide detailed information that can be read and understood at leisure. They provide practical tips, meal plans, success stories, and clear images to reinforce key concepts.[20]
• *Audio-Visual Aids:* Educational videos, podcasts, and virtual cooking classes add another dimension to T1D education. These resources can offer interactive learning experiences, providing auditory and visual cues to reinforce learning. Audio-visual aids are helpful for people who like to learn by listening or seeing things demonstrated.[21]

Combining visual, written, and audio-visual educational tools gives individuals a well-rounded and engaging learning experience. Sharing positive experiences of people successfully managing diabetes can be inspiring for others.

17.4.4. CGM as a (Nutrition) Education Tool

CGM helps understand how different foods affect BG levels in real-time and is thus a valuable tool for nutrition education. It also allows PwD and families to explore other aspects of the meal's impact, like portion size, timing, and sequence of eating, and allows for informed dietary choices, leading to healthier eating habits and better diabetes management.[22]

17.4.5. Carbohydrate Counting (CC)

CC is important for regulating BG, calculating insulin needs accurately, and enabling meal plan flexibility, thus improving glycemic control.[23] Regular education and support from the HCPs are needed to master CC skills. (refer to Chapter 5) These are the different tiers of CC to explore:

• *Understanding Carbohydrates:* Educate on identifying carbohydrates in foods, as well as foods that have low or no carbohydrates, using handouts, food labels, smartphone applications, and guides.[24]
• *Portion Estimation:* Teach sizing for accurate carbohydrate assessment in meals and snacks.
• *Basic Method:* Start with total carbohydrate grams per meal, using labels, hand measures, and cups. Measure and record staple foods at home, like *chapati*, dal, and rice, to track carbohydrate intake. Use the same bowl each time for easy counting, and to avoid needing to measure each time for staple food items.
• *Advanced Method:* Consider GI, GL, fiber, and meal composition (including fat and protein). Use carbohydrate exchanges and insulin ratios for tailored doses.
• *Levels of Counting:* Apply at meal and snack levels for precise management.[25]

17.4.6. Food Exchanges

Integrate food exchange systems/ lists, which can be made available in hard copy and digital formats, to facilitate carbohydrate measurement and meal planning.[22] These systems categorize foods into groups based on their carbohydrate content, providing flexibility in food options for both traditional users (printed lists) and digital users (mobile apps, websites).[23] (refer to Chapter 5)

17.4.7. Carbohydrate Counting Applications, including Indian foods

CC applications like Nutrify India Now[26], MyFitnessPal[27], HealthifyMe[28], Contour Diabetes[29], Glucose Buddy[30], and MySugr[31] help to manage Indian foods by offering extensive databases and customization options for tracking carbohydrate intake. Regular use and consultation with HCPs enhance their effectiveness, permitting informed dietary choices even with diverse Indian cuisine.[32]

17.4.8. Books on T1D-specific Nutrition Education

The International Society for Pediatric and Adolescent Diabetes – Life For A Child (ISPAD-LFAC) book on "Healthy Eating and Carbohydrate Counting for Children and Adults with Type 1 Diabetes[23]," features Indian foods. Medtronic also has a "Nutrition Basics and Quick Guide to Carb Counting.[33]" These resources are easily accessible (links given below), as they are available online, free of cost, and offer tailored guidance and visual aids for accurate CC, focusing on Indian foods.

- Nutrition basics and a quick guide to carbohydrate counting https://www.medtronic-diabetes.in/sites/default/files/carb_counting_nutrition_combine_booklet_hr_new_nov_2018.pdf
- ISPAD-LFAC book for Indian foods (https://lifeforachild.org/wp-content/uploads/2022/05/Healthy_eating_and_carbohydrate_counting_Indian_foods_1stedition.pdf)

17.4.9. Mobile Applications for Tracking Food Intake and BG Levels

Applications like Dexcom G6[34], Freestyle Libre Link[35], Glimp, Medtronic Guardian Connect[36], Carelink[37], etc., enable regular BG monitoring, and thus promote awareness of the effects of dietary items, accurate CC, and better insulin dose adjustment. These applications analyze data over time, identifying trends like the impact of food on BG. Integration of CGM devices provides real-time insights for immediate adjustments. Some apps allow data sharing with HCPs, fostering remote monitoring and support. Overall, these applications empower proactive diabetes management.[38–40]

17.4.10. Interactive Educational Websites and Online Platforms

Several websites of reputed medical societies provide reliable diabetes information. Resources include online courses and talks for laypersons and HCPs, interactive features like quizzes and videos, tracking tools for health data, or online community support and discussions, to which families may be guided, while being cautioned that much of the information available online is unreliable. Some platforms offer virtual healthcare appointments.[23] Regular feedback from users is helpful.[41]

A few such websites include:

- Indian Society for Pediatric and Adolescent Endocrinology (ISPAE): https://ispae.org.in/
- Research Society for the Study of Diabetes in India (RSSDI): https://www.rssdi.in/newwebsite/index.php.
- Juvenile Diabetes Research Foundation (JDRF) India: https://www.jdrf.org/
- Blue Circle Diabetes Foundation: https://bluecircle.foundation/
- Dr. Mohan's Diabetes Specialties Centre: https://drmohans.com/
- Mayo Clinic: https://www.mayoclinic.org/
- Diabetes India: https://diabetesindia.com/
- Beyond Diabetes: https://beyondtype1.org/portfolio/

17.4.11. Reading Food Labels

Learning to read food labels, including serving size, carbohydrates, fiber, and sugars, is important to make smart food choices. Focusing on carbohydrates and portion sizes is needed to calculate insulin doses. The ingredient list must be checked for added or hidden sugars.[42] Label reading should be taught by the HCPs.[43] (refer to Chapter 4 & Chapter 5)

17.4.12. Culturally Relevant Resources for T1D Nutrition Education

Educational materials incorporating specific dietary habits and traditions of diverse cultural groups must be developed. They should be available in local languages to ensure accessibility, while maintaining accuracy and cultural context. Guidance in modifying traditional foods and enhancing their nutritional content while emphasizing their cultural significance is likely to improve adherence.

Standardized educational modules from basic to advanced

The material developed should cater to varying levels of complexity, from basic to advanced, to ensure it is suitable for PwD and families of different backgrounds. Basic modules should focus on fundamental concepts of T1D and provide simple nutrition and healthy eating guidelines and exchange lists suitable for beginners. Intermediate modules can delve deeper into topics such as basic CC, meal planning, and basic cooking techniques. Advanced modules should offer in-depth insights into nutrition, including detailed CC, accounting for fats and protein, using healthy fats, and managing BG during physical activity. (Table 17.1)

Table 17.1: Levels of Nutrition education for T1D: Recommendations[44]

	Comprehensive Care	*Intermediate Care*	*Minimum Care*
Goal	Achieve optimal BG control and overall health through a personalized nutrition plan.	Support BG control with essential nutrition education.	Provide basic guidance for BG control and prevention of complications.
Individualized Approach	Tailor meal plans to unique needs and preferences, including CC.	Offer general advice on healthy eating, portion control, and carbohydrate awareness.	Offer balanced meal plans and basic nutrition education by teaching recognition of macronutrients and fiber.
Ongoing Support	Provide ongoing education and access to resources for sustained management.	Introduce CC and tracking BG for better understanding.	Encourage regular BG monitoring and follow-up appointments.
Behavioral Strategies	Address challenges with food choices and habits.	Conduct educational workshops for peer support. Address conscious food choices.	Provide guideline handouts. Focus on nutrition benefits they can relate to, e.g., improved growth, strength, etc. Encourage experts to log a food diary for evaluation and modification.
Access to teaching tools/ resources	Ensure the availability of counseling and tools for informed decision-making.	Provide resources for self-learning and reinforcement.	Connect individuals to community resources for additional support.

Hands-on learning Activities for T1D Nutrition Education, with simultaneous BG monitoring

Enjoyable, practical learning experiences like using food models, cooking workshops, family contests, encouraging interactive group activities, and motivation to manage diabetes can help with complex skills like CC.[45] Make the family understand that effective BG control and diabetes management hinge on meal planning, stressing the significance of CC and portion management. Organize interactive sessions where participants work together to select meals and estimate carbohydrate content, monitor BG before and after meals, and understand the implications of meal planning. They should be able to grasp the glycemic response to various foods and correlate with insulin doses.[46]

Cooking Workshops for T1D Management

Cooking workshops at different levels – large-scale events, small gatherings, as a part of cooking classes, and even as a routine at every diabetes clinic, can be worthwhile.[47] Guest speakers, including persons successfully living with diabetes, can be invited. The agenda should cover dietary importance, measurement tools (cups, spoons, food weighing scales), and healthy recipe demonstrations, using visual aids and models to explain portion sizes and cooking techniques.[33] Incorporating pre-recorded video demonstrations and question-and-answer sessions, providing video recordings and recipe cards for future reference, and seeking feedback to improve future workshops can result in effective learning. By following this structured approach of periodic workshops, clinics can educate individuals with diabetes and families about dietary management during working hours, empowering them to make healthier choices.

Family Cooking Contest with T1D-Friendly Recipes

Family cooking contests can be organized, choosing themes such as "Healthy Comfort Foods" or "International Cuisine with a Twist" to inspire T1D-friendly recipes. Encourage families to submit balanced recipe videos and recipes focusing on nutrition and portion control. Promote cooking participation from all family members to foster teamwork.[48] Judging criteria should include nutritional value, taste, creativity, presentation, and adherence to T1D dietary principles. Incorporate tasting, judging, prizes, and recognition to boost engagement. These contests promote healthy habits, creativity, and family unity while raising awareness about nutrition management in T1D.[49,50]

Grocery Store Tours with Focus on T1D-Friendly Food Choices

Grocery store tours led by diabetes educators, focusing on T1D-friendly food choices, have been found useful. Participants learn to identify T1D-friendly foods, read labels, and plan balanced meals, with interactive learning boosting confidence.[51]

17.5. SUMMARY & RECOMMENDATIONS

- Nutrition education is best initiated at the time of diagnosis of T1D and has to be ongoing.
- For the HCPs to provide diabetes education, the approach to teaching and the knowledge of teaching resources and tools for nutrition education are as important as the nutrition education content.
- For nutrition education to be effective, locally customized resources of differing levels of complexity have to be developed and used, tailoring resources to the individual's educational, financial, and motivation status and needs.
- All key family members should be involved in meal planning and CC. Including a pediatric diabetes educator and dietitian in the care team can greatly support nutrition education.
- One-on-one or virtual sessions, peer-led workshops, and support groups offer flexible education options, particularly for caregivers with low literacy or those in remote regions.
- Regular follow-up sessions, ideally 3-4 times per year, help reinforce dietary strategies, address questions, and assess knowledge retention. Combining these sessions with medical visits can improve convenience and reduce costs.
- Using household tools for measuring food portions helps caregivers accurately estimate carbohydrates, proteins, and fats, essential for insulin dosing and BG control.
- Teaching CC skills using hand measures, household utensils, and food labels supports BG control and dietary flexibility. CC applications, especially those tailored for Indian foods, provide additional support.
- Technology can be a very useful tool, with CGM and smartphone applications helping the PwD and family understand the basic principles of nutrition management and adjustments needed for good glycemic control and quality of life. The care team should make sure reliable applications and information are being used by the families.

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APPENDIX

Healthy plates (Veg)

Healthy plates (Non-veg)

ABBREVIATIONS RSSDI T1D NUTRITION GUIDELINES

ABC: Automated Bolus Calculator
ACSM: American College of Sports Medicine
ADA: American Diabetes Association
ADI: Acceptable Daily Intake
AHCL: Advanced Hybrid Closed Loop
AI: Artificial Intelligence
AID: Automated Insulin Delivery
AMA: Advanced Meal Assist
AMDR: Acceptable Macronutrient Distribution Range
BCAA: Branched-chain Amino Acids
BDI: Beck Depression Inventory
BG: Blood Glucose
BGM: Blood Glucose Monitoring
BMI: Body Mass Index
BP: Blood Pressure
CBSE: Central Board of Secondary Education
CC: Carbohydrate Counting
CD: Celiac Disease
CDRR: Chronic Disease Reduction Risk
CE: Conformité Européene
CGM: Continuous Glucose Monitoring
CHILD: Cardiovascular Health Integrated Lifestyle Diet
COVID 2019: Coronavirus Disease 2019
CSII: Continuous Subcutaneous Insulin Infusion
CV: Cardiovascular
CVD: Cardiovascular Disorders
DASH: Dietary Approaches to Stop Hypertension
DCCT: Diabetes Control and Complications Trial
DDS: Diabetic Distress Scale
DEB: Disordered Eating Behaviors
DEPS-R: Diabetes Eating Problems Survey-Revised
DHA: Docosahexaenoic Acid
DIYAP: Do It Yourself Artificial Pancreas
DKA: Diabetic Ketoacidosis
DKD: Diabetic Kidney Disease
DMP: Diabetes Management Plan
DRI: Dietary Reference Intakes
DSME: Diabetes Self-Management Education
DTMS: Diabetes Tele Management System
EAR: Estimated Average Requirement
ED: Eating Disorders
EDIC: Epidemiology of Diabetes Interventions and Complications
EMR: Electronic Medical Record
EPA: Eicosapentaenoic
ESP: Eating Disorder Screen for Primary Care
FBG: Fasting Blood Glucose
FDA: Food and Drug Administration
FSSAI: Food Safety and Standards Authority of India
GAD-7: General Anxiety Disorder
GFD: Gluten-free Diet
GI: Glycemic Index
GL: Glycemic Load
GRAS: Generally Recognized as Safe
GWG: Gestational Weight Gain
HbA1c: Glycated Hemoglobin
HCP: Healthcare Professionals
HDL-C: High-density Lipoprotein Cholesterol
HDL: High-density Lipoprotein
HFCS: High Fructose Corn Syrup
HFSS: High Fat Sugar Salt
HFSS: High Fat, Sugar, and Salt
HIIT: High-intensity interval training
IAP: Indian Academy of Pediatrics
IBW: Ideal Body Weight
ICF: Insulin Correction Factor
ICMR-NIN: Indian Council of Medical Research - National Institute of Nutrition
ICMR: Indian Council of Medical Research
ICR: Insulin-Carbohydrate Ratio
ICT: Information and Communication Technology
IDF: International Diabetes Federation
IOB: Insulin on Board
ISAPP: International Scientific Association for Probiotics and Prebiotics
ICF: Insulin Correction Factor
ISF: Insulin Sensitivity Factor
ISPAD: International Society for Pediatric and Adolescent Diabetes
ISPAE: Indian Society for Pediatric and Adolescent Endocrinology
IV: Intravenous
LCD: Low-carbohydrate Diet
LDL: Low-density Lipoprotein
LMIC: Lower and Middle Income Countries
MDI: Multiple Daily Injection
MEDFICTS: Meats, Eggs, Dairy, Fried foods, fat In baked goods, Convenience foods, fats added at the Table and Snacks
MNT: Medical Nutrition Therapy
MPH: Mid-parental Height
mSCOFF: modified Sick, Control, One, Fat, Food
MUFA: Monounsaturated Fatty Acids
NASEM: National Academies of Science, Engineering and Medicine
NCPCR: National Commission for Protection of Child Rights
NFC: Near-Field Connectivity
NGO: Non-Governmental Organization

NNS: Non-nutritive Sweeteners
NPH: Neutral protamine Hagedorn
OPD: Outpatient Department
ORS: Oral Rehydration Salt
OS-AID: Open-source Automated Insulin Dosing
PA: Physical Activity
PDE: Pediatric Diabetes Educators
PE: Physical Education
PHQ-9: Patient Health Questionnaire
PP: Post-prandial
PPBG: Post-prandial Blood Glucose
PT: Physical training
PUFA: Polyunsaturated Fatty Acids
PwD: People with Diabetes
QoL: Quality of Life
RAA: Rapid Acting Analog
RDA: Recommended Dietary Allowance
RIR: Readings In Range
RSSDI: Research Society for the Study of Diabetes in India
SAP: Sensor-augmented Pump
SCARED: Screen for Child Anxiety Related Disorders
SFA: Saturated Fatty Acids
SMB: Super-micro-boluses
SMBG: Self Monitoring Blood Glucose
SSB: Sugar-sweetened Beverages
T1D: Type 1 Diabetes Mellitus
T2D: Type 2 Diabetes Mellitus
TAR: Time Above Range
TBR: Time Below Range
TC: Total Cholesterol
TDD: Total Daily Dose
TEDDY: The Environmental Determinants of Diabetes in the Young
TFAs: Trans Fatty Acids
TG: Triglycerides
TIR: Time In Range
TSH: Thyroid Stimulating Hormone
TTG-IgA: Tissue Transglutaminase IgA
TUL: Tolerable Upper Limit
UPF: Ultra-processed Foods
VLCD: Very-low-calorie Diet
WHO: World Health Organization