ISPAD Clinical Practice Consensus Guidelines 2022:

Nutritional Management in Children and Adolescents with Diabetes

S. Francesca Annan\textsuperscript{a}, Laurie A. Higgins\textsuperscript{b}, Elisabeth Jelleryd\textsuperscript{c}, Tamara Hannon\textsuperscript{d}, Shelley Rose\textsuperscript{e}, Sheryl Salis\textsuperscript{f}, Juliana Baptista\textsuperscript{g}, Paula Chinchilla\textsuperscript{h}, M. Loredana Marcovecchio\textsuperscript{i}

\textsuperscript{a}University College London Hospitals, London, UK
\textsuperscript{b}Pediatric, Adolescent and Young Adult Section, Joslin Diabetes Center, Boston, MA, USA
\textsuperscript{c}Karolinska University Hospital, Stockholm, Sweden.
\textsuperscript{d}School of Medicine, Indiana University, Indianapolis, IN, USA.
\textsuperscript{e}Diabetes & Endocrinology Service, MidCentral District Health Board, Palmerston North, New Zealand
\textsuperscript{f}Department of Nutrition, Nurture Health Solutions, Mumbai, India
\textsuperscript{g}Sao Paolo, Brazil
\textsuperscript{h}London North West Healthcare NHS Trust, London, UK
\textsuperscript{i}Department of Paediatrics, University of Cambridge and Cambridge University Hospitals NHS Foundation Trust, Cambridge, UK

Corresponding author:
Francesca Annan, University College London Hospitals, London, UK, email: francesca.annan@nhs.net

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1. SUMMARY OF WHAT IS NEW OR DIFFERENT

• The guide to the distribution of macronutrients has been updated and re-enforces family preferences and healthy eating patterns
• Food security should be assessed, and advice adapted to the resources of the family
• Non-medical Insulin adjustment and prescribing by dieticians should be considered where health settings allow
• Continuous glucose monitoring is a useful tool for educating both the clinician and young person with diabetes on food related behaviors and the impact of specific meals on glucose levels.

2. EXECUTIVE SUMMARY

• Nutrition therapy is recommended for all children and adolescents with diabetes. Nutritional advice should be adapted to cultural, ethnic and family traditions, as well as the cognitive and psychosocial circumstances of the child and family (E)
• Implementation of an individualized meal plan with prandial insulin adjustments improves glycemic control (A)
• Dietary recommendations are based on healthy eating principles suitable for all children and families with the aim of improving diabetes outcomes and reducing cardiovascular risk (E)
• A specialist pediatric dietician with experience in pediatric diabetes should be part of the multidisciplinary team and should be available as soon as possible at diagnosis to develop a consistent relationship with the people with diabetes and their families (E)
• Energy intake and essential nutrients should aim to maintain ideal body weight, optimal growth and development and help to prevent acute and chronic complications. Regular monitoring of height and weight is required to identify both excessive weight gain and failure to grow (C)
• The optimal macronutrient distribution varies depending on an individualized assessment of the young person. As a guide, Carbohydrate should approximate 40-50% of energy, Fat <35% of energy (saturated fat <10%), and Protein 15-25% of energy (C)

• Matching of insulin dose to carbohydrate intake on intensive insulin regimens allows greater flexibility in carbohydrate intake and mealtimes, with improvements in glycemic control and quality of life (A). Meal-time routines and dietary quality are important for optimal glycemic outcomes (B)

• Fixed insulin regimens require consistency in carbohydrate amount and timing to improve glycemic control and reduce the risk of hypoglycemia (C)

• Pre-prandial insulin dosing should be encouraged from diabetes onset for children of all ages (A)

• Carbohydrate counting is best introduced at onset of type 1 diabetes (T1D) and should include education about the impact of mixed meals on post-prandial glucose profiles. (E)

• There are several methods of quantifying carbohydrate (CHO) intake (gram increments, 10-12 g CHO Portions and 15g CHO Exchanges). There is no strong evidence to suggest that one method is superior to another (E)

• The use of the glycemic index provides additional benefit to glycemic control over that observed when total carbohydrate is considered alone (B)

• Dietary fat and protein affect early and delayed postprandial glycemia (A). Changes to both the insulin dose and pattern of delivery are needed for meals higher in protein and fat (A).

• Prevention of overweight and obesity in pediatric T1D is a key management strategy and should be based on a family-based approach (B)

• Repeated episodes of diabetic ketoacidosis or worsening glycemic control may be a sign of disordered eating (C)

• Nutritional advice should be provided on how to successfully manage both regular and unanticipated physical activity; and how to meet individual goals in competitive sports (E)
Nutritional management of type 2 diabetes (T2D) requires a family and community approach to address the fundamental problems of excessive weight gain, lack of physical activity and the increased risks of cardiovascular disease (E).

3. INTRODUCTION

Nutritional management is one of the cornerstones of diabetes care and education. Different countries and regions have widely varying cultures and socio-economic status that influence and dominate dietary habits. Although there is strong evidence for nutritional requirements in young people, the scientific evidence base for many aspects of diabetes dietary management is still emerging and it is important to individualize nutrition interventions and meal plans.

These consensus guidelines are an update from 2018 that reflect national and international pediatric position/consensus statements(1-4) and, whilst considerations of evidence derived from recommendations for adults with diabetes (5, 6) are included, this chapter is aimed at the pediatric and adolescent population. Nutritional advice for young adults (18-24 years) should be based on the adult nutrition recommendations (5-7).

A need for further research remains in many areas of pediatric diabetes management and education, particularly in effective nutrition therapy interventions in relation to long-term outcomes, newer technologies and hybrid closed loop (HCL) systems.

Dietary recommendations for children and adolescents with diabetes are based on population healthy eating recommendations (1, 4) and therefore are suitable for the whole family. Nutritional advice must be adapted to cultural, ethnic, and family traditions and the psychosocial needs of the individual child/adolescent. Regardless of nation and economic status, consideration should be given to food security. Likewise, the choice of insulin regimen, where possible, should account for the dietary habits and lifestyle of the child.

A specialist pediatric dietician with experience in pediatric diabetes should be available wherever possible as part of a pediatric multidisciplinary diabetes care team to provide education, monitoring
and support to the child, parents, carers, extended family, nursery, schoolteachers, and babysitters (8, 9). Access to qualified nutrition professionals varies across the world. Recognized qualifications may be in nutrition and/or dietetics. The definition of a dietician according to the international confederation of dieticians is “a person with a qualification in nutrition and dietetics recognized by national authority(s). The dietician applies the science of nutrition to the feeding and education of groups of people and individuals in health and disease”. There is currently no information on the number of children living with diabetes who do not have access to a qualified nutrition professional.

There is limited data on the impact of access to qualified nutrition professionals in children with diabetes. Data from adult care (10, 11) and other long-term conditions (12) supports the effectiveness of qualified dieticians and nutrition professionals as part of multidisciplinary care teams.

The dietician should advise on planning, content, and the timing of snacks/meals in the context of each child’s individual circumstances, lifestyle and the insulin action profile and insulin dose adjustment. The extended role of the dietician can and should include medicines management (adjustment of insulin doses and other medications and prescribing of insulin and other medications) in countries where qualifications are available. Non-medical prescribing by allied health professionals has been shown to be safe, improve satisfaction and access to timely advice across a range of long-term conditions (13, 14).

Nutrition therapy, when used in combination with other components of diabetes care, can further improve clinical and metabolic outcomes (15). Nutritional education and lifestyle counselling should be adapted to individual needs and delivered in a person-centered manner. Education can be delivered both to the individual child and family and in small group settings. It is important that the whole family is involved in making appropriate changes based on healthy eating principles. Regularity in mealtimes and routines where the child and family sit down and eat together, helping to establish better eating practices and monitoring of food intake has been shown to be associated with better glycemic outcomes (16, 17).
The impact of diabetes on eating behavior must not be underestimated and may cause psychological disturbances. Therefore, experienced professionals should facilitate dietary and lifestyle changes. Education should include behavior change approaches, motivational interviewing and/or counseling and should be regularly reviewed to meet the constantly changing needs and requirements of the developing child. In order to be most effective, the dietician needs to develop a consistent, trusting and supportive relationship with the families concerned (18, 19) and also have clear agreed goals with the multidisciplinary team (20).

These recommendations target healthy eating principles, glycemic control, the reduction of cardiovascular risk factors, the maintenance of psychosocial well-being and family dynamics. Use of these recommendations should acknowledge the impact of food security on the ability to adhere to treatment guidelines.

4. AIMS OF NUTRITIONAL MANAGEMENT

• Encourage appropriate eating behavior and healthy lifelong eating habits whilst preserving social, cultural, and psychological well-being
• Three meals a day incorporating a wide variety of nutritious foods from all food groups, with appropriate healthy snacks (if necessary), will supply all essential nutrients, maintain a healthy weight, prevent binge-eating, and provides a framework for regular monitoring of blood glucose levels and supervision of insulin doses (as required)
• Provide sufficient and appropriate energy intake and nutrients for optimal growth, development, and good health. Avoid restrictive diets as they may result in poor growth, nutrient deficiencies and increased psychosocial burden
• Achieve and maintain an appropriate Body Mass Index (BMI) and waist circumference. This includes the strong recommendation for children and young people to undertake regular physical activity
• Achieve a balance between food intake, metabolic requirements, energy expenditure and insulin action profiles to attain optimum glycemic control
• Reduce the risk of vascular complications, particularly cardiovascular disease (CVD)
• Develop a supportive relationship to facilitate behavior change and positive dietary modifications
• Tailor advice to individual goals, including appropriate energy intake, weight loss and high-level sports goals
• Use diabetes technologies such as continuous glucose monitoring to aid dietary education and inform prandial insulin adjustments and dietary modifications

5. GUIDELINES ON NUTRITION FOR HEALTH, GROWTH AND DEVELOPMENT

5.1 Energy balance

All children and adolescents need access to adequate amounts of good quality food, that provides sufficient energy to support their growth and development, and to maintain a healthy body weight (21). When a child is diagnosed with diabetes, a specialist pediatric dietician should assess the food intake and eating patterns of each family, and offer advice to help them develop a routine meal plan that meets their child’s nutritional needs, and provides adequate energy for an active lifestyle (3, 4, 8). For young people living with food insecurity, strategies to alleviate the challenges and stresses experienced by families finding it difficult to achieve the dietary recommendations for diabetes, need to be explored (22).

• Children’s energy requirements change as they grow and regular reviews of their food intake, particularly in younger children, are essential so families can retain flexibility with their meal plans (4, 23).

• Energy prediction equations are a useful guide to estimate energy requirements in young people, however, these calculations must be tailored to an eating plan that is achievable and meets the needs of the individual (24).

• Regular dietary reviews also help families understand how to adjust total energy intakes with
changes in age and stage of development, to promote optimal growth, and avoid restrictive diets (25) or over-nutrition that can lead to excess weight gain (26).

Some young people experience acute weight loss prior to the diagnosis of T1D, followed by an increased appetite soon after diagnosis, and this can lead to rapid weight gain if not monitored closely (27, 28). Nutrition education to guide families towards food and drink choices that reflect a balanced energy-appropriate diet will help restore body weight to a healthy range and achieve target glucose control early on (3, 4). An experienced team of professionals should provide regular clinical support to families following diabetes onset by optimizing insulin doses, providing medical nutrition therapy, and encouraging regular participation in physical activity (26).

- The first year following diabetes onset is a critical period to avoid substantial weight gain and promote maintenance of a healthy body weight over the longer term (29).

- Total energy intake and appetite can change significantly leading up to (and during) puberty, and this is an important time to routinely reassess individual’s nutritional requirements and habitual eating patterns and to consider screening for disordered eating behaviors (30, 31).

5.2 Maintenance of healthy body weight

Achieving and maintaining a healthy body weight is an important goal in the clinical management of diabetes in children and adolescents (32). The prevalence of overweight and obesity in youth with type 1 and T2D is at least as high as the general population (33, 34). Global trends in childhood obesity are multifactorial and related to changes in food intake, decreased physical activity, and the obesogenic environment; all contributing to a positive energy imbalance in recent decades (35).

- Diabetes teams can provide family-based guidance on modifiable lifestyle factors such as nutrition, physical activity, and healthy sleep behaviors, at diagnosis and on an ongoing basis.

- Healthy eating habits and daily physical activity are recommended for weight management and CVD risk reduction in youth with diabetes.

- Multi-national studies show that for large proportions of youth with T1D, patterns of high BMI can persist through puberty into late adolescence (36), particularly among females (36, 37),
increasing their risk of cardiovascular and other vascular complications of diabetes in adulthood (26, 37).

- Screening for cardiovascular risk factors and early interventions to reduce these factors is required from childhood (38).

- At each clinic visit, families can expect that children and adolescents will have their height and weight measured, BMI calculated, and growth monitored using appropriate growth charts, to identify any significant changes in weight or failure to grow (4). Waist circumference and waist/height ratios are less commonly measured in clinic but may be a more useful predictor than BMI of metabolic or cardiovascular risk in some population groups (34, 39).

- Dietary review with a specialist pediatric dietician is recommended for advice to prevent excess weight gain and how to adjust energy intake to support maintenance of a health body weight.

- Regular review of insulin requirements as children grow can minimize the need for large snacks between meals or before bed to prevent hypoglycemia.

- Similarly, adjustment of insulin in preference to intake of additional carbohydrate to prevent hypoglycemia during physical activity is recommended (40).

- The use of glucose monitoring technology can be a useful tool to assess amounts of carbohydrate needed to treat hypoglycemia and avoid overtreatment with additional snacks that can contribute to weight gain. The impact automated insulin delivery systems may have on the risk of weight gain in youth with T1D is as yet unknown. Healthy food choices in appropriate portion sizes in line with population recommendations are likely to remain a key recommendation.

5.3 Energy intake recommendations

A guide to the distribution of macronutrients according to total daily energy intake is as in Box 1.
These reflect guidelines for healthy eating for children without diabetes (41, 42). They are also based on food group servings to meet vitamins, minerals, and fiber recommendations for age, without supplementation. An optimal percentage of energy from macronutrients has not been defined and individual and family preferences should be considered (15). This may vary depending on meal patterns, cultural influences, and metabolic priorities. Restricted access to food may require adjustment of the contribution of carbohydrate to total energy intake to 60% to achieve an adequate intake of other micronutrients and vitamins. Dietary patterns that restrict intake from one macronutrient may compromise growth and lead to nutritional deficiencies (43).

Translation of the distribution of macronutrients is dependent on the estimation of total energy requirements. Dietary reference values (DRV) are guides for populations (43, 44) and individual estimation of energy requirements will ensure appropriate advice is provided. Use of the DRV/daily reference intake (DRI) for energy may result in recommendations to over or under consume macronutrients. For example, a calculation for a 7 years-old female with normal activity levels, on the 25th centile for weight and height versus use of a UK DRV is shown in Box 2.

Box 2: CHO calculation for 7 years old female with normal activity levels (25th centile weight and height)

<table>
<thead>
<tr>
<th>DRV</th>
<th>40% Energy as CHO</th>
<th>50% Energy as CHO</th>
<th>Calculated energy expenditure</th>
<th>40% Energy as CHO</th>
<th>50% Energy as CHO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1703kcal/day</td>
<td>170g/day</td>
<td>212g/day</td>
<td>1292kcal/day</td>
<td>129g/day</td>
<td>161g/day</td>
</tr>
</tbody>
</table>
National guidelines for adults and children with diabetes exist in many countries. Some, including those from Australia and Canada, recommend a carbohydrate intake of at least 45% energy (1, 6), whereas others, such as the UK or US adult recommendations, do not include an amount of carbohydrate expressed as a percentage of energy intake. Clinical consensus is that carbohydrate intakes in older, overweight, or obese adolescents may be lower (40% energy) with higher protein intakes (25% energy). The quality of fats is more important than the quantity, with a need to replace saturated fats with polyunsaturated and monounsaturated fats (45). In countries where the Mediterranean diet is followed, up to 40% of the diet may be from monounsaturated fat with no adverse impact on metabolic outcomes (46). Of concern, dietary studies of children with diabetes in many developed countries have found that as carbohydrate intake decreases, children tend to consume lower quality diets (47, 48).

6. FOOD COMPONENTS

6.1 Carbohydrates

Carbohydrate requirements in children and adolescents are individually determined based on age, gender, activity, and previous intake. Clinical evidence suggests that individuals can consume 40-50% energy from carbohydrate and achieve optimal postprandial glycemic control with appropriately matched insulin to carbohydrate ratios and insulin delivery. Healthy sources of carbohydrate foods such as whole grain breads and cereals, legumes (peas, beans, lentils), fruit, vegetables and low-fat dairy products (full fat in children under 2 years) should be encouraged to minimize glycemic excursions and improve dietary quality.

6.1.1 Low carbohydrate diets

There is increasing interest in utilizing low carbohydrate (<26% energy from carbohydrate) (49) and very low carbohydrate (20-50 g/day) diets as an adjunct treatment option for people with T1D (49, 50). Currently, scientific evidence is lacking to support the practice of very low carbohydrate
diets or excessive carbohydrate restriction in children and adolescents with T1D. Strict adherence to very low carbohydrate diets may result in ketonemia or ketosis, dyslipidemia, and disordered eating behaviors (43). There is evidence from ketogenic diets that very low carbohydrate diets can be nutritionally inadequate and result in growth failure (51). Restricted carbohydrate diets may increase the risk of hypoglycemia or potentially impair the effect of glucagon in hypoglycemia treatment (52)

Whether or not carbohydrate restriction is associated with better health outcomes in children and adolescents with T1D is not well-studied. Dietary intake studies in children and adolescents using intensive insulin therapy have previously reported an association between lower total carbohydrate intakes and less favorable glycemic outcomes. (53) However, other studies suggest lower daily intake of carbohydrate being associated with lower HbA1c (54). Current research in the field suffers from the problem of selection and reporting bias, as most data comes from those families/individuals who choose to follow carbohydrate restricted diets, rather than from clinical trials. Clearly, further research is needed to explore potential metabolic and glycemic benefits from moderate carbohydrate restriction in the management of diabetes.

While there is insufficient evidence to recommend very low carbohydrate diets in children and adolescents with diabetes, it is important to respectfully explore the reasons families may choose to implement carbohydrate restriction. The perception of what a carbohydrate restriction entails differs among families and diabetes care providers. An emphasis should be on maintaining positive relationships between the family and treating team. If an individual child or family chooses to routinely consume a moderately low (<40% energy) or low (<26% energy) carbohydrate diet it is recommended that they discuss this with a dietician to ensure the diet is nutritionally complete, particularly in regard to calcium, B vitamins, iron and fiber (43).

A specialist pediatric dietician will be able to complete a detailed dietary assessment with the family to understand the degree of carbohydrate restriction, discuss the risks associated with restrictive
diets in children and adolescents, including eating disorders (55), and offer a range of strategies the family can use to ensure their goals align with their child’s medical needs (8).

Regardless of the amount of carbohydrate in the diet, caregivers and children with diabetes require strategies to minimize the postprandial excursions caused by carbohydrate. Early pre-prandial insulin administration up to 15-20 mins before the meal (56) or the addition of a moderate amount of protein to a meal containing predominantly carbohydrate (57) can assist in reducing post-prandial excursions. Substituting low Glycemic Index (GI) for High GI carbohydrate (58, 59) and increasing dietary fiber intake (53) are other useful dietary options. A meal-time routine with limits on snacking episodes can assist in preventing prolonged periods of postprandial hyperglycemia (17).

6.1.2. Sucrose

Sucrose and sucrose-containing food and fluids should be consumed in the context of a healthy diet (60). Sucrose does not increase glycemia more than isocaloric amounts of starch (61). However, consumption of foods containing added sucrose should be minimized to avoid displacing nutrient-dense food choices and decreasing dietary quality. If added, sucrose should be appropriately balanced against insulin doses. Sucrose can provide up to 10% of total daily energy intake. Not all countries have a specific recommendation on the percentage of sugar or mono- or disaccharides in the diet.

Sucrose sweetened beverage consumption has been linked to excessive weight gain (62). Large quantities of sugary beverages cause high postprandial glucose peaks and is difficult to adequately cover with insulin. The consumption of sweetened drinks, soft-drinks and cordials should be discouraged for the whole family. Diet or light drinks can be recommended for children with diabetes instead of sugary drinks on special occasions. Sucrose may be used instead of glucose to prevent or treat hypoglycemia (63, 64). See ISPAD 2022 Consensus Guideline Chapter 11 on Management of Hypoglycemia in children and adolescents with diabetes for more details.

6.2 Fiber
There are wide variations in recommendations and intakes of fiber internationally (65), and amounts may be expressed as grammes/kilocalorie (g/kcal) or grammes/day (g/d). Recommendations are often made for adults with children expected to achieve a percentage of the adult recommendations. Reported intakes of fiber are often lower than recommended and vary geographically. Where available, national population guidelines on fiber intake should be followed. Where national recommendations do not exist the guidance in Table 1 can be used.

Table 1: Fiber recommendations

<table>
<thead>
<tr>
<th>Age</th>
<th>Fiber Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth through 1 year</td>
<td>Not determined</td>
</tr>
<tr>
<td>1 year or greater</td>
<td>14g/4184 kilojoule (1000 kcals) -3.3g/megajoule</td>
</tr>
<tr>
<td>Alternative Formula</td>
<td>Age in years + 5 = grams of fiber per day</td>
</tr>
</tbody>
</table>

- Intake of a variety of fiber containing foods such as legumes, fruit, vegetables, and wholegrain cereals should be encouraged. Soluble fiber in vegetables, legumes and fruit may be particularly useful in helping to reduce lipid levels (67).

- Dietary fiber intakes of children in many countries are lower than recommended (66).

- High fiber diets, especially from sources with insoluble fiber, are associated with lower CVD (68).

- Dietary fiber is associated with digestive health and modulates bowel function, fermentation, and effects of gut microbiota (68). Dietary fiber aids in laxation and should be increased slowly in the diet to prevent abdominal discomfort and should be accompanied by an increase in fluid intake.

- Increasing fiber intake can assist in improving glycemic control (53).

- Diet high in whole grains may help to improve satiety, replace more energy dense foods and prevent weight gain (69).

- Processed foods tend to be lower in fiber; therefore, unprocessed, fresh whole foods should be encouraged.
6.3 **Fats**

Population based nutritional guidelines recommend a fat intake of no greater than 30-40% total daily energy intake (25). A range of recommendations currently exist in adult diabetes guidelines, from no specific recommendation for percentage total energy up to 35% energy from fat (1, 5, 6). The American Heart Association Academy supports children consuming a healthy diet which limits saturated fat and recommends replacement with polyunsaturated and monounsaturated fat to reduce cardiovascular risk in later life (45).

High total fat intakes have been shown to increase the risk of overweight and obesity (25) and high saturated and trans-fat intakes have been linked to an increased risk of CVD (1). Studies show children and young people with diabetes consume fat and saturated fat above dietary recommendations (48).

The primary goal regarding dietary fat in clinical practice is to ensure saturated fat, trans fatty acid and total fat intakes do not exceed population recommendations. Monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) can be used as substitutes to improve the lipid profile (5). Eating patterns which resemble the Mediterranean diet (based on monounsaturated fats, wholegrain carbohydrate, plant-based food choices with a reduced intake of red and processed meats) are likely to be of benefit to long-term health and reduction of CVD risk (46, 70).

Care should be taken when giving dietary education that methods of quantifying carbohydrate do not increase total fat and/or saturated fat intake.

- Recommendations for saturated and trans fatty acids should be in line with those for the general population. No more than 10% energy from saturated fat is recommended (7). Saturated fat is the principal dietary determinant of plasma LDL cholesterol. Saturated fats are found in full fat dairy products, fatty meats, and high fat snacks. Trans fatty acids, formed when vegetable oils are processed and solidified (hydrogenation), are found in margarines, deep-frying fat, cooking fat and manufactured products such as cookies and cakes. Trans fat should be limited as much as possible.
• Replace saturated fat with unsaturated fats by using lean meats, fish, low fat dairy products and changing to MUFA and PUFA cooking oils and margarines.

• Unsaturated fatty acids are important components of lipid membranes

• MUFA (particularly cis configuration), found in olive, sesame and rapeseed oils, and also in nuts and peanut butter may be beneficial in controlling lipid levels and convey some protection against CVD. They are recommended replacements for saturated fats (45).

• PUFA derived from vegetable origins such as corn, sunflower, safflower, and soybean or from oily marine fish may assist in the reduction of lipid levels when substituted for saturated fat.

• Consumption of oily fish, which is rich in n-3 fatty acids, is recommended. Advice for children is to eat oily fish once or twice weekly in amounts of 80 – 120 grams (71).

• n-3 supplements or an increase in the intake of oily fish should be considered if triglyceride levels are elevated.

• The use of plant sterol and stanol esters (in margarine and dairy products) may be considered for children 5 years and older if total and/or LDL cholesterol remains elevated (72).

6.4 **Protein**

• Protein intake decreases during childhood from approximately 2 g/kg/day in early infancy to 1 g/kg/day for a 10 years-old and to 0.8 – 0.9 g/kg/day in later adolescence (73).

• Worldwide intake of protein varies greatly depending on economy and availability.

• Protein promotes growth only when sufficient total energy is available.

• High protein drink and food supplements are generally unnecessary for children with diabetes. Their use requires dietary review with individualized advice.

• Sources of vegetable protein such as legumes should be encouraged. Sources of animal protein also recommended include fish, lean cuts of meat and low fat dairy products (1).
• When persistent albuminuria, decreased glomerular filtration rate or established nephropathy occurs, excessive protein intake (>25% energy) should be avoided. It is prudent to advise that intake should be at the lower end of the recommended range for age (74). However, there is insufficient evidence to restrict protein intake. Any modifications to protein intake in adolescence should not interfere with normal growth and requires expert management by a dietician.

6.5 **Vitamins, minerals, and antioxidants**

Children with diabetes have the same vitamin and mineral requirements than other healthy children (1). There is no clear evidence of benefit from vitamin or mineral supplementation in children with diabetes who do not have underlying deficiencies (3).

Meal planning should optimize food choices to meet recommended dietary allowance/dietary reference intake for all micronutrients. Medical nutrition therapy visits with a dietician are recommended to ensure the child or adolescents’ diet is nutritionally complete.

6.6 **Sodium**

Children with diabetes should limit their sodium intake to at least that of recommendations for the general population. Guidelines for sodium intake in children 1 to 3 years: 1,000 mg/day (2.5 g salt/day); 4 to 8 years: 1,200 mg/day (3 g salt/day); 9 years and older: 1,500 mg/day (3.8 g salt/day). High dietary sodium intake in children with T1D is common and relates to vascular dysfunction (58).

6.7 **Alcohol and substance use**

In young people with T1D, drinking alcohol can contribute to a range of additional health risks, including hypoglycemia and/or hyperglycemia, making them more vulnerable to alcohol-related harms than youth without diabetes (75). Consequences of alcohol consumption in T1D can include
moderate or severe hypoglycemia due to suppression of gluconeogenesis, impaired growth hormone response, alcohol-induced hypo-unawareness, and increased risk of delayed hypoglycemia for 8-12 hours after drinking alcohol (76). Hyperglycemia is another consequence that can be related to drinking and occurs when consuming alcoholic beverages that are high in sugar, or by consuming additional carbohydrate before and after drinking to prevent hypoglycemia (75, 77).

In many countries there are strict limits on the minimum legal age required for the purchase of alcohol, but not always the same level of regulation on alcohol consumption. Alcohol is prohibited in many societies, however where there is exposure to alcohol, studies show adolescents and young adults with T1D have similar or slightly lower rates of participation in drinking alcohol compared to their peers without diabetes (78, 79). For those youth and families who have chosen to include alcohol in their lifestyle, encourage people to ask questions and raise awareness about the negative impact drinking alcohol can have in the short term on glucose levels and on the long term on cardiovascular risk (80). It is important for pediatric diabetes teams and families to talk with young people about alcohol, and to discuss the facts so that young people are supported to make better choices about drinking. These conversations can be part of a program of education that prepares adolescents for transition to adult services (81) or at any time there is a need identified to reduce the harm of alcohol and substance use (77, 82).

- Young people should be aware of the guidelines for sensible drinking for adults and understand this it is not recommended that children and adolescents consume alcohol (83).

- Education is needed on the alcohol content of different drinks and what defines a standard drink.

- Carbohydrate should be eaten before and/or during and/or after consuming alcohol. It may be also necessary to decrease the insulin dose, particularly if young people are physically active (e.g., dancing, walking) at the time that they are drinking.

- Young people should be aware there are different types of alcoholic drinks available and understand how these drinks might impact on glucose levels, for example, some drinks contain carbohydrates and can cause initial hyperglycemia, but contribute to risk of delayed hypoglycemia due to the
alcohol content.

- Advice should include avoidance of binge drinking (more than 4 standard drinks) and young people given practical suggestions to reduce alcohol intake if they are exposed over long periods of time, such as having low alcohol drinks or alternating between non-alcoholic sugar-free drinks (including water) and drinks containing alcohol. Low carbohydrate or ‘diabetic’ beers should be viewed with caution as many do not have reduced alcohol content.

- Alcohol intake in young people may lead to increased risk-taking behaviors and interfere with the ability to recognize hypoglycemia symptoms. It is important to carry diabetes identification and always have quick-acting carbohydrate treatment options available.

- Drinking alcohol can be a risk factor in young people not following their usual diabetes self-care routine, such as checking glucose levels, eating regular meals, adjusting their insulin with physical activity, and as a result, their glucose levels can become unpredictable or unmanageable (84).

- Excessive amounts of alcohol can cause vomiting and dehydration which can lead to diabetic ketoacidosis (DKA) and hospitalization (84, 85).

- Special care should be taken to prevent nocturnal hypoglycemia by having a carbohydrate snack at bedtime and monitoring glucose levels more often than usual during the night and the following day, at least until lunchtime (76). Continuous glucose monitoring can also be very helpful in preventing nocturnal hypoglycemia.

The health implications of using of cannabis and other substances (including tobacco, vaping and illicit drugs) should be discussed with adolescents and emerging young adults with diabetes as part of their routine care (82). Cannabis use is associated with changes in appetite and eating behaviors, inconsistent glucose monitoring and insulin administration (77, 86) and increased risk of DKA among adults with T1D (87). Young people with diabetes should be offered support to abstain from substance use and personalized harm-reduction strategies discussed with those at risk (88). Further research is needed to explore the potential metabolic and glycemic effects of emerging substances.
(including vaping) and the need for routine screening in young people with diabetes at risk of substance use disorders (89).

6.8 **Non-nutritive sweeteners and specially labeled diabetic foods**

Non-nutritive sweeteners provide insignificant amounts of energy and elicit a sweet sensation without increasing blood glucose or insulin concentrations. There are currently seven commonly used non-nutritive, FDA-approved sweeteners found to be safe when consumed within FDA acceptable daily intake amounts (ADI) that have been established in some countries (Table 2).

Table 2: Acceptable Daily Intake of Non-nutritive Sweeteners

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Sucralose</td>
<td>0-15 mg/kg body weight</td>
</tr>
<tr>
<td>Saccharin</td>
<td>0-5 mg/kg body weight</td>
</tr>
<tr>
<td>Acesulfame K</td>
<td>0-15 mg/kg body weight</td>
</tr>
<tr>
<td>Aspartame</td>
<td>0-40mg/kg body weight</td>
</tr>
<tr>
<td>Steviol glycosides (expressed as steviol)</td>
<td>0-4 mg/kg body weight</td>
</tr>
<tr>
<td>Monk Fruit/Luo Han Guo</td>
<td>Not specified</td>
</tr>
</tbody>
</table>

All of these FDA approved non-nutritive sweeteners are used in low sugar, “light” or “diet” products to improve sweetness and palatability.

- Country specific guidelines on the intake of sweeteners may exist that should be followed.
- International nutritional guidelines advise that a moderate amount of sucrose can be consumed by people with diabetes (1, 5) and diabetic labelled foods are not necessary.
- Diabetic labelled foods can be more expensive due to the cost of the ingredients, may be high in fat and may contain sweeteners with laxative effects such as polyols (sugar alcohols).
- Polyols (sorbitol, mannitol, erythritol, xylitol, D-tagatose, isomaltose, maltitol, lactitol and trehalose)
are used as sweeteners and bulking agents, are generally recognized as safe by the FDA. Polyols are only partially absorbed from the small intestine, allowing for the claim of reduced energy per gram. Polyols can cause diarrhea at ≥20 grams, especially in children. Some people may be much more sensitive to polyols in smaller amounts.

7. FOOD SECURITY

Food security is an important social determinant of health: Food security in a household exists when “all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life.”

Food Insecurity (FI) is the limitation in the accessibility and/or the lack of resources for nutritionally adequate and safe foods to support normal growth due to household-level economic and social conditions.

In 2019, an estimated 135 million people faced life-threatening FI, according to the World Food Program. Currently that number has risen to nearly double due to the coronavirus pandemic, with food emergencies afflicting countries that have not required interventions in the past.

Food security should be considered when applying the guidance in this chapter in clinical practice. The impact of FI was seen to be higher in youths and adults with T1D than in those without diabetes. Food-insecure populations are at risk for less diverse, lower quality diets, reduced micronutrient intake, iron-deficiency anemia, and low intake of fruits and vegetables.

Diabetes management is particularly challenging for families facing FI and the risks associated are amplified in children with diabetes, where nutrition plays a vital role in diabetes management. Limited budgets among food-insecure people lead to purchasing cheaper, energy dense foods, inexpensive poor-quality carbohydrates (refined grains, added sugars), lower nutrient dense foods which may increase dietary glycemic load, and therefore, worsen glycemic control. A study conducted in Jordan reported that obese individuals with diabetes who were severely food-insecure
had a significantly higher average BMI, even though they consumed fewer calories than mildly food-insecure or food-secure individuals leading to the “obesity-hunger paradox” (99).

FI is seen to be cyclic and episodic. This pattern of recurrent exposure to inadequate food may result in disordered eating, in particular binge-fast cycles. The cyclic nature of FI may therefore not only result in binge eating behaviors but may also interact with stress pathways that promote obesity (100, 101).

Nutritional counselling for food insecure young people with diabetes should be tailored to fit their incomes and living circumstances. Healthcare providers must try and understand the challenges that may hinder an individual’s ability to follow the prescribed diet and should consider the available resources for purchasing, preparing, and cooking food. Advice to shift dietary intake away from inexpensive carbohydrates and fats and toward vegetables, fruits, protein, and dairy products, while acknowledging limited budgets should be given. Discussing portion sizes of food items that are culturally preferable and acceptable to the people with diabetes and their families may be as important as recommending foods that are affordable. Identifying resources within neighborhoods may be a helpful strategy. The kitchen garden concept (growing vegetables in the backyard/terrace) may be appropriate in some settings (102). Nutrition counselling should include a discussion of how to adhere optimally to the dietary advice with limited access to nutritious foods to achieve healthier diets.

8. GUIDELINES FOR NUTRITIONAL CARE, EDUCATION, AND MEAL PLANNING

Initial dietary advice by a pediatric diabetes dietician should be provided as soon as possible after diagnosis to promote a secure, trusting, and supportive relationship (2, 19). A dietary history should be taken including:

- Pre-existing family dietary habits, traditions, and beliefs
- The child’s usual food intake including energy, carbohydrate amount and distribution, fat intake, quality of food choices and mealtimes or patterns of food intake
• The child’s daily activities including the impact of nursery/school/work, physical activity, and exercise schedules

Advice should be given at diagnosis based on the dietician’s assessment and the individualized plan provided by the diabetes team. Carbohydrate counting is best commenced at diagnosis for those using intensive insulin therapies (3).

A series of follow-up appointments should be completed with the specialist pediatric dietician within 3-6 months after diagnosis with the first review within a month after diagnosis (103). It is important that the initial assessment includes identification of any body image or weight concerns. Contacts thereafter depend on local arrangements, a minimum should include 2–4 times in the first year and annual reassessment (103). These are necessary to keep pace with the child’s growth, diabetes management, lifestyle changes and the identification of specific dietary problems such as dysfunctional eating habits, family issues around food, obesity and eating disorders. Ongoing support and review by a dietician is essential for optimal care (3). Frequency of review will be impacted by factors such as changing insulin regimen, dyslipidemia, need for age-appropriate education, weight gain or weight loss. Co-morbidities such as celiac disease require extra education and dietary intervention with more frequent review.

9. EDUCATION TOOLS, METHODS AND INSULIN REGIMENS

Education tools and methods are used to provide knowledge and skills to optimize glycemic control, growth, and cardiovascular outcomes.

• Methods of healthy eating education and tools for carbohydrate quantification are essential.

• There is a lack of high-quality, long-term, randomized studies to support one method of carbohydrate counting compared with another.

• Blood glucose monitoring (pre and post-prandial) or continuous glucose monitoring (CGM) provide essential information on post-prandial glucose excursions and can direct the education needed,
which may be a need to improve carbohydrate counting accuracy, adjustment of prandial insulin timing or amount, or alter the insulin delivery or dose for meals high in fat and protein (104)

- As families become more confident with managing diabetes, education should be responsive to their observations with whole food education used to explain glycemic index, mixed meal impacts and adjustment of insulin.
- Basic dietary education should cover healthy eating with some method of carbohydrate quantification.
- Delivery of education may be face to face, group or virtual. The use of telehealth and virtual consultations may help promote self-care and glucose management and improve access to nutrition education and advice (105).

9.1 Healthy eating education tools

Country specific education tools exist for population specific healthy eating education across the world. The Plate Model method (Fig. 1) is one example that can be useful in providing basic nutritional information and healthy eating concepts. The plate can be thought of as a guide to both the individual meal and the day as a whole. It provides a visual illustration of carbohydrate-containing foods in relation to other food components and is an attractive aid for visual learners. As part of healthy eating education regular meals and with small snacks if needed are encouraged to ensure that a range of nutrients are consumed to meet daily recommended requirements(106).
9.2 Carbohydrate assessment and methods

The amount of carbohydrate and premeal insulin bolus is one of the most important factors influencing postprandial glycemic control (60, 107). Other dietary variables such as glycemic index, fat, protein, and fiber impact postprandial glycemia and should be considered in interpreting and optimizing postprandial glucose levels (108, 109). However, most educational tools are based upon the premise that carbohydrate amount and type is recognized as the major determinant of the postprandial response and along with distribution of carbohydrate forms the basis of most education programs.

Extensive diabetes education materials are available in many countries to help adolescents and families estimate the carbohydrate content of foods in grams, portions, or exchanges. This approach is usually described as carbohydrate counting. Dietary sessions involve educating people with diabetes on how to read and interpret food labels, assess the carbohydrate content of the snack/meal, and understand the nutrient content of foods in order to make healthy choices. Most national diabetes associations also produce useful literature on how to read food labels. Carbohydrate counting education can improve glycemic control and increase flexibility in food
choices (110). Carbohydrate counting should be part of team-based approach to management that includes healthy eating principles and meal-time routines (23). Information about dietary quality and carbohydrate counting should be provided together, given that poor dietary quality has been widely described in young people living with T1D (111).

9.3 Dietary recommendations for specific insulin regimens

- **Twice daily insulin regimens**
  Twice daily insulin regimens of short and longer acting insulin require day-to-day consistency in carbohydrate intake (often as three regular meals with snacks between) to balance the insulin action profile and prevent hypoglycemia during periods of peak insulin action (112). Most twice daily insulin regimens require carbohydrate intake before bed to help in the prevention of nocturnal hypoglycemia. These insulin regimen should not be used in youth with T1D.

- **Intensive insulin regimens**
  A more flexible approach using individualized ICR, which enables the pre-prandial insulin dose to be matched to carbohydrate intake, should be used for children and adolescents on intensive insulin therapy. To assess the accuracy of the ICR information about post-prandial glucose profile is required. Although this method increases flexibility of the meal timing and the carbohydrate amount, mealtime routines and dietary quality remain important.

International consensus is that carbohydrate counting is best introduced at the onset of diabetes for those using intensive insulin therapy (see ISPAD 2022 consensus guidelines Chapter 9 on Insulin therapy).

Two systematic reviews, based mainly on studies in adults, have reported positive trends in glycemic and life-style benefits when carbohydrate counting is used as an intervention for people with T1D (113, 114). These benefits include improved glycemic control as measured by lower HbA1c levels; improved diabetes-specific quality of life; and improved coping ability in daily life (114, 115). Both
reviews concluded that carbohydrate counting was a useful method for insulin dosing. Nutrition guidance recommendations for adults receiving multiple daily injections (MDI) or continuous subcutaneous insulin therapy (CSII) state that carbohydrate counting using insulin-to-carbohydrate ratios should be used to optimize glycemic outcomes (15).

9.4 Insulin to Carbohydrate ratios

ICRs are used to determine insulin doses based on amounts of carbohydrate. Calculation and assessment of these ratios is considered in the chapter on insulin, however advice about management of post prandial glucose levels may include advice on adjustment of ICR or specific mealtime dosing strategies. The ICR is individualized for each child according to age, sex, pubertal status, duration of diagnosis and activity. This approach has been endorsed by several international clinical consensus guidelines (1, 60). In younger children using insulin pump therapy lower percentage basal insulin contribution is effective for achieving high time in range (116), and lower total basal insulin will usually result in the use of stronger ICRs. A number of formulas using total daily dose for calculation of ICR have been proposed, however those formulas such as the 500 rule initially used in adults can result in weak ICR in children (117). Suggested ICR for the pediatric and adolescent population can be found in the insulin chapter (see ISPAD 2022 Consensus guidelines Chapter 9 on Insulin therapy). Younger children often require stronger ICR compared to the total daily dose. Breakfast may also require a stronger insulin to carbohydrate ratio than other meals. When assessing ICR the meal composition and the timing of the insulin delivery should also be considered (118). Post prandial glucose responses in the first hour are most likely due to the timing of the insulin, between 90 minutes and 2 hours the predominant factor is probably carbohydrate and in the later period meal composition.

Studies in adults using multiple daily injections (MDI) with ICRs have shown improvements in dietary freedom, glycemic control, and quality of life (115), particularly if delivered as part of a
comprehensive education package. ICRs have also been evaluated in children and adolescents using MDI, often as part of structured education programs (119-122).

Care should be taken when an ICR is used in MDI and pump therapy, that the overall quality of the diet is not reduced (123). The use of mealtime insulin bolus calculators in both MDI therapy and insulin pump therapy has been shown to assist insulin dose calculations and potentially improve postprandial glycaemia (124-126) and reduce hypoglycemia fear (127).

In a large study of children, adolescents and young adults’ carbohydrate counting was related to better diabetes specific health related quality of life and optimal glycemic control (128). A recent small study confirmed improved quality of life associated with advanced carbohydrate counting (ACC) in children (129).

Methods of quantifying carbohydrate in common use include:

- Gram increments of carbohydrate
- 10-12 gram carbohydrate portions
- 15 gram carbohydrate exchanges

Research has not demonstrated that one method of teaching carbohydrate counting (grams, portions, or exchanges) is better than others (130). It has been shown that a single mealtime bolus of insulin may cover a range of carbohydrate intake without deterioration in postprandial control (131). The method of carbohydrate counting used will depend on local population needs.

Carbohydrate content of foods can be difficult to assess and there is a need for country and cuisine specific carbohydrate counting resources. ACC requires skills to quantify portion sizes, estimate carbohydrate contents of various foods consumed, read, and understand nutrition labeling on food packages. Access to measuring cups and spoons, food weighing scales, carbohydrate counting resources (pictures, weights, measures of food with carbohydrate counts, nutrition labels, apps and digital games) are useful tools to estimate carbohydrate contents of foods (125, 132). Bolus calculators (BC), used in association with carbohydrate counting, can aid insulin dose calculations.
and may further improve glycemic control (124). Adults trained in ACC using bolus calculators experienced less fear of hypoglycemia than those not using BC (114).

Accuracy in carbohydrate counting is important to optimize postprandial glycemia and reduce glucose variability (133, 134). There is no universal definition for accuracy and one study has shown that a variation of 20g between actual and calculated intake will impact on glycemic outcomes (134). Research has shown that children, adolescents and their parents can carbohydrate count with a degree of accuracy, however under and over-estimation of foods remains a challenge (135). Regular review of carbohydrate counting skills is necessary as children grow and new foods are introduced (130).

Methods to simplify carbohydrate counting can be used where numeracy and literacy may limit the ability of a family to adopt use of grams, portions, and exchanges. The use of the hand size measure is one example. Hand measures (Figure 2) can be used estimate the amount of food and carbohydrate amount.

Figure 2: Hand measures to estimate amount of food.

10. GLYCEMIC INDEX AND GLYCEMIC LOAD

The use of the glycemic index (GI) has been shown to provide additional benefit to glycemic management when used in addition to total carbohydrate (136, 137). In T1D GI should not be used in isolation, but together with a method of carbohydrate quantification (1). Suggested cut points for classification are: high (GI ≥70), medium (GI 56–69), and low (GI ≤55) GI values.

It has been demonstrated that high fiber, low GI foods can help delay the absorption of glucose into the bloodstream, consequently helping to manage blood glucose levels. The GI of a food is
influenced by factors such as cooking/preparation method, physical state of a food, type of starch, amount of fat and protein consumed with the food.

A controlled study in children using twice daily insulin, substituting low GI for high GI foods found that lower GI diet improved glycemic control after 12 months compared to prescriptive dietary advice (138).

In clinical practice GI is used as a tool to minimize post prandial glucose rises and to improve the quality of the diet.

- Low GI foods may lower postprandial hyperglycemia when they are chosen to replace higher GI foods (139). This has been demonstrated in a meal study with children using MDI(58).

- Low GI food sources include whole-grain breads, pasta, temperate fruits and dairy products (140).

- The GI of some foods can differ depending on the geographical location. Dairy products, legumes, pasta, and fruits tend to be low (GIs 55 or less on the glucose scale) and are remarkably consistent around the world. Cereals and cereal products, however, including whole-grain or whole-meal versions, show wide differences, presumably arising from variation in manufacturing methods. Breads, breakfast cereals, rice, and snack products are available in both high- and low-GI versions. Many varieties of potato and rice are high-GI foods, but more low-GI varieties have been identified by research and development.

- Education on GI should incorporate understanding of individual glucose responses to specific foods where information is available from continuous and intermittently scanned glucose monitoring devices.

- The timing and type of insulin delivery may be adjusted depending on the GI of the food. Early delivery of insulin with high GI foods may blunt post prandial glucose spikes and use of combination type bolus may be beneficial with lower GI foods (56).

Glycemic load (GL) is another method of predicting the postprandial blood glucose response, which considers both the GI of the food and the carbohydrate portion size(141). A small pilot study on the feasibility of GL counting in nine adults with T1D found that this method is feasible in real-life for
prandial insulin dose calculations (142). Further studies are needed to investigate the efficacy of GL for calculating the meal-time insulin dose.

11. MANAGEMENT OF MIXED MEALS

11.1 Fat and Protein

The meal-time insulin dose is typically calculated using an individualized ICR. The impact of fat and protein on post prandial glucose levels has been well established (109). Observations from pediatric and adult studies have shown that meals high in either protein or fat increase delayed hyperglycemia (up to 3-6 hours after the meal) and also reduce the early (1-2 hour) postprandial rise (57, 143-145). These studies highlight the limitations of carbohydrate-based only algorithms for insulin dosage calculations.

Several methods of adjusting insulin doses for fat and protein have been suggested including use of formula to calculate insulin dosing based on fat protein units (FPU) (146) and the Food Insulin Index (FII), has been developed and trialed in adults (147). More practical strategies include making percentage increases in insulin dose based on carbohydrate counting. A higher rate of clinically significant hypoglycemia has been observed in studies using the FPU formula which is a potential a limitation of this method (146, 148, 149). The FII has demonstrated variable outcomes in adult studies (150, 151). A comparison of carbohydrate counting, fat protein units and FII in a pediatric population demonstrated that there was no benefit of FII compared to carbohydrate counting. The fat protein unit formula showed increased post prandial time in range associated with an increase in hypoglycemia (152).

Management of mixed meals and the impact of fat and protein will depend on the method of insulin delivery and glucose monitoring. Currently most of the evidence to support optimal insulin bolus dose and delivery for meals high in fat and protein is specific to insulin pump therapy (153), with fewer studies available to inform management using multiple daily injection therapy and hybrid closed loop (HCL) systems.
• **CSII**

Published systematic reviews of the evidence for insulin dose adjustment for fat and protein provide a range of recommendations, from incremental dose increases up to 30-35% for meals high in fat and protein accompanied by an extended bolus, (56, 154) with other reviews suggesting that increased insulin requirements may range between 25 and 75%, with a starting adjustment of up to 60% dose increase administered 15 minutes before a high protein, high fat meal, using a combination type bolus with the remainder of the dose delivered over 3 hours (109). However substantial inter-individual differences exist in insulin dose requirements for fat and protein and individualized advice based on postprandial glucose monitoring up to 6 hours is required (155, 156).

• **MDI**

Data is available from studies showing that additional insulin for high protein and fat meals can be delivered in the pre-prandial injection. Positive outcomes have been reported using a 125% of the calculated insulin dose for carbohydrate content for a high fat and protein breakfast as a pre-prandial injection without adverse outcomes (157). One study using insulin doses calculated based on carbohydrate, fat and protein content of the meal showed improved post prandial glucose profiles without increased hypoglycemia; in this study the ICR was calculated using a 500-rule based on total daily dose (158).

• Adjustment of insulin doses for fat and protein should be made when there is evidence of the post-prandial impact for the individual. A suggested starting point for additional is a 20% increase in the dose calculated for carbohydrate alone.

• Education on the impact of fat protein is helpful from diagnosis to support understanding of the glycemic impact of mixed meals and foods. Education on assessing post-prandial glucose profiles should include understanding of when the raised glucose levels are likely to be due to the timing of insulin delivery (the first 60-90 minutes), carbohydrate content of the meal/food (90-120 minutes) fat, protein, and meal composition (120 – 300 minutes+).

• Education on the application of evidence of the impact of fat and protein may be beneficial for
example, adjusting breakfast content to contain protein to dampen post prandial spike, use of meals higher in protein when delayed hypoglycemia is a risk.

- Clinical assessment and use of CGM profiles should guide individual advice and recommendations on dose adjustment, the adjustment is likely to be influenced by several factors, which may include the rule or method used to calculate the ICR, the amount of carbohydrate in the meal, physical activity immediately before and after the meal along with the basal insulin type and amount.

- Insulin dosing software is an important tool to assist bolus insulin dose calculations. Pilot studies indicate insulin dosing applications are useful tools to assist accuracy and replace manual methods of meal-bolus estimations (159, 160). Evaluations of applications are needed in addition to evaluating their acceptability to individuals with diabetes.

The management of protein and fat in HCL systems is not well studied in adult or children yet. Clinical experience suggests that individual advice will be needed and some strategies to manage high fat and protein meals may be needed by some. To understand the advice that may be needed, the dietician needs to understand how the HCL algorithm adjusts insulin and the bolus options available. The timing of insulin bolus delivery remains important in HCL (161).

11.2 Timing and Type of Insulin Boluses

The timing of the prandial bolus is important. Several studies have shown that pre-prandial bolus insulin is preferable to insulin administered during or after the meal (58, 118, 162, 163). Delivering a bolus dose 15–20 min before eating rather than immediately before additionally improves postprandial glycemia (118). Newer rapid acting insulins also require pre-prandial dosing for optimal outcomes.

One of the advantages of CSII is its ability to tailor prandial insulin delivery to the meal composition. This enables the meal bolus to match the glycemic effect of the meal (low GI, high fat, or high protein content). For high fat, carbohydrate dense meals such as pizza and battered fish and chips, the combination bolus has been shown to most effectively match the postprandial glycemic profile.
A combination bolus prior to a low GI meal is also helpful in matching the postprandial glucose excursion (59). The combination bolus has similarly been used efficaciously for high protein, high fat meals, combined with additional insulin for the fat and protein components (109, 165).

A systematic review concluded differences in the duration and split of bolus types across studies, which make it difficult to recommend a specific duration and split for all meal types (56) (154).

Studies indicate intra-individual variation in the pattern of insulin delivery required for meals (109, 149). A study in children and adolescents found the optimum combination bolus split to maintain postprandial glycemia with a high-fat and high-protein meal was a 60/40% or 70/30% split delivered over 3 hours (166). However, a study in adults demonstrated the mean optimal pattern of delivery for a high protein, high fat meal was a 30/70% split delivered over 2.4 hours, with a range from 10%/90% to 50%/50% and a delivery duration from 2 to 3 hours (167). Studies have confirmed that the standard bolus is not as effective as the combination bolus for high fat and high protein meals (166, 168). In clinical practice, use of the combination bolus with sufficient insulin upfront to control the initial postprandial rise is needed. Initial experience with HCL systems suggests that the timing and delivery of insulin bolus with meals remains central to improved outcomes, with the ICR being one of the settings that the user can adjust (161).

For those on MDI, it has been suggested from clinical experience at some centers short-acting (regular/soluble) insulin may be given when a prolonged insulin effect is desired to match certain meals, for example high fat, carbohydrate dense foods. Two studies which have compared analog insulin (insulin aspart) and regular insulin have shown no benefit in substituting regular insulin for a faster acting analog (157, 169). Split insulin doses have also been recommended by some centers. One study examining this found that for a high fat, high carbohydrate meal administration of 130% of the prandial insulin dose as a split bolus (100%: 30%), 3 hours post meal consumption produced a glycemic response similar to the low-fat (5g) control condition with no increase in hypoglycemic episodes (170). When this dose was delivered as a normal bolus however, the incidence of hypoglycemia significantly increased. Another study looking at insulin delivery at breakfast
demonstrated that 125% of the calculated insulin dose can safely be given at this time for a high fat and protein meal without any benefit in splitting the dose. Pre- and post-prandial blood glucose testing at 1, 3, 5 and 7 hours or CGM can be useful in guiding insulin adjustments and evaluating the outcomes of changes to the insulin dose or timing (171)

- For all methods of insulin delivery optimal timing of prandial rapid acting insulin is before eating, insulin may be needed up to 20 minutes before meals to diminish the postprandial glucose excursions and to decrease the likelihood of insulin being forgotten (172).
- Snacks without insulin boluses and missed meal boluses result in deterioration of glycemic control (173-175).
- Grazing and snacking have been shown to worsen glycemic management (176).
- Both health care professionals and children, young people and families living with diabetes should be educated on the interpretation of glucose profiles after meals (177).

12. AGE GROUP SPECIFIC ADVICE

The challenges of nutrition education for children and adolescents with diabetes are often age-related and reflect the nutritional and developmental needs of different age groups. Family functioning and interactions at mealtimes have been demonstrated to impact on eating behavior and glycemic control in younger children (178) and adolescents (179). Adolescence represents a critical stage in the development of self-management of food intake and diabetes, accompanied by independent decisions about lifestyle choices, and education should be revised at this time. Below is a summary of the specific characteristics to consider when working with different age groups. See ISPAD 2022 Consensus Guidelines Chapter 23 on Managing Diabetes in Preschool Children and Chapter 21 on Managing Diabetes in Adolescents for more detailed information on the nutritional management in these age groups.

12.1 Toddler and Preschool children
• Toddlers have variable appetites. Routine, small meals over the day promote improvements in glycemic control and nutritional adequacy. Grazing on small foods quantities should be discouraged as this may contribute to food refusal issues at mealtimes and can result in postprandial hyperglycemia.

• Insulin pump therapy may help manage toddler-eating behaviors (16, 180). It is preferable that pre-prandial insulin doses are given (23), although the dose can be split to pre-prandial and during the meal when eating is erratic or new foods are offered.

• Positive parental role models and early participation in family meals may promote improved cooperation regarding food and healthy food choices. Discourage the re-introduction of a bottle of milk or juice for “easy” carbohydrate intake.

• Parental anxiety regarding food intake is common in this age group and strategies should be provided for pre-prandial dosing.

• Daycare providers and babysitters need instruction on diabetes management.

12.2 School-aged children

12.2.1 Diabetes in school

Managing diabetes in a school setting requires a high degree of teamwork, with families, teachers, foodservice providers, non-medical staff, school nurses and diabetes teams all having an active role to play (181, 182) (see ISPAD 2022 Consensus Guidelines Chapter 22 on Management of diabetes in School for more detailed information).

• A regular meal and snack plan usually works well in a school environment, although flexibility in the school timetable will be required for children to test glucose levels frequently across the day and be supported to take medications and remedial action to treat hypoglycemia and hyperglycemia as required.

• Diabetes management plans for each child need to be regularly updated and include information on the child’s routine eating plan and management of carbohydrate content of school meals or ‘lunchbox’ food.
• Some children will need encouragement to eat their food (and take insulin in required) before going out to play at break times.

• School staff (including non-medical and school nurses) will require further education and support from the family and diabetes team to appropriately supervise children taking insulin before food and apply effective diabetes management strategies (181, 183).

• The child’s diabetes management plan will need to be adjusted depending on their schedule during and after school, their insulin regimen, and availability of an adult to supervise and/or administer insulin and monitor glucose levels as required (102, 182). Schools will require individualized guidance for children participating in school events such as sports days, field trips and camps, and families may be asked to provide additional foods and diabetes supplies for these occasions (182).

12.2.2. Ongoing Education

The child should start to acquire an age appropriate recognition of carbohydrate foods and understanding of carbohydrate amounts in foods with supervision and support (135).

• Advice on healthy food choices, food portion size, and physical activity to reduce the risks of inappropriate weight gain and cardiovascular disease is important.

• Although some school-age children are gaining knowledge and skills in carbohydrate counting and glucose monitoring (184), when arranging play-dates, sleepovers and parties, families are encouraged to discuss their child’s normal routine for food, physical activity and sleep with other family members and friends, and be available to support their child’s diabetes management.

12.3 Adolescents

Adolescents may choose to be more independent in their food choices and have more freedom on what to eat, when and how much. This can negatively affect their glycemic management and food choices (185). If adolescents have been diagnosed during their childhood, re-education about the importance of healthy eating, nutrition and diabetes self-management may be needed.
Challenging behaviors may include staying out late, sleeping in, skipping insulin, missing meals and in some cultures, drinking alcohol.

Emphasis should be placed on the importance of healthy, routine meals particularly during periods of rapid growth to prevent excessive afternoon or evening snacking.

The insulin and meal timing may need to be adapted to suit variable schedules, including school, exercise, and work commitments.

Weight monitoring is recommended for early recognition of either weight loss or inappropriate weight gain.

• Excessive weight gain requires careful review of insulin dosage, food intake, glycemic control, and physical activity.

• Weight loss or failure to gain weight may be associated with insulin omission for weight control and may be indicative of a disordered eating behavior or an eating disorder. In those with high HbA1c, irrespective of weight profile, further assessment of disordered eating thoughts and behaviors should be considered.

• Parties, vacations, peer pressure to eat inappropriately and healthy lifestyle advice all require discussion, problem solving and target setting.

• Advice on the safe consumption of alcohol and the risk of prolonged hypoglycemia is important in some societies.

• Information on the nutritional content of snack and takeaways with appropriate healthier alternatives is important.

• It can be challenging for healthcare professionals to encourage changes in behavior during adolescence. Strategies to promote adherence with positive health behaviors should be explored. Joint working with other health care professionals including clinical psychologists and those with counselling skills may be helpful.

• Integrating technology in diabetes care may be attractive to engage the adolescents in the decision making of their diabetes and promote healthy behaviors (carbohydrate counting through apps,
exercise routines, understanding the impact of different foods in their glucose levels and food diaries) (185)

•

13. FESTIVITIES AND SPECIAL EVENTS

Detailed guidance on the management of fasting can be found in the ISPAD 2022 Consensus Guidelines Chapter 24 on Ramadan and other Religions fasting. Special events may include a range of activities including parties, celebrations, and festivities specific to culture and religion. These will all need individual advice and planning according to insulin regimen. Both feasting and fasting occur in many religions. Special dispensation is usually given to children with diabetes during fasts such as Ramadan, however children and adolescents may wish to fast and may from the age of 8 years start to participate in fasting for short periods. In these situations, individualized structured medical nutrition therapy with education on carbohydrate and insulin adjustment, hypoglycemia management needs to be provided alongside risk assessment (186)

• Emphasis needs to be placed on the importance of routine with respect to meal timings rather than following an erratic and frequent eating pattern (186)

• Feasting or post fast meals include consumption of high glycemic index, high fat, high sodium, and high calorie foods. A nutritional assessment reviewing carbohydrate intake with guidance on making healthy food choices, moderation, portion control, reading nutrition labels, maintaining appropriate energy, adequate hydration and physical activity should be given.

• The principle of carbohydrate, protein and fat counting along with additional insulin and type of bolus (if appropriate) that may be used to manage delayed post prandial blood glucose excursions can be especially useful on these special days. Family involvement and support is crucial in ensuring individual’s ability to maintain the diet (102, 187, 188). Meal planning, exercise recommendations, frequent glucose monitoring and revision in timing and dosage of insulin enables people with diabetes to fast without major complications (186)
• Individual management plans should be developed with clear guidance on when the fast should be broken, including broken in case of hypoglycemia, acute illness, or persistent hyperglycemia, or dramatic changes in their blood glucose profile during fasting period (186)

• CGM/ frequent SMBG can help understand the glucose variability during fasting and feasting. This information can help the health care team in adjusting medications as well as give timely suggestions on meal modification to achieve optimal glycemic control (189).

14. NUTRITIONAL MANAGEMENT OF EXERCISE AND PHYSICAL ACTIVITY

Children and adolescents with diabetes should be encouraged to participate in regular physical activity because it promotes cardiovascular health and aids weight management. The use of physical activity as an adjunct therapy to manage glucose levels has not been studied in this population. The focus of advice and studies is usually hypoglycemia prevention. The ISPAD 2022 Consensus Guidelines Chapter 14 on Management of diabetes during exercise provides further detailed explanation of the glycemic impact of physical activity, insulin adjustment strategies and the use of nutrition for hypoglycemia prevention. Where activity levels fall within the recommended 60 minutes a day (190) it is unlikely that total energy expenditure will be significantly increased therefore attention should be paid to the impact of nutritional strategies for hypoglycemia prevention on energy balance and body weight. Adult recommendations on energy balance suggest that participation in general fitness does not necessitate an increase in energy intake above normal recommendations whereas those involved >2hour of training per day will require an increased energy intake (191, 192).

Sports nutritional recommendations are for the most part adapted from adult recommendations with consideration given to the differences that exist in exercise physiology between the child and adolescent athlete and adults. In T1D further consideration of avoiding hypo and hyperglycemia is needed. Recommendations that include nutritional intake for adult athletes with T1D are available
Application of these recommendations requires adaption to account for the training or sports regimens, individual glucose responses, and sports aims of the individual athlete.

14.1 Energy requirements

Energy needs for the young athlete will vary with volume and type of sports being performed. Requirements may be increased above population guidelines and should be calculated on an individual basis. Requirements may be underestimated by predictive equations. Dietary intake needs to be appropriate to support growth and the demands of the specific sport (194). Low energy availability (LEA) and Relative energy deficiency in sports (RED-s) have been demonstrated to be common in certain populations, including female and adolescent athletes (195). The bone and endocrine disturbances caused by LEA and RED-s are well documented. Whilst no studies exist specific to T1D if LEA is linked to low carbohydrate intake, then this will probably increase hypoglycemia risk both during and after exercise. Sports with a requirement for specific body types may pose a higher risk for LEA, for example dance, gymnastics, weight making competitive sports. RED-s has many features of disordered eating, specific screening tools exist but have not been validated in the population with T1D, however they may be useful in identifying areas of concern.

Adequate total nutrition is important to ensure that increased energy needs of the sport do not impair growth. The nutritional demands of exercise vary with the type, intensity and duration of exercise, as well as the age, sex and fitness level so an individual approach to advice is required in addition, nutritional strategies. Exercise management plans should emphasize the importance of careful planning, individual attention to detail (blood glucose monitoring, food intake and insulin adjustment) and incorporate the personal experiences of the young person. Advice on overall nutritional intake with a focus on carbohydrate, protein, fluid, and micronutrient intake should be provided to meet the needs of the sport performance aims of the young person, based on sports nutrition guidelines are presented below (table 1)
Table 1 Nutrition guidelines for physical exercise

<table>
<thead>
<tr>
<th>Component</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>1.2 - 1.8g/kg/day with 20g shortly after exercise</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>50% of total energy intake across the day or 3-8g/kg body weight dependent on exercise intensity</td>
</tr>
<tr>
<td></td>
<td>30-60g per hour during exercise lasting longer than 60 minutes</td>
</tr>
<tr>
<td></td>
<td>1 - 1.5g/kg body weight within 30 minutes of finishing of session</td>
</tr>
<tr>
<td>Fat</td>
<td>No more than 30% energy intake</td>
</tr>
<tr>
<td>Fluid</td>
<td>5 - 7ml/kg 4 hours before exercise</td>
</tr>
<tr>
<td></td>
<td>During exercise fluid intake sufficient to minimize body mass changes to &lt;2%</td>
</tr>
<tr>
<td></td>
<td>After exercise sufficient fluid to replace losses 460-675mL per 0.5kg weight loss</td>
</tr>
</tbody>
</table>

14.2 Carbohydrate

The primary fuel for muscles for most types of activity is carbohydrate. Adequate amounts of carbohydrate are vital for optimal sports performance, of total energy as carbohydrate is recommended (194). Advice on carbohydrate intake for sports performance should be distinguished from advice on carbohydrate intake for hypoglycemia prevention. Dependent on exercise type, additional carbohydrate may require insulin to enhance utilization and sports performance (196). Carbohydrate intake should be distributed across the day, to meet the demands of training and recovery. Specific nutrition advice should cover the pre and post exercise periods. Prior to exercise (1-3 hours), a low-fat, carbohydrate containing meal should be consumed to maximize glycogen stores and availability of carbohydrate for exercise. Assessment of body composition should be considered when using guidelines based on body weight. Young athletes with a greater lean mass may have higher requirements than those of the same body weight or BMI with a high body fat mass. Amounts of carbohydrate required will also be impacted by insulin adjustment, hypoglycemia risk is increased when exercise is performed during peak insulin action. The challenges of sport performed within the school day may make this situation unavoidable. Where possible the guidance in the chapter on exercise management should be followed to adjust insulin based on activity type and glucose trajectory to prevent hypo- and hyperglycemia and support sports nutrition goals. For some high intensity strenuous or anaerobic activities, pre-exercise carbohydrate may also require
additional bolus insulin (197). Food consumed prior to competitive sports may require increased insulin doses compared to training situations. CGM can be used to guide both carbohydrate and insulin adjustments for exercise (198).

Aerobic exercise lasting 60 minutes or longer may require additional carbohydrate to maintain performance. Additional carbohydrate needed during activity should be distributed across the activity. An isotonic sports drink containing 6-8% carbohydrate may be useful during prolonged activity (>1 hour) to address both increased fluid and carbohydrate needs (199). Examples of suitable carbohydrate sources for exercise include carbohydrate gels, isotonic sports drinks, fruit, and fruit juices. Additional carbohydrate during exercise can cause gastrointestinal upset, so advice should be adapted to suit the individual. Carbohydrate ingestion during exercise should be practiced in training.

Post-exercise carbohydrate intake needs to be sufficient to ensure replacement of both muscle and hepatic glycogen stores, and prevent post exercise hypoglycemia caused by increased insulin sensitivity during muscle recovery (197). To ensure muscle recovery it is sensible to consume a low fat, protein and carbohydrate containing meal or snack after training. Consuming carbohydrate mixed with protein may be beneficial in the prevention of post exercise hypoglycemia (193, 200). Post exercise carbohydrate needs will vary with the intensity and duration of exercise but may be as high as 1.5g/kg bodyweight (201). Post exercise carbohydrate will require carefully adjusted insulin doses to reduce glycemic excursions.

14.3 Protein

Protein is needed for muscle protein synthesis and when consumed with carbohydrate post exercise may enhance muscle glycogen re-synthesis. The amounts of protein needed to support and enhance sports performance for both resistance and endurance exercise is debated in the literature. For the child/adolescent with T1D it is unlikely that total protein intake will be inadequate or that requirements are as high as those stated in adult recommendations. Distribution and timing of
protein intake is important and advice about suitable foods to be eaten before and after exercise and before sleep should be given. Adult literature suggests that 25-30g protein per meal is optimal to enhance muscle protein synthesis (202, 203). Ensuring protein is included in the meal prior to exercise may help reduce the risk of hypoglycemia during exercise (200). Co-ingestion of carbohydrate and protein post exercise may help attenuate the risk of late onset hypoglycemia. One study using milk as a post exercise drink in T1D demonstrated reduced nocturnal hypoglycemia when compared with carbohydrate only drinks (204). Milk based drinks are recommended as appropriate sources of protein and carbohydrate for enhancing muscle protein synthesis in sports nutrition literature (205). A further advantage of milk is its leucine content as this has been specifically associated with the ability to train, compete, and recover (206).

14.4 Fluid

Fluid intake should be maintained at a level appropriate to the activity to maintain optimal hydration (144). A 1% decrease in body mass has been shown to impair performance (207). Fluid requirements in children during strenuous exercise are of the magnitude 13ml/kg/hour. The fluid should be consumed throughout the activity (208). Nutrition counseling should include advice about drinking appropriate amounts of fluid across the day for both health and sports performance. Water is suitable for most activities up to 60 minutes duration; however, drinks containing 6-8% carbohydrate are useful when additional carbohydrate is required either for sports performance or hypoglycemia prevention (209).

14.5 Micronutrients

Young athletes are at risk of micronutrient deficiency particularly iron (especially females), calcium and vitamin D (210). Advice on dietary quality needs to ensure that recommended intakes of these nutrients are achieved. Monitoring of Vitamin D status is recommended due to increased risk in the young athlete. Correction of Vitamin D deficiency may be needed for optimal sports performance.
Risk of low intakes is likely to be higher when there is relative energy deficiency which is more likely in sports where low body weight is desired.

14.6 Supplements

Sports nutrition advice uses a food first approach. Nutrition counselling should address the use of supplements. Evidence from young sports competitors demonstrates a high use of sports supplements and it is likely that young people with T1D will display similar behaviors. In most cases supplements are unnecessary. Counselling on how to use food to maximize training adaptions is essential. Popular supplements used by adolescent athletes include protein supplements and creatine (211). Young athletes may also be interested in the use of caffeine, which may contribute to hypoglycemia prevention (212). Guidance on the use of supplements and the evidence to support use is available (213) and can be used to guide advice which should include information about the risks of supplement use and guidance on anti-doping according to the sport and level of competition (See exercise chapter).

15 NUTRITIONAL MANAGEMENT OF TYPE 2 DIABETES IN CHILDREN AND YOUNG PEOPLE

In young people with T2D and insulin resistance, the presence of multiple cardiovascular risk factors is likely to be associated with earlier severe complications (214).

15.1 Aims of nutritional management is:

- Achieve normal glycemia and HbA1c (15)
- Prevent further weight gain in those with BMI at 85–95th percentile or achieve weight loss for those with BMI >95th percentile whilst maintaining normal linear growth
- Address co-morbidities, such as hypertension and dyslipidemia

15.2 Treatment recommendations
There is little evidence regarding the nutritional management of T2D in children and adolescents. Therefore, recommendations are derived from the treatment of overweight and obese children, T2D in adults and T1D in children.

Evidence suggests that there is no ideal macronutrient distribution for weight loss and plans should be individualized (15). There is some evidence that calorie controlled, lower carbohydrate diets may achieve greater reductions in lipid profiles and diabetes medications; and are therefore an effective strategy for the optimization of T2D management (215).

Most children and adolescents with T2D are overweight or obese, therefore treatment should be centered on education and lifestyle interventions to prevent further weight gain or achieve weight loss with normal linear growth. The entire family should be included in the lifestyle intervention, since parents and family members influence the child’s food intake and physical activity, and they are often overweight or obese and have diabetes as well. Studies indicate that a family approach to treatment of overweight is likely to be most effective (216). Families should be counseled to decrease energy intake by focusing on healthy eating, strategies to decrease portion sizes of foods, and lowering the intake of high energy, fat and sugar containing foods. Simply eliminating beverages such as soft drinks and juices can accomplish improvement in blood glucose and weight.

Increasing energy expenditure by increasing daily physical activity to 60 minutes daily is an important component of treatment (217). Limiting sedentary behaviors, such as television viewing and computer use has been shown to be an effective way to increase daily physical activity and help maintain or achieve a healthy weight in children. Physical activity may also help lower lipids in adolescents with diabetes (218).

An interdisciplinary approach including a physician, diabetes nurse educator, dietician, mental health provider and exercise physiologist (if possible) is recommended.

Children on MDI or pump therapy should be taught to adjust insulin to carbohydrate intake using an ICR (219). This may be helpful in reducing the need for snacks and large meals.
Medical nutrition therapy should be provided to prevent and treat co-morbidities including obesity, dyslipidemia, hypertension and micro- and macro-vascular complications (2). Regular follow-up is essential to monitor weight, glycemic control, and review of the meal plan.

Very low-calorie-ketogenic (VLCK) diets can be safely and effectively used in the management of young adults with T2D (220). Clinical experience suggests obese older adolescents with T2D may also benefit from a carefully monitored VLCK weight loss program (221).

16 MANAGEMENT OF CO-MORBIDITIES

16.1 Dyslipidemia

Dyslipidemia is often overlooked or inadequately treated in adolescents and young adults with diabetes, despite the fact that CVD remains a major cause of mortality in adults with diabetes (222). Hyperglycemia and insulin deficiency/resistance are associated with dyslipidemia, thus the initial therapy should be to optimize glucose control. After initiation of insulin therapy and establishment of glycemic and metabolic control of diabetes, the management of dyslipidemia requires a comprehensive approach, which includes attention to medical nutrition therapy (2, 223). Medical nutrition therapy should address the following:

General recommendations to consume less highly processed food products and increase consumption of whole-food, plant-based meals and snacks where feasible. Lifestyle changes should be addressed as necessary including healthy weight maintenance and increased physical activity to improve insulin sensitivity, cardiovascular and musculoskeletal health, and overall wellbeing. If applicable, discontinue tobacco use. If dyslipidemia persists despite these measures or in the face of

<table>
<thead>
<tr>
<th>Box 3: Medical Nutrition Therapy for Dyslipidemia in Diabetes</th>
</tr>
</thead>
<tbody>
<tr>
<td>o Reduce saturated fat intake to less than 7% and eliminate trans fats.</td>
</tr>
<tr>
<td>o Total dietary fat: 25-35% of energy</td>
</tr>
<tr>
<td>o Diet rich in fruits and vegetables (&gt;5 servings a day)</td>
</tr>
<tr>
<td>o Increase dietary sources of both soluble fiber and antioxidants</td>
</tr>
<tr>
<td>o Eliminate sugar-sweetened beverages and juices</td>
</tr>
</tbody>
</table>
multiple risk factors for CVD, pharmacological treatment should be considered according to published guidelines (223). Further guidance on pharmacological treatment is addressed in the chapter on microvascular complications.

16.2 Celiac disease

Celiac disease is more common in children with T1D than in the general population—Celiac disease is often diagnosed after diabetes and may be asymptomatic (224). It is more common in girls and in children diagnosed with T1D at an early age (225). It may be associated with poor growth, delayed puberty, nutritional deficiencies, reduced bone density, hypoglycemia, and hyperglycemia (226). Some studies have reported increase in insulin requirements and dietary problems following the diagnosis of celiac disease in children with T1D (227).

A gluten-free diet (GFD) is the only accepted treatment for celiac disease. The GFD requires elimination of wheat, rye, barley, triticale, possibly oats and products derived from these grains, brewer’s yeast, malt, food products with artificially added gluten or cross-contaminated with gluten (228). Alternatives such as rice preferably brown/unpolished rice and millets, quinoa, legumes/pulses, buckwheat, amaranth, potato, corn, soy, tapioca, maize, water chestnut and products derived from these must be used as substitutes (229).

The recommendation to exclude oats varies between countries. Short and long-term studies involving children and adults suggest that oats can be safely included for most people. However, a small minority of people with celiac disease have been found to react to oats (230). Research supports the view that gluten free oats (meaning oats not contaminated with gluten) may be acceptable at moderate amounts (20-25 g/day dry rolled oats for children: 50-70 g/day for adults) for the majority but not all children with celiac disease (229-231).

In addition to advice on foods allowed or to avoid, emphasis should be placed on the nutritional quality of the GFD, particularly iron, folate, magnesium, zinc, calcium, iodine, fiber and B vitamin intakes (232). Nutritional deficiencies arising from a GFD can be avoided by including naturally
occurring, local GF whole grains, fruits, vegetables, plant and animal sources of protein, dairy, fats and oils, gluten-free commercial products that have been fortified or enriched and avoiding processed, high fat and sugar packaged foods. This will help lower the glycemic index of the meals which are significantly altered when on a GFD (232).

Probiotics may improve gastrointestinal symptoms in individuals with celiac disease (233). However, more evidence is required to prove the efficacy of therapeutic use and clinical impact of probiotics in CD.

It is accepted in Europe and some other countries such as Canada and USA that foods containing less than 20 parts per million (ppm) (20 mg/kg) gluten are suitable for a GFD (even if gluten is detectable) in accordance with Codex Alimentarius (234). Wheat starch is used in some European countries as part of a GFD. However, wheat starch is not recommended for inclusion in other countries such as Australia and New Zealand where food laws require that foods must not contain any detectable gluten (less than 3 parts per million) if labelled as gluten-free (235). There are no published studies to determine if there are differences in short- and long-term outcomes with the more stringent levels of gluten restriction.

A GFD is usually well adopted by people with diabetes and has not been found to be harmful to the metabolic balance of children with coexisting T1D. In fact, a strict GFD diet may improve glycemic control and HbA1c concentrations and decrease in episodes of hypoglycemia (228, 236).

It is common for people with diabetes who develop celiac disease to have challenges with maintaining GFD. Improved understanding of the diet as well as access to a dietician and regular follow up may improve nutrition management (237). Dietician-led follow-up visits have shown to provide lower long-term costs (238).

The additional diagnosis in children with T1D may have a minimal effect on the quality of life of the child, although non-adherence predisposes individuals to hypoglycemia, and this may negatively influence quality of life as well as glycemic control (228, 239).
In accordance with celiac disease management recommendations, for those young people with maladaptive eating behaviors, similar to known risk factors eating disorders, ongoing follow-up with gastroenterologists and dietitians and psychosocial support referrals are recommended to improve quality of life (240).

Children and adolescents with both T1D and celiac disease are at increased risk for microvascular complications (241, 242). Adverse lipid profile, including low HDL levels and high LDL values is a complication of untreated celiac disease (228, 243). Monitoring of cholesterol levels and frequent supportive dietetic contacts are needed to enhance GFD adherence and ensure ongoing healthy food choices even after many years on the GFD (244). Providing educational materials (list of gluten free foods, nutrition label reading, recipes, eating out and travel guidelines) and access to support groups, social workers, or family counselling will help improve adherence to healthy eating and GFD (232).

### 16.3 Disordered Eating and Eating disorders

Eating Disorders (ED) and disordered eating behavior (DEB) are more common in young people with diabetes than their peers (245). DEB is a term used to describe a variety of disturbed eating behaviors whereas an ED is a clinical diagnosis; consequently, DEB are overrepresented. Disturbed eating behaviors include intentional over- and underdosing of insulin, dietary restriction and self-induced vomiting (31, 246). Diabetes is unique in making it possible for weight and body shape control without overt avoidance of food by means of insulin restriction. Insulin omission for weight control has been reported in pre-teens, adolescents and young adults with and overrepresentation in girls (247).

Diabulimia is a term that casually refers to the purging of calories through insulin restriction with the aim to lose weight or alter body shape. Diabulimia is not a clinical diagnosis and lacks a clear definition, which may lead to inaccurate descriptions of DEB and subsequently inadequate treatment. More work is needed to enable the treatment of young people with either diagnosed
eating disorders or poorly defined disorders to be best treated (see ISPAD 2022 Consensus Guidelines Chapter 15 on Psychological care of children and adolescents with T1D).

Detecting eating problems can be difficult as attention to diet and benefits of avoiding certain foods is fundamental parts of normal diabetes care. A range of screening questionnaires and structured clinical interviews are available to help identify ED and DEB in children and young people with T1D (248, 249). The Diabetes Eating Problem Survey -Revised (DEPS -R) is a 16-item diabetes-specific self-report screening tool for disordered eating that can be completed in <10 min during a routine clinical appointment (248). A recent study from Australia showed insignificant utilization of screening tools in pediatric clinics and low reported rates of ED, emphasizing the importance of both using existing tools as well as the need for user-friendly screening tools (250). Most questionnaires are in English, ineligible for use in non-English speaking countries, warranting screening tools in more languages. One article has found a single screening question; “Have you ever been overweight?” to have high precision in at risk individuals for further screening and early interventions (251). Acknowledging risk factors and being attentive to signs and symptoms of DEBs can prevent them from becoming clinical eating disorders and further deteriorating glycemic control.

See table 3.(252)

Table 3: Risk factors and indicators of disordered eating behaviors in people with diabetes

<table>
<thead>
<tr>
<th>Risk factors</th>
<th>Warning signs</th>
<th>Confirmation Screening tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 7-18 years</td>
<td>- Suboptimal</td>
<td>Revised Diabetes Eating</td>
</tr>
<tr>
<td>- Female</td>
<td>- glycemic</td>
<td>Problem Survey (DEPS-R)</td>
</tr>
<tr>
<td>- Detailed</td>
<td>- Recurrence</td>
<td>Modified SCOFF (mSCOFF)</td>
</tr>
<tr>
<td>meal planning</td>
<td>of hypoglycemic</td>
<td>test</td>
</tr>
<tr>
<td>- precision</td>
<td>- Systematic</td>
<td>Single question “Have you</td>
</tr>
<tr>
<td>- in food</td>
<td>calculations</td>
<td>ever been overweight?”</td>
</tr>
<tr>
<td>- proportion</td>
<td>of caloric</td>
<td></td>
</tr>
<tr>
<td>- Overweight</td>
<td>- values and</td>
<td></td>
</tr>
<tr>
<td>- obesity</td>
<td>weighing of</td>
<td></td>
</tr>
<tr>
<td>- Body</td>
<td>- foods</td>
<td></td>
</tr>
<tr>
<td>- dissatisfaction</td>
<td></td>
<td></td>
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<tr>
<td>- Anxious,</td>
<td>- Frequently</td>
<td></td>
</tr>
<tr>
<td>- poor quality of</td>
<td>- missed</td>
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<tr>
<td>- life</td>
<td>- medical</td>
<td></td>
</tr>
<tr>
<td>- Poor</td>
<td>- Refusal to</td>
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<tr>
<td>- attention</td>
<td>- be weighed</td>
<td></td>
</tr>
<tr>
<td>- in family</td>
<td>- Concern for</td>
<td></td>
</tr>
<tr>
<td>- to healthy eating,</td>
<td>appearance</td>
<td></td>
</tr>
<tr>
<td>- maternal overweight or binge-eating</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- disorders in mothers</td>
<td></td>
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</tr>
</tbody>
</table>
The risk for ED increases with diabetes duration and/or age (253). This is of clinical importance as adolescents transition into adulthood and require continuity of care, often across two diabetes teams. Extra attention should be paid to girls as they are more prone to DEB and are more likely to meet criteria for overweight/obesity as well as have poorer metabolic control, all risk factors for ED (247, 251, 252). Disordered eating in adolescents and young adults with diabetes are associated with short-term and long-term complications such as DKA, abnormal lipid profiles, retinopathy and neuropathy (253).

Clinicians working with young people with diabetes and ED need to consider the following in planning interventions: insulin regimen and potential for omission, metabolic control, energy requirements, potential for food and insulin manipulation, body dissatisfaction, family functioning, exercise type and frequency, binge eating behaviors, potential laxative abuse and sleeping patterns. An interdisciplinary approach to treatment is considered the standard of care for both ED and diabetes. Close liaison with the Specialist Eating Disorder team is required (254) with a clear common weight goal for the person with diabetes. It is important that insulin adjustments by the diabetes team do not support binge eating or food avoidance behaviors. Supervision of insulin doses and family-based interventions are helpful strategies in treatment of disordered eating (31). More research is needed for interventions to prevent and treat disordered eating in diabetes.

16.4 Obesity

Obesity contributes to the challenges in optimizing glycemic control and increases the already higher risk of CVD in individuals with T1D. Contributing factors identified for all children are over nutrition and insufficient physical activity. For children with diabetes other possible causes include over-insulinization, excess energy intake to avoid or treat hypoglycemia and additional carbohydrate consumed for exercise.

Despite urgent clinical need, there are limited published evidence-based interventions targeted specifically at children and adolescents with diabetes for the prevention and treatment of
overweight and obesity. Very low carbohydrate or ketogenic diets have been used in the short-term successfully in the management of obesity in adolescents without diabetes (255). These require specialist team input including careful monitoring of blood glucose levels, insulin adjustments, weight loss and ketones. Psychological counseling should be given to young people with obesity, and they should be screened for binge eating disorders.

17 RESEARCH
Advances in diabetes technology are not supported by research on optimal nutritional management, there remains a lack of high quality, randomized controlled trials in many aspects of nutritional management. Further research to support the extended role of the dietitian, and outcomes of varying educational methods in relation to dietetic interventions is needed.

18 SUMMARY
The nutritional care of children with diabetes is complex. Diabetes management is set within the context of the family, a surrounding social system, issues of non-adherence, peer pressure, emerging independence and the ultimate aim of maintaining quality of life. It requires a deep understanding of the relationship between treatment regimens and changing physiological requirements, including growth, fluctuations in appetite associated with changes in growth velocity, varying nutritional requirement and physical activity.

Evidence suggests that it is possible to improve diabetes outcomes through attention to nutritional management and an individualized approach to education. This requires a clear focus on dietary goals in relation to glycemic control and reduction in cardiovascular risk.

The fundamental premise of successful dietary outcomes is the development of a trusting relationship between the child/adolescent and care providers, which facilitates behavioral change during the challenges of childhood and adolescent development.
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Food Standards Australia New Zealand (FZANZ).


