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Nutritional management in children and adolescents with diabetes

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This article is a chapter in the *ISPAD Clinical Practice Consensus Guidelines 2014 Compendium*. The complete set of guidelines can be found for free download at www.ispad.org. The evidence grading system used in the ISPAD Guidelines is the same as that used by the American Diabetes Association. See page 3 (the Introduction in *Pediatric Diabetes* 2014; 15 (Suppl. 20): 1-3).

Executive summary and Recommendations

- Nutrition therapy is recommended for all children and adolescents with type 1 diabetes. Implementation of an individualized meal plan with appropriate insulin adjustments can improve 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).
- Nutritional advice should be adapted to cultural, ethnic, and family traditions, as well as the cognitive and psychosocial needs of the individual child (E).
- A specialist pediatric dietician with experience in childhood diabetes should be part of the interdisciplinary team and should be available as soon as possible at diagnosis to develop a lasting trusting relationship (E).
- Energy intake and essential nutrients should aim to maintain ideal body weight, optimal growth, health and development and help to prevent acute and chronic complications. Growth monitoring is an essential part of diabetes management (C).
- The optimal macronutrient distribution varies depending on an individualized assessment of the young person. As a guide, carbohydrate should approximate 50–55% of energy, fat <35% of energy (saturated fat <10%), and protein 15–20% of energy (C).
- Matching of insulin dose to carbohydrate intake on intensive insulin regimens allows greater flexibility in carbohydrate intake and meal times, with potential for improvements in glycemic control and quality of life (B). However, regularity in meal times and eating routines are still important for optimal glycemic outcomes (C).
- There are several methods of quantifying carbohydrate (CHO) intake (gram increments, 10–12 g CHO portions and 15 g CHO exchanges). There is no strong research evidence to suggest that one particular method is superior to another (E).
- Fixed insulin regimens require consistency in carbohydrate amount and timing to improve glycemic control and reduce the risk of hypoglycemia (C).
- The use of the glycemic index (GI) provides additional benefit to glycemic control over that

observed when total carbohydrate is considered alone (B).
- Dietary fat and protein may impact postprandial glycemia (A). Randomized controlled trials of methods to manage hyperglycemia after meals high in fat and protein are required (E).
- Prevention of overweight and obesity in pediatric type 1 diabetes is a key strategy of care and should involve a family based approach (B).
- Weight loss or failure to gain appropriate weight may be a sign of illness (infections, celiac disease, and hyperthyroidism), insulin omission or disordered eating (C).
- Nutritional advice should be provided on how to cope successfully with physical activity, exercise, and competitive sports (E).
- Nutritional management of type 2 diabetes requires a family and community approach to address the fundamental problems of excessive weight gain, lack of physical activity, and the increased risk of cardiovascular disease (E).
- There is a need for more research and evaluation of dietetic management in childhood diabetes (E).

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 reflect national and international pediatric position/consensus statements (1–3) and evidence derived from recommendations for adults with diabetes (4–6). Further research is required in many areas of pediatric diabetes management and education particularly in effective nutrition therapy interventions and long-term outcomes.

Dietary recommendations for children with diabetes are based on healthy eating recommendations suitable for all children and adults (2, 3) and therefore the whole family. Nutritional advice must be adapted to cultural, ethnic and family traditions, and the psychosocial needs of the individual child. Likewise the choice of insulin regimen should take into account the dietary habits and lifestyle of the child.

A specialist pediatric dietician with experience in childhood diabetes should be available as part of a pediatric interdisciplinary diabetes care team to provide education, monitoring and support to the child, parents, carers, extended family, nursery, school teachers, and babysitters. Regularity in meal times and routines where the child and family sit down and eat together help to establish better eating practices and monitoring of food intake has been shown to be associated with better glycemic outcomes (7–9).

Nutrition therapy, when used in combination with other components of diabetes care, can further improve clinical and metabolic outcomes (10, 11). 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 profiles. It is important that the whole family is involved in making appropriate changes based on healthy eating principles. The impact of diabetes on eating behavior must not be underestimated and may cause psychological disturbance. 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 (12, 13) and also have clear agreed goals with the interdisciplinary team (14).

Nutrition education and lifestyle counseling should be adapted to individual needs and delivered in a patient-centered manner. Education can be delivered both to the individual child and family and in small group settings.

These recommendations target healthy eating principles, optimum glycemic control, the reduction of cardiovascular risk factors, the maintenance of psychosocial well-being, and family dynamics.

Aims of nutritional management

- Encourage appropriate eating behavior and healthy life long eating habits while 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 bingeing, and provides a framework for regular monitoring of blood glucose (BG) levels.
- Provide sufficient and appropriate energy intake and nutrients for optimal growth, development, and good health.
- 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.

- Prevent and treat acute complications of diabetes such as hypoglycemia, hyperglycemic episodes, illness, and exercise-related problems.
- Reduce the risk of micro- and macro-vascular complications.
- Maintain and preserve quality of life.
- Develop a supportive relationship to facilitate behavior change and positive dietary modifications.

Guidelines on energy balance, energy intake, and food components

Energy balance

At diagnosis, appetite and energy intake are often high to restore preceding catabolic weight loss. Energy intake should be reduced when appropriate weight is restored (15). Monitoring by the team, particularly in the 6 weeks after diagnosis, is necessary to assess appropriate weight gain (16).

- Energy intake varies greatly within subjects on a daily basis due to age, growth rate, physical activity, and other important environmental factors such as the type and availability of food.
- Energy intake should be sufficient to achieve optimal growth and maintain an ideal body weight.
- Flexibility in the advice about the amount of food to meet varying energy needs is necessary.
- Dietary advice/meal planning should be revised regularly to meet changes in appetite and insulin regimens and to ensure optimal growth (17).
- Insulin (amount and type) should be adapted where possible to the child's appetite and eating pattern. Making a child eat without an appetite or withholding food in an effort to control BG should be discouraged as this may adversely impact growth and development (17).
- During puberty, energy intake and nutritional demands increase substantially along with significant increase in insulin dosage.

Weight maintenance

- Energy intake may be regulated by appetite, but when food is in abundance excess energy intake contributes to obesity.
- The prevalence of childhood obesity is increasing rapidly worldwide (18). This is caused by a combination of overnutrition and insufficient physical activity. For children with diabetes other contributing factors may include overinsulinization, snacking, and excess energy intake to avoid or treat hypoglycemia.
- Prevention of overweight/obesity is a key strategy of care. Guidance on family food choices, appropriate portion sizes, energy density of foods, meal routines, and physical activity is essential (2).
- Children with diabetes at all ages and in both sexes have been reported to be heavier than their peers without diabetes (19). More recent studies have demonstrated similar rates of overweight and obesity as the general population (20, 21).
- Important aspects of management in the prevention of overweight are:
    - Plotting the growth curve, BMI (18), and if possible waist circumference every 3 months. Currently there are no international reference ranges for waist circumference in children <16 yr. Target reference values for young people aged ≥ 16 yr are <80 cm for females and <94 cm for males (22).
- Regular review by a dietician.
- Promotion of regular moderate-vigorous physical activity for 60 min/d on a daily basis (23).
- Consistent advice on the prevention and appropriate treatment of hypoglycemia (to prevent overtreatment) by all team members.
- Adjustment of insulin in preference to intake of additional food for hypoglycemia prevention in the management of physical activity.
- Review of the insulin regimen to minimize hypoglycemia and the need for large snacks.
- Psychological counseling should be given to young people with disordered eating/eating disorders.

Energy intake recommendations

A guide to the distribution of the total daily energy intake is as below. However, the optimal macronutrient distribution may vary depending on an individualized assessment of the young person. National guidelines for adults and children with diabetes in Australia and Canada recommend a carbohydrate intake of 45–60% energy (2, 6). However, with a lower carbohydrate intake the quality of fat becomes more important. Dietary studies of children with diabetes have found that as carbohydrate intake decreases children tend to consume more saturated fat (32–35).

- Carbohydrate 50–55% (3)
- Moderate sucrose intake (up to 10% total energy) (6)
- Fat 25–35%
- $<10\%$ saturated fat + trans fatty acids
- $<10\%$ polyunsaturated fat
- $>10\%$ monounsaturated fat (upto 20% total energy) (5)
- Protein 15–20% (2, 3)

Food components

Carbohydrates

There is international agreement that carbohydrate should not be restricted in children and adolescents with type 1 diabetes as it may result in deleterious effects on growth.

- Caregivers should encourage healthy sources of carbohydrate foods such as whole grain breads and cereals, legumes (peas, beans, and lentils), fruit, vegetables, and low-fat dairy products (full fat in children under 2 yr).

Sucrose

Sucrose and sucrose-containing food should be eaten in the context of a healthy diet, and the intake of other nutrients ingested with sucrose, such as fat, should be taken into account (4).

Sucrose does not increase glycemia more than isocaloric amounts of starch (24). Sucrose can be substituted in moderation for other carbohydrate sources without causing hyperglycemia. If added, sucrose should be appropriately balanced against insulin doses (17).

Sucrose should provide up to 10% of total daily energy intake (6). Not all countries have a specific recommendation on the percentage of sugar or monosaccharide or disaccharides in the diet.

- Sucrose sweetened beverage consumption has been linked to excessive weight gain (25). Large quantities of sugary beverages are difficult to adequately cover with insulin and may cause hyperglycemia. Diet or light drinks can safely 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. See guideline on hypoglycemia for more details.

Fiber

- Estimates of dietary fiber intakes in children in many countries are lower than recommended (27).
- The recommendation (3.3 g of fiber per megajoule) gives a higher amount of fiber per day.

Age	Fiber recommendations
Birth to 1 yr	Not determined
≥1 yr (26)	14 g/4184 kJ (1000 kcals) 3.3 g/MJ
Alternatively	
Children >2 yr old (27)	Age in years + 5 = grams of fiber per day

- 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 (28, 29),
- Fruit pectin may also be useful in enhancing the protection against cardiovascular disease (30).
- Insoluble fiber found in grains and cereals promotes healthy bowel function.
- Fiber should be increased slowly in the diet to prevent abdominal discomfort.
- Any increase in fiber intake should be accompanied by an increase in fluid intake.
- Higher fiber foods may help to improve satiety and replace more energy dense foods.
- Processed foods tend to be lower in fiber therefore, unprocessed, fresh foods should be encouraged.

Fats

Population-based nutritional guidelines recommend a fat intake of no greater than 30–35% total daily energy intake (31). A range of recommendations currently exist in adult guidelines, from no specific recommendation for percentage total energy up to 35% energy from fat (2, 4, 6). High total fat intakes have been shown to increase the risk of overweight and obesity (31). High saturated and trans fat intakes have been linked to an increased risk of cardiovascular disease (2, 32). Studies have shown children and young people with diabetes have consumed fat and saturated fat above dietary recommendations (32–35).

The primary goal regarding dietary fat in clinical practice is usually to decrease the intake of total fat, saturated fat, and trans fatty acids. Monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) can be used as substitutes to improve the lipid profile (5).

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

Saturated fat and trans fatty acids

- 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 and trans fatty acids is recommended (36). Saturated fat is the principal dietary determinant of plasma low-density lipoprotein (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.
- 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. Whole diet approaches may be useful in changing intake, for example, the Mediterranean diet (37).

MUFAs and PUFAs

- Unsaturated fatty acids are important components of lipid membranes.
- 10–20% energy from MUFA is recommended (36). 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 cardiovascular disease. They are recommended replacements for saturated fats.
- Less than 10% energy from PUFA is recommended (36). 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 g (38, 39).
- 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 yr if total and/or LDL cholesterol remains elevated (40, 41).

Hyperlipidemia

Management of hyperlipidemia requires a comprehensive approach (42):

- Initial therapy should be to optimize glucose control.
- Medical nutrition therapy to reduce saturated fat intake to less than 7%, and increase dietary sources of both soluble fiber and anti-oxidants.
- Lifestyle changes (control weight and increase physical activity) and if applicable, discontinue tobacco use.
- Only if glucose control and/or lifestyle cannot be optimized, or hyperlipidemia persists despite these measures, should pharmacological treatment be considered (see guideline on Chronic Complications).

Protein

- Intake decreases during childhood from approximately 2 g/kg/d in early infancy to 1 g/kg/d for a 10 yr old and to 0.8–0.9 g/kg/d in later adolescence(43).
- Worldwide intake of protein varies greatly depending on economy and availability.
- Protein promotes growth only when sufficient total energy is available.
- High protein diets, >25% energy, are not generally advised for children with type 1 diabetes as they may impact growth and vitamin and mineral intake.
- 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 (2).
- When persistent microalbuminuria or established nephropathy occurs, excessive protein intake (>25% energy) may be detrimental. It is prudent to advise that intake should be at the lower end of the recommended range (5). However, there is insufficient evidence to restrict protein intake. Any modifications to protein intake in adolescence should not be allowed to interfere with normal growth and requires expert management by a dietician.

Vitamins, minerals, and antioxidants

Children with diabetes have the same vitamin and mineral requirements as other healthy children (2).

There is no clear evidence of benefit from vitamin or mineral supplementation in children with diabetes who do not have underlying deficiencies.

It is recommended that individualized meal planning include optimization of food choices to meet recommended dietary allowance/dietary reference intake for all micronutrients.

Many fresh fruits and vegetables are naturally rich in antioxidants (tocopherols, carotenoids, vitamin C, and flavonoids) and are strongly recommended for young people with diabetes for cardiovascular protection.

Supplements such as vitamin D for young children are recommended in some countries following the national guidelines for healthy children. If vitamin D levels are low, supplementation in line with the general population should occur (44).

Salt

Children with diabetes should limit their salt intake to at least that of recommendations for the general population. A guide is 1500 mg/d (3.8 g of salt/day) for children aged ≥9 yr (26).

Guidelines for salt intake in younger children are 1–3 yr: 1000 mg/d (2.5 g salt/day); 4–8 yr: 1200 mg/d (3 g salt/day) (26).

Salt is added to many processed foods (only 20% of intake is usually added at the table and in cooking).

- Salt intake is too high in many countries due to the high intake of processed foods.
- Processed foods should be decreased for the whole family and practical advice given to develop cooking skills with fresh foods.
- Dietary advice should include minimizing salt addition to cooking or meals and lower salt products/foods where practical.

Alcohol

Excess alcohol is dangerous because of suppression of gluconeogenesis and it may induce prolonged hypoglycemia in young people with diabetes (up to 10–12 or more hours after drinking, depending on the amount ingested) (45). Education on the following points should be emphasized when a child or young person starts to include alcohol in their lifestyle or prior to transition to adult services.

- Alcohol is prohibited in many societies and age restricted in most, but remains a potential problem from abuse.
- Alcohol in children may lead to increased risk-taking behaviors.
- Many types of alcoholic drinks are available, some of which are particularly targeted at young people. Education is needed on the alcohol content of different drinks.
- Carbohydrate should be eaten before and/or during and/or after alcohol intake. It may be also necessary to adjust the insulin dose particularly if exercise is performed during/after drinking.
- Advice should include drinking in moderation and practical ways to reduce alcohol intake such as the use of alcohol reduced beers.
- Low carbohydrate or 'diabetic' beers should be viewed with caution as many do not have reduced alcohol content.
- Special care should be taken to prevent nocturnal hypoglycemia by having a carbohydrate snack at bedtime and monitoring BG levels more often than usual during the night and the following day, at least until lunchtime (3).
- Young people should be encouraged to wear identification for diabetes.

Specially labeled diabetic foods

- Such foods are not recommended because they are not necessary, are expensive, often high in fat, and may contain sweeteners with laxative effects. These include the sugar alcohols such as sorbitol.
- Although international nutritional guidelines advise that a moderate amount of sucrose can be consumed (2–6), 'diabetic foods' are still for sale in some countries.

Artificial and intense sweeteners

- Water should be encouraged instead of sugary drinks and cordials.
- Sugary drinks are not encouraged as they lead to weight gain and may cause hyperglycemia as the insulin dose is commonly not matched to the carbohydrate quantity. Diet soft drinks or diet cordials are a better alternative.
- Products such as low-fat yoghurt with intense sweeteners can be useful, especially for those who are overweight.
- Saccharin, neotame, aspartame, acesulfame K, cyclamates (in some countries), alitame, and sucralose are used in low sugar, 'light' or 'diet' products to improve sweetness and palatability.
- Acceptable daily intakes (ADI) have been established in some countries.
- There are no published scientific reports documenting harm from an intake of artificial sweeteners in doses not exceeding ADI (46).

Guidelines for nutritional care, education, and meal planning

1 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 (13). A dietary history should be taken including:
   - ◦ Preexisting family dietary habits, traditions, and beliefs.
   - ◦ The child's usual food intake including energy, carbohydrate distribution and fat intake, quality of food choices, fast-foods and mealtimes, or patterns of food intake.
   - ◦ The child's daily activities including the impact of nursery/school/college/work, physical activity, and exercise schedules.

2 Advice should be given at diagnosis based on the dietician's assessment and the individualized plan provided by the diabetes team. 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 (11). It is important that the initial or review assessment includes identification of any body image or weight concerns.

3 Contacts there after depend on local arrangements, a minimum should include two to four times in the first year and annual reassessment (11). These

are necessary to keep pace with the child's growth, diabetes management, psychosocial adaptation, lifestyle changes, and the identification of specific dietary problems such as dysfunctional eating habits, family issues around food, obesity, and eating disorders.

4 There is consensus that continuation of care, support, and review by a dietician is essential for optimal care.

5 Circumstances such as changing insulin regimen, dyslipidemia, poor dietary knowledge, excessive weight gain, and comorbidities such as celiac disease require extra education and dietary intervention with more frequent review.

6 Dietary education should be individualized and appropriate for the age and maturity of the child to help engage the child in active learning (47).

Education tools and methods

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

- There is no international consensus on the most appropriate tools and method/s for education, although a method of carbohydrate assessment is essential.
- There are no high quality, long term, randomized studies to support one particular method of carbohydrate counting compared with another.
- BG monitoring (preprandial and postprandial) provides essential information to confirm the success of the chosen method.
- As families become more confident with managing diabetes, education should be responsive to their observations, and education on GI or insulin coverage of high fat, high protein meals may be discussed.
- As children grow and take more responsibility, regular reeducation is essential.

The following are examples of a range of tools ranging from simple to complex that can be used at various stages of education. Basic dietary education should cover healthy eating and carbohydrate assessment, with some method of carbohydrate quantification.

Healthy eating education tools

The Plate Model method (Fig. 1) is useful in providing basic nutritional information and healthy eating concepts. It also illustrates visually carbohydrate-containing foods in relation to other food components and are attractive visual aids for children. Regular meals and snacks (at least three balanced meals per day) ensures that the range of nutrients are consumed to meet daily recommended requirements (48).

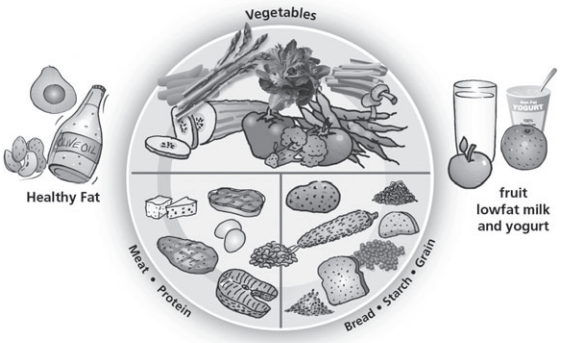

Fig. 1. Joslin Diabetes Center Healthy Plate Copyright © 2013 by Joslin Diabetes Center (www.joslin.org). All rights reserved. Reprinted with permission.

Carbohydrate assessment and methods

- The amount of carbohydrate and available insulin is one of the most important factors influencing postprandial glycemic control (4, 49).

Other dietary variables such as GI, fat, protein, and fiber impact postprandial glycemia and should be considered in interpreting and optimizing postprandial glucose levels (50–53). However, most education tools are based upon the premise that carbohydrate amount and type is recognized as the primary determinant of the postprandial response (54) and along with distribution of carbohydrate (55) form the basis of most education programs.

Extensive patient education materials are available in many countries to help adolescents and families estimate the carbohydrate content of foods in grams or exchanges or portions. Considerable time is often spent educating patients 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. It remains important to ensure that the principles of a healthy balanced diet underlie all education to not only improve glycemic control but also decrease cardiovascular risk.

Education regarding carbohydrate intake must be individualized to the child and family according to their understanding and the insulin regimen. Practical guidance on the distribution of carbohydrate intake necessary for both fixed and more flexible insulin regimes (4, 17).

Carbohydrate counting

Carbohydrate counting is a meal planning approach that focuses on carbohydrate as the primary nutrient affecting postprandial glycemic response. It aims to improve glycemic control and allow flexibility of food choices (56).

Studies in adults have reported glycemia and life-style benefits when carbohydrate counting is used as an intervention for people with diabetes (57–59). These benefits include improved glycemic control as measured by lower hemoglobin A1c (HbA1c) levels (59–62), improved diabetes-specific quality of life (59, 60), and improved coping ability in daily life (59, 61, 62).

However, it is essential that carbohydrate counting is incorporated as part of team-based approach to management and that healthy eating principles and routines underlie all education. Furthermore carbohydrate counting should not be seen as an emphasis on one nutrient only and dietary quality remains important (63).

Three levels of carbohydrate counting have been identified by the American Academy of Nutrition and Dietetics (64).

- *Level 1*: Consistent carbohydrate intake. This level introduces the basic concept of carbohydrate as the food component that raises BG. A consistent intake of carbohydrate is encouraged using exchange or portion lists of measured quantities of food. This is appropriate for those on twice daily insulin doses where a consistent carbohydrate intake from day-to-day is required (55).
- *Level 2*: Pattern management principles. This level is an intermediate step in which patients continue to eat regular carbohydrate, use a consistent baseline insulin dose and frequently monitor BG levels. They learn to recognize patterns of BG response to carbohydrate intake modified by insulin and exercise. With this understanding and team support they make adjustments to their insulin dose for food and exercise to achieve BG goals. Pediatric teams use this method less frequently, as most now employ either consistency in carbohydrate intake or insulin to carbohydrate ratios (ICRs).
- *Level 3*: ICRs. This level of carbohydrate counting is appropriate for people using multiple daily injections (MDI) or insulin pump therapy. It involves the calculation of ICR that is individualized for each child according to age, sex, pubertal status, duration of diagnosis, and activity. This enables young people with diabetes to adjust their prandial insulin dose according to carbohydrate consumption.

Many pediatric diabetes centers use only level 3 carbohydrate counting for patients on intensive insulin therapy (65).

Methods of quantifying carbohydrate in common use include:

- Gram increments of carbohydrate
- 10–12 g carbohydrate portions
- 15 g carbohydrate exchanges.

Research has not demonstrated that one method of teaching carbohydrate counting (grams, portions, or exchanges) is better than other methods (66, 67).

Studies have evaluated carbohydrate counting accuracy in the pediatric population because accurate carbohydrate counting has been demonstrated to be important to optimize postprandial glycemia (68–70). Research has shown that children, adolescents, and their parents can measure carbohydrate with a degree of accuracy, however underestimation and overestimation of foods remains a challenge (67, 69, 71). Regular review is necessary as children grow and new foods are introduced (67).

GI and glycemic load

The use of the GI has been shown to provide additional benefit to glycemic control over that observed when total carbohydrate is considered alone (72, 73). In type 1 diabetes GI should not be used in isolation, but with a method of carbohydrate quantification or regulation (74).

A controlled study in children substituting low GI for high GI foods found the lower GI diet improved glycemic control after 12 months compared with more traditional dietary advice (75).

- Low GI foods may lower postprandial hyperglycemia when they are chosen to replace higher GI foods (6). This has been demonstrated in a meal study with children using MDIs (76).
- Low GI food sources include whole-grain breads, pasta, temperate fruits, and dairy products (77).

Glycemic load (GL) is another method of predicting the postprandial BG response, which takes into account both the GI of the food and the portion size (78). There has been no assessment of its efficacy in children or adults with type 1 diabetes.

Dietary recommendations for specific insulin regimes

Conventional therapy

- 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 (55).
- On twice daily insulin, the carbohydrate content consumed in the meals eaten at the time of the insulin doses can be flexible if the patient/family is taught to adjust the short/rapid acting insulin to the carbohydrate eaten (79). Clinical experience indicates that preprandial and

postprandial BG testing can assist with determining the appropriateness of insulin dosage changes. Prescription of carbohydrate in a fixed meal plan requires regular review in a growing child and can be unsuitable because of the daily variability of total energy and carbohydrate intake.
- Particular attention should be paid to the total energy/carbohydrate intake and timing of meals or snacks to optimize glycemic control and to prevent excessive weight gain
- Most conventional insulin regimens require carbohydrate intake before bed to help in the prevention of nocturnal hypoglycemia.

MDI therapy and pumps

A more flexible approach using individualized ICRs, which enable insulin dose to be matched to carbohydrate intake, may be used for children and adolescents on intensive insulin therapy. This approach has been endorsed by a number of international consensus guidelines (1–4, 6). In order to assess the accuracy of the ICR preprandial and 2–3 h postprandial BG testing is required. The '500 rule' is often used to obtain an initial ratio, although other methods are also used (see 'Insulin' chapter).

This approach increases flexibility, by allowing more variable food intake at different meal times, decreasing the need for between meal snacks and allowing greater flexibility in meal times. Research suggests that a single meal time bolus of insulin may cover a range of carbohydrate intake without deterioration in postprandial control (80).

Insulin pump therapy provides the greatest degree of flexibility in meal times and a greater variation in carbohydrate intake.

- Care should be taken when an ICR is used in MDI and pump therapy, that the overall quality of the diet is not reduced (63).
- Increased flexibility should not mean total freedom without consideration of healthy eating principles and meal-time routines (9).

Studies in adults using MDI with ICRs have shown improvements in dietary freedom, glycemic control, and quality of life (57, 58, 60), 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 (47, 81–85). The results have been variable some indicating improvement in glycemic control and others not, but most have reported improved quality of life outcomes.

The use of meal time insulin bolus calculators in both MDI and pump therapy has been shown to assist insulin dose calculations and potentially improve postprandial glycemia (86, 87).

Rapid acting insulin analogs are usually given in these regimens immediately before meals to diminish the postprandial BG-excursion (88) and to decrease the likelihood of being forgotten (89). In addition, snacks without meal boluses are common in adolescents and result in deterioration in glycemic control (90). Giving insulin boluses after a meal (91) and frequent snacking (9) have also been shown to worsen glycemic control.

- For those on MDI clinical experience at some centers suggests short-acting (regular/soluble) insulin may be given when a prolonged insulin effect is desired to match certain meals (e.g., high fat, carbohydrate dense foods). Preprandial and postprandial BG testing should be used to evaluate this regimen.
- One of the advantages of pump therapy 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 and/or high-fat or high-protein content). For high-fat carbohydrate dense meals such as pizza and battered fish and chips, the dual wave bolus has been shown to most effectively match the postprandial glycemic profile (92, 93). Additionally, a dual-wave bolus prior to a low GI meal was found to significantly reduce the postprandial glucose excursion (94).
- Continuous glucose monitoring systems can be useful in guiding insulin adjustments to match the glycemic responses of different meals (95).
- To date, the meal-time insulin dose is typically calculated using an individualized ICR. However, there is increasing evidence that the impact of other macronutrients (fat and protein) should be considered when determining the bolus insulin dose and delivery (50, 52, 53, 96).

Recent studies in both children and adults using intensive insulin therapy have shown that meals high in protein or fat increase delayed hyperglycemia (53, 96). These studies highlight the limitations of current carbohydrate-based algorithms for insulin dosage calculations. The calculation of fat and protein units has been suggested to cover the postprandial excursions caused by high fat and protein meals (97, 98). Another novel insulin dosing algorithm based on the Food Insulin Index, has also been developed and trialed in adults (99).

Randomized controlled trials of methods to manage delayed postprandial glycemia after meals high in fat and protein are required, in addition to evaluating their acceptability to individuals with diabetes.

Age-group-specific advice

The challenges of nutrition education for children and adolescents with diabetes are often age-related and require consideration of the specific nutrition and developmental needs for different age groups. The defining characteristics of different age groups must be considered when providing nutrition care to children and adolescents. Below is a summary of some of the specific characteristics to consider when working with different age groups.

Toddlers

- Toddlers have variable appetites. Routine, small meals over the day may promote better glycemic control and nutritional adequacy. Discourage continual eating as this may contribute to food refusal issues at meal-times and can lead to difficulty in interpreting BG levels.
- Insulin pump therapy may be effective in helping manage toddler-eating behaviors (8, 100). It is preferable that preprandial insulin doses are given, although the dose can be split to preprandial 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 reintroduction of a bottle of milk or juice for 'easy' carbohydrate intake.
- A variety of tastes, colors, and textures of foods should be encouraged.
- Parental anxiety regarding food intake is common in this age group and consideration of this needs to be given when deciding on an insulin regimen. Daycare providers need instruction on diabetes management.

School aged children

Meal and snack routine ideally should be incorporated into the usual school timetable.

The child should start to acquire an understanding of carbohydrate amounts in foods with supervision and support (67).

- Individual advice should be provided regarding carbohydrate intake to prevent hypoglycemia particularly for school events such as sports days, excursions, and camps. This should not be needed for the child's usual active play.
- Advice on healthy food choices, food portion size, and physical activity to reduce the risks of inappropriate weight gain and cardiovascular disease is important.
- Sleepover and party advice should be discussed.
- School personnel need understanding and training in diabetes management.

Adolescents

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, family-based meals particularly during periods of rapid growth to prevent excessive afternoon or evening snacking.

Negotiations and consideration of the insulin management regime to suit variable schedules, including school, exercise, and work commitments is an important consideration.

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 (see below). 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 risks of prolonged hypoglycemia is important in some societies.
- Information on the nutritional content of snack and takeaways is important.

Parties, festivities, and special events. Special dispensation is usually given to children with diabetes during fasts such as Ramadan. If the family wishes to participate in fasts, education on carbohydrate and insulin adjustment needs to be provided.

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.

Planned or unplanned physical activity is one of the commonest causes of hypoglycemia in young people

with type 1 diabetes. However, intense exercise can cause hyperglycemia during the activity, with potential for delayed hypoglycemia. See Guideline on Exercise for more details.

Children and young people undertaking regular physical activity and training have the same nutritional requirements as their peers without diabetes. Dietary intake needs to be appropriate to support growth and the demands of the specific sport (101). In addition, nutritional strategies are needed to prevent the potential hypoglycemic and hyperglycemic effects of exercise. The energy and carbohydrate demands of exercise vary with the type, intensity, and duration of exercise so an individual approach to advice is required.

Advice on physical activity, exercise, and sport should emphasize the importance of careful planning, individual attention to detail (BG monitoring, food intake, and insulin adjustment) and incorporate the personal experiences of the young person. Advice on additional carbohydrate intake should relate to the energy and carbohydrate demand of the activity and the type and intensity of the exercise being undertaken.

Exercise should be delayed if control is poor [BG >14 mmol/L (250 mg/dL) or if ketones are present] until the diabetes is under better control with insulin administration.

Unplanned and spontaneous activity

Hypoglycemia is commonly associated with unplanned physical activity. Depending on the duration and intensity of exercise, this may occur during or after exercise, in the period of increased insulin sensitivity and muscle recovery. See Guideline on Exercise for more details.

Young people with diabetes need to have rapidly absorbed carbohydrate readily available when undertaking exercise.

- If extra carbohydrate is necessary for a short-duration activity then quick acting carbohydrate as a beverage is usually most useful.
- The amount of carbohydrate required for exercise is dependent on the BG level at the start of exercise, the intensity of the exercise, the frequency of routine exercise, the prevailing insulin level, the insulin regimen, and the age and weight of the young person.
- During moderate exercise, additional carbohydrate may be consumed to prevent hypoglycemia. This will vary depending on the type of activity. The requirements will be lower if the pre-meal insulin bolus for the meal before the exercise is lowered or the exercise is performed several hours after the bolus dose has been given.

Additional carbohydrate (above general population recommendations), is only recommended when the exercise level increases above the recommended 60 min/d. Redistribution of carbohydrate intake and insulin adjustment is more appropriate for normal levels of activity.

- Carbohydrate sources or snacks for unplanned exercise should not provide an intake in excess of energy expenditure. They should be low in fat such as fruit juice, sports drinks, dried fruit, fruit bars, and cereal bars.

Following unplanned physical activity, BG testing will enable more appropriate management of variations in BG levels. Reduction of evening insulin doses may be required to prevent delayed hypoglycemia, in addition to an increase in carbohydrate intake at the meals/snacks following significant periods of activity (102). Pre-bed and overnight BG testing can guide the appropriate administration of additional carbohydrate at dinner and before bed to help prevent nocturnal hypoglycemia (103).

Although it is difficult in unplanned exercise, whenever possible, particularly for children on MDI or pumps, rapid acting insulin should be reduced prior to exercise rather than extra carbohydrate consumed, to prevent excessive weight gain.

Planned or competitive sports

Regular participation in physical activity, training, and competitive sports require careful planning and individual strategies for nutrition and insulin management. Appropriate insulin adjustment, adequate nutrition, and fluid intake are essential for optimal performance (104). Adequate amounts of carbohydrate are vital for optimal sports performance; 50–65% of total energy as carbohydrate is recommended (105).

A carbohydrate based, low-fat meal should be eaten 1–3 h prior to sport to ensure adequacy of glycogen stores and availability of carbohydrate for exercise (106). In the case of elite athletes, it may be preferable to have a meal 4 hours prior to activity to maximize glycogen stores and to help ensure only basal insulin is acting.

- Additional 'quick acting carbohydrate' may be needed prior to and during strenuous exercise lasting $\geq$60 min to maintain performance. An isotonic sports drink containing 6–8% carbohydrate may be useful during prolonged activity to address both increased fluid and carbohydrate needs (107).

An intake of up to 1.0–1.5 g carbohydrate per kg body weight per hour of exercise may be required during aerobic exercise performed during peak insulin

action, if a reduction in insulin is not performed (108). Examples of suitable carbohydrate sources for exercise include carbohydrate gels, isotonic sports drinks, fruit, and fruit juices. Additional fluid should be consumed when solid forms of carbohydrate are used during exercise.

Additional carbohydrate during exercise can cause gastrointestinal upset, so advice should be adapted to suit the individual.

- Preexercise carbohydrate consumption should be related to pre-exercise BG. The idea is to distribute the carbohydrate intake throughout the activity. However, if BG is low, carbohydrate (10–15 g) should be consumed prior to the exercise and/or appropriate adjustments made to insulin to prevent hypoglycemia. For some high intensity strenuous/anaerobic activities, pre-exercise carbohydrate may also require additional bolus insulin (103, 108).
- Exercise when the patient is underinsulinized may result in hyperglycemia and poor performance (109).
- Fluid intake should be maintained at a level appropriate to the activity to maintain optimal hydration (110). Fluid requirements in children during strenuous exercise are of the magnitude 13 ml/kg/h. The fluid should be consumed throughout the activity (111).

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. 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 (112).

Nutritional management of type 2 diabetes in children and young people

In young people with type 2 diabetes and insulin resistance, the presence of multiple cardiovascular risk factors is likely to be associated with earlier severe complications (113).

Aims of nutritional management:

- Achieve normal glycemia and HbA1c (11, 17).
- Prevent further weight gain in those with BMI at 85th−95th percentile or achieve weight loss for those with BMI >95th percentile while maintaining normal linear growth (114).
- Address comorbidities, such as hypertension and dyslipidemia (115).

Treatment recommendations

There is little evidence regarding the nutritional treatment of type 2 diabetes in children. Therefore, recommendations are derived from the treatment of overweight and obese children, type 2 diabetes in adults, and type 1 diabetes in children.

- Most children with type 2 diabetes 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, as 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 (116, 117). Interventions have shown improved outcomes from including parents as positive role models in encouraging healthy food choices and changing behaviors to increase physical activity.
- 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 high sugar and high energy beverages such as soft drinks and juices can accomplish improvement in blood sugars and weight (118).
- Increasing energy expenditure by increasing daily physical activity to 60 min is an important component of treatment (115). 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 (119). Physical activity may also help lower lipids in adolescents with diabetes (120).
- An interdisciplinary approach including a physician, diabetes nurse educator, dietician, mental health provider, and exercise physiologist (if possible) is recommended.
- An individualized meal plan incorporating low fat and energy choices and carbohydrate management may assist weight loss and BG targets.
- Children on MDI or pump therapy should be taught to adjust insulin to carbohydrate intake using an ICR (121). This may be helpful in reducing the need for snacks and large meals.
- Substitution of low GI foods for high GI foods may assist with control of appetite, weight, and lipid levels in adolescents with type 2 diabetes (72).
- Regular follow-up is essential to monitor weight, glycemic control, and adherence to the meal plan.

Celiac disease

Celiac disease is more common in children with type 1 diabetes than in the general population. Prevalence ranges from 0.6 to 16.4% of children with diabetes (122, 123). It is often asymptomatic (124), although may be associated with poor growth, delayed puberty, nutritional deficiencies, hypoglycemia, and hyperglycemia (125). A gluten-free diet (GFD) is the only accepted treatment for celiac disease. It is common for people with diabetes who develop celiac disease to have challenges with adherence to the GFD and improved understanding of the diet may assist adherence (126).

The GFD requires elimination of wheat, rye, barley, triticale, possibly oats, and products derived from these grains. Alternatives such as potato, rice, soy, tapioca, maize, buckwheat, and products derived from these and other gluten-free grains must be used as substitutes.

The inclusion of oats in the GFD remains controversial. Short- and long-term studies involving children and adults suggest that oats can be safely included for the majority of people (127–129). However a small minority of people with celiac disease have been found to react to oats (130). Concern also remains about cross-contamination of oats with gluten containing products. Thus the use of oats is not widely recommended in some countries. Research supports the view that contamination free oats may be acceptable for the majority but not all children with celiac disease (131).

There is debate as to the accepted definition of a GFD. It is now generally accepted in Europe and some other countries such as Canada and USA that foods containing less than 20 parts per million (ppm) gluten are suitable for a GFD (even if gluten is detectable) in accordance with Codex Alimentarius (International Food Standards).

Wheat starch is used in some European countries as part of a GFD (132). This too is controversial; as wheat starch is not recommended for inclusion in some countries such as Australia even at levels less than 20 ppm. In addition to advice on foods allowed or to avoid, emphasis should be placed on the nutritional quality of the GFD, particularly iron, calcium, fiber, and vitamin B intakes (133).

Children with diabetes and celiac disease require more frequent review by a pediatric dietician with experience in GFDs.

Eating disorders and diabetes

A range of screening questionnaires and structured clinical interviews are available to help identify and diagnose eating disorders in children and young people with diabetes (134–136).

Disordered eating and disturbed eating behavior is more common in young people with type 1 diabetes than their peers without diabetes (137). Diabetes is unique in making it possible for weight and shape control without overt avoidance of food. Insulin omission for weight control has been reported in pre-teens, adolescents, and young adults (138–140). It is increasingly recognized that adolescents may manipulate their insulin dose and/or diet because of weight and shape concerns, in ways that may not be immediately or easily identified as symptoms of an eating disorder.

It is well recognized that poor glycemic control may reflect insulin omission in association with disordered eating. This may be driven by weight concerns as well as additional emotional disorders (141). Eating disorders in adolescents and young adults with diabetes are associated with poor metabolic control and diabetic complications (142).This association is even more of a concern in young people with an increased risk of early onset of diabetic complications and evidence of ineffectiveness of treatment for the eating disorder (143).

Clinicians working with young people with diabetes and eating disorders need to consider the insulin regimen and potential for omission, metabolic control, dietary requirements, food manipulation, body dissatisfaction, and family functioning as well as high frequency of hospital admissions and/or failure to attend clinic appointments.

Interventions

An interdisciplinary approach to treatment is considered the standard of care for both eating disorders and diabetes. Close liaison with the Specialist Eating Disorder team may be required (144). More research is needed to assess the value of interventions to treat or prevent eating disorders in diabetes. A randomized controlled trial designed to specifically address eating disorder symptoms in young females with diabetes, found that an intervention was helpful for the eating disorder symptoms but did not improve either metabolic control or insulin omission (145).

Techniques may be important which enable young people to focus on positive skills in order to take control of the eating disorder and diabetes and empower families to continue to participate in the day today management of diabetes. All members of the team should have a degree of familiarity with these therapeutic approaches (144).

Behavioral approaches in diabetes dietary education

The management of diabetes in children is recognized as requiring a team approach, and parents are in need

of understanding and support from all health care professionals (146).

Family functioning and interactions at mealtimes have been demonstrated to impact on eating behavior and glycemic control in younger children (147, 148). Adolescence represents a critical stage in the development of self-management of food intake and diabetes, accompanied by independent decisions about health and lifestyle choices. It is known that psychological issues such as behavior disorders and depression are greater in children with diabetes, and this in turn is associated with poor metabolic control (149). Risk-taking behaviors, eating disorders, and non-adherence to diabetes regimens are common (150).

Systematic reviews have shown that psycho-educational interventions provide a model of patient care that has small to medium beneficial effects on glycemic and behavioral outcomes (151, 152). Further studies have shown the benefit of using behavioral techniques such as empowerment, cognitive behavioral therapy, and motivational interviewing(153, 154).

Family communication is also important and structured education programs which support open communication about diabetes and regular renegotiation of roles and shared family responsibilities throughout adolescence may be more effective than skills training alone (154). It is important that these approaches are employed as part of routine care from diagnosis, to enable children, young people, and families to develop effective self-management skills (155). A recent study has demonstrated that these approaches introduced to children and families with established diabetes may improve quality of life, however, only those with the poorest control benefited in terms of improvement in HbA1c (156).

- Pediatric dieticians should be trained in family communication skills, counseling, psychology, behavior modification approaches, and motivational interviewing.
- Training in behavioral and psychological skills would enable earlier identification of those children and families who may be struggling with food- or weight-related issues and allow earlier referrals to specialist care such as, psychologists, eating disorder teams, and child and family therapists.

Research

- There is a lack of high quality, randomized controlled trials in many aspects of nutritional management.
- Metabolic, quality of life outcomes, and the effectiveness of educational methods in relation to dietetic interventions need to be rigorously examined.

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 the reduction in cardiovascular risk.

The fundamental premise of successful dietary outcomes is the development of a trusting relationship between the health professional, child, and care providers, which facilitates behavior change during the challenges of childhood and adolescent development.

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Conflicts of interest

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