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ISPAD Clinical Practice Consensus Guidelines 2018 Compendium

Nutritional management in children and adolescents with diabetes

Carmel E. Smart^{a,b}

Francesca Annan^c

Laurie A. Higgins^d

Elisabeth Jellery^e

Mercedes Lopez^f

Carlo L. Acerini^g

^a John Hunter Children's Hospital, Newcastle, Australia

^b University of Newcastle, Newcastle, NSW, Australia

^c University College London Hospitals, London, UK

^d Joslin Diabetes Center, Boston, Massachusetts, USA

^e Karolinska University Hospital, Stockholm, Sweden

^f Fundacion Diabetes Juvenil, Quito, Ecuador

^g Department of Paediatrics, University of Cambridge, UK

Corresponding author: Dr Carmel Smart carmel.smart@hnehealth.nsw.gov.au

John Hunter Childrens Hospital

Lookout Road

New Lambton Heights

NSW Australia 2299

Acknowledgments: Sheridan Waldron, Ellen Aslander-Van Vliet, Peter Swift, Luciana Bruno, Alexandra Marlow

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Summary of What is New/Different

- The guide to the distribution of macronutrients has been updated and re-enforces family preferences and healthy eating patterns.
- The importance of meal-time routines with limitations on snacking has been emphasized in order to improve dietary quality and optimize glycemic outcomes.
- The impact of dietary fat and protein should be considered in the calculation of the meal-time insulin dose and how it is delivered.
- 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.

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 childhood diabetes should be part of the multidisciplinary team and should be available as soon as possible at diagnosis to develop a consistent relationship (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 45-50% 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 improvements in glycemic control and quality of life (A). Meal-time routines and dietary quality are important for optimal glycemic outcomes (B)

- Carbohydrate counting is best introduced at onset of type 1 diabetes (E)
- There are several methods of quantifying carbohydrate (CHO) intake (gram increments, 10g-12 g CHO Portions and 15g CHO Exchanges). There is no strong research evidence to suggest that one particular method is superior to another (E)
- Pre-prandial insulin dosing should be encouraged from diabetes onset for children of all ages (A)
- 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 provides additional benefit to glycemic control over that observed when total carbohydrate is considered alone (B)
- Dietary fat and protein impact 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.
- Prevention of overweight and obesity in pediatric type 1 diabetes is a key strategy of care and should involve 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 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)

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 multidisciplinary 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, helping 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) and also have clear agreed goals with the multidisciplinary team(13).

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, 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 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 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 micro and macro-vascular complications, particularly cardiovascular disease
- Develop a supportive relationship to facilitate behavior change and positive dietary modifications
- Tailor advice to individual goals, including weight loss and high level sports goals
- To use diabetes technologies such as continuous glucose monitoring to aid dietary education and inform prandial insulin adjustments and 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. It is vital that energy intake is reduced when appropriate weight is restored (14). The first year following diabetes onset is a critical period to ensure excessive weight is not gained and to promote maintenance of a healthy body weight (15).

- Energy intake varies greatly within subjects on a daily basis due to age, growth rate, physical activity and 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. Energy balance equations are a guide; however, a limitation is that they can over-estimate energy requirements
- Dietary advice/meal planning should be revised regularly to meet changes in appetite and insulin regimens and to ensure optimal growth (1)
- Insulin (amount and type) should be adapted where possible to the child's appetite and eating pattern. Making a child eat or withholding food in an effort to control blood glucose should be discouraged as this may impact adversely on growth and development (1)
- During puberty, energy intake and nutritional demands increase substantially along with significant increases in insulin dosage. This is an important time to monitor for disordered eating and/or excessive weight gain.

Maintenance of healthy body weight

- 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 worldwide (16). Large multi-center studies in the US, Australia, and Germany and Austria have assessed the prevalence of overweight in children and adolescents with type 1 diabetes and report prevalence rates of overweight and obesity at least as high as the general population (17-19).
- Prevention and management of overweight/obesity are key strategies of care. Guidance on family food choices, appropriate portion sizes, energy density of foods, meal routines and physical activity is essential (20). Regular review by the multidisciplinary team to adjust insulin as weight is lost and for physical activity is necessary to prevent hypoglycemia.
- Important aspects of management in the prevention of overweight are:
 - Plotting the growth curve, BMI (16) and if possible waist circumference every 3 months. Currently there are no international reference ranges for waist circumference in children younger than 16 years. Target reference values for young people aged 16 years and older are <80 cm for females and <94 cm for males (21).
 - Regular review by a dietician
 - Promotion of regular moderate-vigorous physical activity for 60 minutes a day, on a daily basis (22).

- Adjustment of insulin in preference to intake of additional carbohydrate for hypoglycemia prevention during physical activity
- Consistent advice on the prevention and appropriate treatment of hypoglycemia (to prevent overtreatment) by all team members
- Review of the insulin regimen to minimize hypoglycemia and the need for large snacks

Energy intake recommendations

A guide to the distribution of macronutrients according to total daily energy intake is as below. These reflect guidelines for healthy eating for children without diabetes (23,24). 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 taken into account (25). This may vary depending on meal patterns, cultural influences and metabolic priorities. Dietary patterns that restrict intake from one macronutrient may compromise growth and lead to nutritional deficiencies (26).

National guidelines for adults and children with diabetes in Australia and Canada recommend a carbohydrate intake of at least 45% energy (2, 6). 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 (27). 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. 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 (28-31).

Carbohydrate 45– 50 % Energy

Moderate sucrose intake (up to 10% total energy)

Fat 30 – 35% Energy

<10% saturated fat + trans fatty acids

Protein 15 – 20 % Energy

Food components

Carbohydrates

Carbohydrate requirements in children and adolescents are individually determined based on age, gender, activity and previous intake. The mean requirement for carbohydrate if a child is consuming 45% energy from carbohydrate at age 10 years is up to 170grams and in adolescents aged 14 years approximately 213grams. However it is important that this is high quality carbohydrate. Clinical evidence suggests that individuals can consume 45-50% 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.

Low carbohydrate diets

There is international agreement that carbohydrate should not be excessively restricted in children and adolescents with type 1 diabetes as it may result in deleterious effects on growth, a higher cardiovascular risk metabolic profile and increase the risk of disordered eating behaviors (26). There is evidence from ketogenic diets that low carbohydrate diets can be nutritionally inadequate and result in growth failure (32). Restricted carbohydrate diets may increase the risk of hypoglycemia or potentially impair the effect of glucagon in hypoglycemia treatment (33).

It is important to respectfully explore the family reasons for carbohydrate restriction. The meaning of a low carbohydrate diet may differ and it is important to understand what it means to the individual family. If an individual child or family chooses to routinely consume a diet <40% energy from carbohydrate it is recommended that they discuss this with a dietitian to ensure the diet is nutritionally complete, particularly in regard to calcium, B vitamins, iron and fiber (26). Dietary intake studies in children and adolescents using intensive insulin therapy have previously reported an association between lower total carbohydrate intakes and poorer glycemic outcomes (34,35), although more evidence is needed. An emphasis should be on maintaining positive relationships between the family and treating team.

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 (37) or the addition of a moderate amount of protein to a meal containing predominantly carbohydrate (38) can assist in reducing post-prandial excursions. Substituting low Glycemic Index (GI) for High GI carbohydrate (39, 40) and increasing dietary fiber intake (35) are other useful dietary options. A meal-time routine with limits on snacking episodes can assist in preventing prolonged periods of postprandial hyperglycemia (9).

Sucrose

Sucrose and sucrose-containing food and fluids should be consumed in the context of a healthy diet (4). Sucrose does not increase

glycemia more than isocaloric amounts of starch (41). However, consumption of foods containing added sucrose should be minimized to avoid displacing nutrient-dense food choices and decreasing dietary quality (4). If added, sucrose should be appropriately balanced against insulin doses. Sucrose can provide up to 10% of total daily energy intake (6). 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 (42). 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. Water should be encouraged instead of sugary drinks for everyone.
- Sucrose may be used instead of glucose to prevent or treat hypoglycemia. See guideline on Hypoglycemia for more details.

Fiber

Age	Fiber Recommendations
Birth through 1 year	Not determined
1 year or greater	14g/4184 kilojoule (1000 kcals) 3.3g/megajoule
Alternative Formula	
Children > 2 years old (43)	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 (44)
- Dietary fiber intakes of children in many countries are lower than recommended (43).
- High fiber diets, especially from sources with insoluble fiber, are associated with lower cardiovascular disease (CVD) and coronary heart disease (CHD). In addition, greater intake of fiber from fruit is associated with lower CVD (45, 46)
- Dietary fiber is associated with digestive health and modulates bowel function, fermentation and effects of gut microbiota (45).
- Increasing fibre intake can assist in improving glycemic control (35)

- 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.
- Diet high in whole grains may help to improve satiety, replace more energy dense foods and prevent weight gain (47)
- Processed foods tend to be lower in fiber therefore; unprocessed, fresh whole foods should be encouraged

Fats

Population based nutritional guidelines recommend a fat intake of no greater than 30-35% total daily energy intake (48). A range of recommendations currently exist in adult diabetes guidelines, from no specific recommendation for percentage total energy up to 35% energy from fat (2, 4, 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 (27).

High total fat intakes have been shown to increase the risk of overweight and obesity (48). High saturated and trans-fat intakes have been linked to an increased risk of cardiovascular disease (2, 28). Studies show children and young people with diabetes consume fat and saturated fat above dietary recommendations (28-31).

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 (49).

- 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 is recommended (50). 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.

Monounsaturated fatty acids and Polyunsaturated fatty acids.

- 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 cardiovascular disease. They are recommended replacements for saturated fats (27).
- 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 (51, 52).
- 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 (53, 54).

Protein

- Intake decreases during childhood from approximately 2 g/kg/day in early infancy to 1 g/kg/day for a ten year old and to 0.8 – 0.9 g/kg/day in later adolescence(55)
- 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 (2)
- When persistent micro albuminuria 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 (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 (56).

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

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 type 1 diabetes is common and relates to vascular dysfunction (57).

Alcohol

Young people with type 1 diabetes face more risks when drinking alcohol than people without diabetes. Excess alcohol is more dangerous because of suppression of gluconeogenesis and the possibility this may induce prolonged hypoglycemia in young people with diabetes (up to 10 – 12 or more hours after drinking, depending on the amount ingested) (58). 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 intake in young people may lead to increased risk taking behaviors and interfere with the ability to recognize hypoglycemia symptoms
- Many types of alcoholic drinks are available, some of which contain carbohydrate and can cause initial hyperglycemia, while still predisposing to later hypoglycemia. 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 alcohol intake. It may be also necessary to decrease the insulin dose particularly if exercise is performed during or after drinking
- Advice should include avoidance of binge drinking (more than 4 standard drinks) 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 blood glucose (BG) levels more often than usual during the night and the following day, at least until lunchtime (59). Continuous glucose monitoring can also be very helpful in preventing nocturnal hypoglycemia
- Young people should be encouraged to wear identification for diabetes as symptoms of hypoglycemia can be mistaken for intoxication

Specially labeled diabetic foods

- International nutritional guidelines advise that a moderate amount of sucrose can be consumed (2-6) and "diabetic foods" are not necessary.
- "Diabetic" foods are also not recommended because they are expensive, often high in fat and may contain sweeteners with laxative effects. These include the sugar alcohols such as sorbitol
- Water should always be encouraged instead of drinks sweetened with non-nutritive sweeteners.
- 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 (60).

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 (3).

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

2. 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 (11). It is important that the initial or review assessment includes identification of any body image or weight concerns.

3. Contacts thereafter depend on local arrangements, a minimum should include 2 – 4 times in the first year and annual reassessment (11). 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.

4. Continuation of care, support and review by a dietician is essential for optimal care (11).

5. Circumstances such as changing insulin regimen, dyslipidemia, poor dietary knowledge, excessive weight gain, and co-morbidities 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 (61).

Education tools and methods

Education tools and methods are used to provide knowledge and skills to optimize glycemic control, growth and cardiovascular outcomes. Dietary quality must be promoted alongside all carbohydrate quantification tools.

- Methods of healthy eating education and tools for carbohydrate quantification are essential.
- There exist no high quality, long term, randomized studies to support one particular method of carbohydrate counting compared with another.
- Blood glucose monitoring (pre and post-prandial) or continuous glucose monitoring systems (CGMS) provide essential information on post-prandial glucose excursions and the need to improve carbohydrate counting accuracy, adjust the prandial insulin timing or amount, or alter the insulin delivery or dose for meals high in fat and protein (62).
- As families become more confident with managing diabetes, education should be responsive to their observations and education on glycemic index or insulin coverage of high fat, high protein meals may be discussed.

- As children grow and take more responsibility, regular re-education is essential.

The following are examples of a range of tools ranging from simple to complex that can be used at various stages in education.

Basic dietary education should cover healthy eating 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. The plate can be thought of as a guide to both the individual meal and the day as a whole. It also illustrates visually carbohydrate-containing foods in relation to other food components and is an attractive visual aid 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 (63).

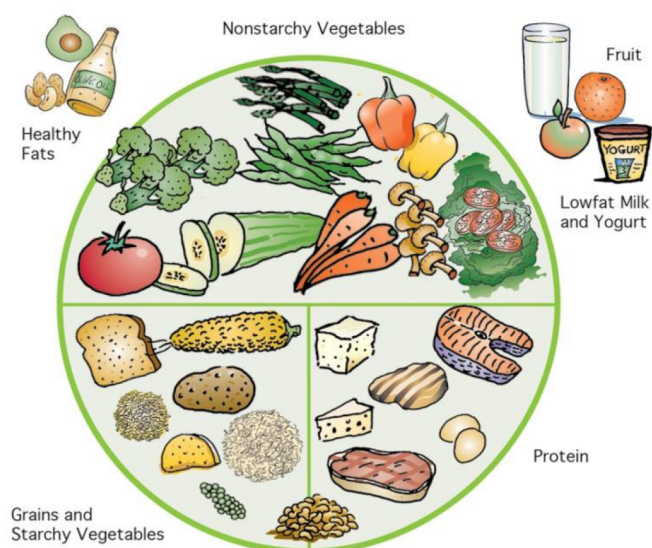


Fig 1 .Joslin Diabetes Center Healthy Plate Copyright © 2017 by Joslin Diabetes Center (www.joslin.org). All rights reserved.

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Carbohydrate assessment and methods

- The amount of carbohydrate and available insulin is one of the most important factors influencing postprandial glycemic control (4, 64).

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 (65-68). However, most education tools are based upon the premise that carbohydrate amount and type is recognized as the primary determinant of the postprandial response and along with distribution

of carbohydrate 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, portions or exchanges. Dietary sessions involve 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.

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 (69). It is essential that carbohydrate counting is incorporated as part of team-based approach to management and healthy eating principles and meal-time routines underlie all education. Information about dietary quality and carbohydrate counting should be provided together (70).

International consensus is that carbohydrate counting is best introduced at the onset of diabetes for those using intensive insulin therapy (71), however no randomized studies exist on the optimal timing of carbohydrate counting interventions.

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 type 1 diabetes (72,73). These benefits include improved glycemic control as measured by lower HbA1c levels (74-77); improved diabetes-specific quality of life (74, 75); and improved coping ability in daily life (74, 76, 77). Both concluded carbohydrate counting was a useful method for insulin dosing. Nutrition guidance recommendations for adults receiving MDI or Insulin Pump state carbohydrate counting using insulin-to-carbohydrate ratios should be used to optimize glycemic outcomes (25).

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 (78).

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 other methods (79). It has been shown that a single meal time bolus of insulin may cover a range of carbohydrate intake without deterioration in postprandial control (80). Therefore, it is not essential that people using intensive insulin therapy count

carbohydrate in grams and other forms of carbohydrate quantification such as exchanges can be used successfully.

Accuracy in carbohydrate counting is important to optimize postprandial glycemia (81-83). There is no universal definition for accuracy. Research has shown children, adolescents and their parents can carbohydrate count with a degree of accuracy, however under and over-estimation of foods remains a challenge (79, 81, 83, 84). Regular review of carbohydrate counting skills is necessary as children grow and new foods are introduced (79).

Mobile applications (apps) and digital games are useful tools to assist carbohydrate estimations (85). Bolus calculators, used in association with carbohydrate counting, can aid insulin dose calculations and may further improve glycemic control (86).

Glycemic index and glycemic load

The use of the glycemic index (GI) has been shown to provide additional benefit to glycemic control over that observed when total carbohydrate is considered alone (87, 88). In type 1 diabetes GI should not be used in isolation, but with a method of carbohydrate quantification (89). A controlled study in children substituting low GI for high GI foods found the lower GI diet improved glycemic control after 12 months compared to prescriptive dietary advice (90).

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 (6). This has been demonstrated in a meal study with children using multiple daily injections (91).
- Low GI food sources include whole-grain breads, pasta, temperate fruits and dairy products (92).

Glycemic load (GL) is another method of predicting the postprandial blood glucose response, which takes into account both the GI of the food and the carbohydrate portion size (93). A small pilot study on the feasibility of GL counting in nine adults with type 1 diabetes found that GL counting is feasible in real-life for prandial insulin dose calculations (94). Further studies are needed to investigate the efficacy of GL for calculating the meal-time insulin dose.

Fat and Protein

The meal-time insulin dose is typically calculated using an individualized insulin-to-carbohydrate ratio. However, there is evidence that the impact of dietary fat and protein should be considered when determining the insulin bolus dose and delivery (65, 67, 68, 95). 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 (38, 68, 95, 96). These studies highlight the limitations of current carbohydrate-based algorithms for insulin dosage calculations.

Clinical guidelines recommend mealtime insulin dose adjustments to compensate for the delayed hyperglycemic excursions caused by fat and protein (97). Several methods of adjusting insulin doses for fat and protein have been suggested. A systematic review recommended incremental dose increases up to 30-35% for meals high in fat and protein, accompanied by a combination or split bolus (37). Another study has suggested up to 65% more insulin for a high protein, high fat meal (98). 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 (95, 98). A conservative starting point for incremental bolus dose increases is an additional 15-20% for high fat, high protein meals.

Novel algorithms have also been suggested to cover the postprandial excursions caused by high fat and protein meals. The calculation of fat and protein units has been proposed with the additional insulin provided as an extended bolus (99). This has been trialed in a number of studies, however a higher rate of clinically significant hypoglycemia was a limitation of this method (99-101). Another novel insulin dosing algorithm based on the Food Insulin Index (FII), has also been developed and trialed in adults (102). Its clinical applicability has been investigated in a randomized pilot trial in adults, which demonstrated no significant difference in glycemic outcomes compared to carbohydrate counting (103). The Food Insulin Index has also been compared to carbohydrate counting in dosing for protein-only foods in a small acute postprandial study in adults (104). However, hypoglycemia rates were high for both dosing methods (FII 48% vs CC 33%). Currently the optimal insulin bolus dose and delivery for meals high in fat and protein is undefined with randomized controlled trials required.

Insulin dosing software is emerging as 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 (105, 106). Evaluations of applications are needed, in addition to evaluating their acceptability to individuals with diabetes.

Dietary Recommendations for Specific Insulin Regimes

PRANDIAL INSULIN DOSING

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 (107).
- 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 (108). Pre-and post-prandial blood glucose testing or CGM 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. Adherence is difficult to a fixed meal plan because of usual 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 twice daily insulin regimens require carbohydrate intake before bed to help in the prevention of nocturnal hypoglycemia.

Intensive insulin regimens

A more flexible approach using individualized insulin to carbohydrate ratios (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. The ICR is individualized for each child according to age, sex, pubertal status, duration of diagnosis and activity. This approach has been endorsed by a number of international clinical consensus guidelines (1-4, 6, 25). In order to assess the accuracy of the insulin to carbohydrate ratio pre- and 2-3 hours post-prandial BGL testing is required. Although this method increases flexibility of the meal timing and the carbohydrate amount, meal time routines and dietary quality remain important.

Studies in adults using MDI with insulin-to carbohydrate ratios have shown improvements in dietary freedom, glycemic control and quality of life (75), particularly if delivered as part of a comprehensive education package. Insulin-to-carbohydrate ratios have also been evaluated in children and adolescents using MDI, often as part of structured education programs (61, 109-113). Results in adults have indicated the use of insulin-to-carbohydrate ratios have resulted in significant decreases in HbA1c of 0.4% to 1.6% and significant increases in quality of life (25).

- Care should be taken when an insulin to carbohydrate ratio is used in MDI and pump therapy, that the overall quality of the diet is not reduced (70).
- The use of meal time insulin bolus calculators in both multiple daily injection therapy and insulin pump therapy has been shown to assist insulin dose calculations and potentially improve postprandial glycaemia (114, 115).

Rapid acting insulin analogues should be given in these regimens up to 20 minutes before meals to diminish the postprandial blood glucose excursion (116) and to decrease the likelihood of being forgotten (117). Snacks without meal boluses result in deterioration in glycemic control (118). "Grazing" or frequent snacking has also been shown to worsen glycemic control (9).

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 (91, 119, 120). Delivering a bolus dose 15–20 min before eating rather than immediately before additionally improves postprandial glycemia (119, 120).

One of the advantages of insulin 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, 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 (121, 122). A combination bolus prior to a low GI meal is also helpful in matching the postprandial glucose excursion (123). The combination bolus has similarly been used efficaciously for high protein, high fat meals, combined with additional insulin for the fat and protein components (101).

A systematic review concluded differences in the *duration* and *split* of bolus types across studies make it difficult to recommend a specific duration and split for *all* meal types (37). Studies indicate intra-individual variation in the pattern of insulin delivery required for meals (98, 121, 124). 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 (125). 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 (98). Studies have confirmed that the standard bolus is not as effective as the combination bolus for high fat and high protein meals (122, 126). In clinical practice, use of the combination bolus with sufficient insulin upfront to control the initial postprandial rise is needed. Further studies are required to determine the appropriate insulin bolus delivery pattern for high fat or high protein meals.

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, for example high fat, carbohydrate dense foods. Split insulin doses have also been recommended by some centers, however there is only one published study that has investigated this (127). This study 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. When this dose was delivered as a normal bolus however, the incidence of hypoglycemia significantly increased. Pre- and post-prandial blood glucose testing at 3, 5 and 7 hours or continuous glucose monitoring systems can be useful in guiding insulin adjustments and evaluating the outcomes of changes to the insulin dose or timing (124).

Age group specific advice

The challenges of nutrition education for children and adolescents with diabetes are often age-related and reflect the nutritional impact on eating behavior and glycemic control in younger children (128, 129) and adolescents (130). Adolescence represents a and developmental needs of different age groups. Family functioning and interactions at mealtimes have been demonstrated to

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 chapter on Managing Diabetes in Preschool Children (71) for more detailed information on the nutritional management of toddlers and preschool-aged children with type 1 diabetes.

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 meal-times and can result in postprandial hyperglycemia.
- Insulin pump therapy may help manage toddler-eating behaviors (8, 131). It is preferable that pre-prandial insulin doses are given, 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 (See Managing Diabetes in Preschool Children (71)).
- Daycare providers and babysitters need instruction on diabetes management

School aged children

Meal and snack routine should be incorporated into the usual school timetable, where possible.

The child should start to acquire an understanding of carbohydrate amounts in foods with supervision and support (79).

- 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, 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 (see later). 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 with appropriate healthier alternatives is important.

Festivities and special events

Celebrations and festivities specific to culture and religion will 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, education on carbohydrate and insulin adjustment needs to be provided alongside risk assessment, fasting is associated with a higher risk of hypoglycemia. Detailed guidance on assessment and management of fasting and Ramadan can be accessed from the IDF (132).

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. Physical activity which may be planned or unplanned 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 on glycemic management, hypoglycemia prevention and insulin adjustment for all types of physical activity and exercise.

Children and young people undertaking regular physical activity and training have the same nutritional requirements as their peers without diabetes. Evidence for sports nutrition in child and adolescent competitors is limited and based on adult guidelines. Within adult literature there is insufficient evidence relating to athletes with type 1 diabetes to make diabetes specific nutrition recommendations as most studies address hypoglycemia prevention rather than sports nutrition needs. An international consensus statement on exercise management in type 1 diabetes provides guidance regarding nutritional requirements for exercise performance and hypoglycemia prevention (133).

Dietary intake needs to be appropriate to support growth and the demands of the specific sport (134). Adequate total nutrition is important to ensure that increased energy needs of the sport do not impair growth. In many countries energy intake recommendations take into account activity levels. When estimating requirements for young sports people with type 1 diabetes the additional energy cost of the activity should be accounted for.

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 contribute to the prevention of hypoglycemic and hyperglycemic episodes during and post exercise. 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. Adequate nutrition and fluid intake coupled with appropriate insulin adjustment are essential for optimal performance (135).

Carbohydrate

The primary fuel for muscles for most types of activity is carbohydrate. Adequate amounts of carbohydrate are vital for optimal sports performance. 50%– 60% of total energy as carbohydrate is recommended (136). 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.

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. Amounts of carbohydrate required will also be impacted by insulin adjustment. Where insulin is not adjusted prior to exercise, additional carbohydrate may be needed over and

above the needs for sports performance. Requirements may be as high as 1-1.5g/kg/body weight for aerobic exercise without prior insulin adjustment (137). For some high intensity strenuous or anaerobic activities, pre-exercise carbohydrate may also require additional bolus insulin (137). Food consumed prior to competitive sports may require increased insulin doses compared to training situations.

The need for carbohydrate immediately prior to exercise will also be related to pre-exercise blood glucose and timing of the last meal/snack. If blood glucose level is below 5mmol/L, an additional 10-15g carbohydrate will be needed prior to starting the activity. Glucose trends can be used to identify the need for additional carbohydrate for hypoglycemia prevention (138). This type of nutritional adjustment is easier to make in the presence of continuous glucose monitoring (see Exercise chapter).

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 (139). 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 (140). 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 (141). Post exercise carbohydrate needs will vary with the intensity and duration of exercise but may be as high as 1.5g/kg bodyweight. Post exercise carbohydrate will require carefully adjusted insulin doses to reduce glycemic excursions.

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 type 1 diabetes 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 (142). Ensuring protein is included in the meal prior to exercise may help reduce the risk of hypoglycemia during exercise (143). 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 (141). Milk based drinks are recommended as appropriate sources of protein and carbohydrate for enhancing muscle protein synthesis in sports nutrition literature. A further advantage of milk is its leucine content as this has been specifically associated with the ability to train, compete and recover (142).

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 (145). Fluid requirements in children during strenuous exercise are of the magnitude 13ml/kg/hour. The fluid should be consumed throughout the activity (146). 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 (133).

Micronutrients

Young athletes are at risk of micronutrient deficiency particularly iron (especially females), calcium and vitamin D (147). 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 adolescent 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.

Supplements

Nutritional counseling should address the use of supplements. Evidence from child/adolescent sports competitors demonstrates a high use of sports supplements (148) and it is likely that young people with type 1 diabetes will display similar behaviors. In most cases supplements are unnecessary. Counselling on how to use food to maximize training adaptations is essential. Advice on the risks of supplement use should be provided along with guidance on anti-doping according to the sport and level of competition (See exercise chapter).

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 (149).

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 whilst maintaining normal linear growth (150)
- Address co-morbidities, such as hypertension and dyslipidemia (151)

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.

- Evidence suggests that there is no ideal macronutrient distribution for weight loss and plans should be individualized (25). 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 type 2 management (152).
- 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, 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 (153, 154). 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 beverages such as soft drinks and juices can accomplish improvement in blood glucose and weight (155).
- Increasing energy expenditure by increasing daily physical activity to 60 minutes daily is an important component of treatment (151). 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 (156). Physical activity may also help lower lipids in adolescents with diabetes (157).
- An interdisciplinary approach including a physician, diabetes nurse educator, dietitian, 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 insulin:carbohydrate ratio (158). This may be helpful in reducing the need for snacks and large meals.
- Medical nutrition therapy should be provided to treat co-morbidities including obesity, dyslipidemia, hypertension and microvascular complications (56). Regular follow-up is essential to monitor weight, glycemic control and adherence to the meal plan.
- Very low-calorie-ketogenic (VLCK) diets can be safely and effectively used in the management of young adults with type 2 diabetes (159). Clinical experience suggests obese older adolescents with type 2 diabetes may also benefit from a carefully monitored VLCK weight loss program.

Management of Co-morbidities

Dyslipidemia

Management of dyslipidemia requires a comprehensive approach (56, 160)

- Initial therapy should be to optimize glucose control
- Medical nutrition therapy (MNT) should address the following:
 - Reduce saturated fat intake to less than 7%
 - Total dietary fat 25-35% of energy
 - Diet rich in fruits and vegetables (>5 servings a day)
 - Increase dietary sources of both soluble fiber and anti-oxidants
- Lifestyle changes should be addressed as necessary including healthy weight maintenance and increased physical activity. If applicable, discontinue tobacco use.
- If dyslipidemia persists despite these measures, pharmacological treatment should be considered

Celiac disease

Celiac disease is more common in children with type 1 diabetes than in the general population. Worldwide prevalence ranges from 1.6% to 16.4%. This variability may be partly explained by differences in screening, as well as environmental differences (161, 162). Celiac disease is often diagnosed after diabetes and may be asymptomatic (163). Celiac disease is more common in girls and those diagnosed with type 1 diabetes at an early age (164). It may be associated with poor growth, delayed puberty, nutritional deficiencies, reduced bone density, hypoglycemia and hyperglycemia (165). 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. 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 recommendation to exclude oats varies between countries. Short and long-term studies involving children and adults suggest that oats can be safely included for the majority of people (166-168). However, a small minority of people with Celiac Disease have been found to react to oats (169). Research supports the view that contamination free (meaning oats not contaminated with gluten) oats may be acceptable for the majority but not all children with celiac disease (170). 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 B vitamin intakes (171).

It is 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 (172). 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. Food laws in these countries require that foods must not contain any detectable gluten (less than 3 parts per million) if labelled as gluten-free (173). 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.

It is common for people with diabetes who develop celiac disease to have challenges with adherence to the GFD. Improved understanding of the diet as well as access to a dietitian and regular follow up may assist adherence (174). Asymptomatic children have not shown reduced adherence to a GFD (175). The additional diagnosis in children with type 1 diabetes may have a minimal effect on the quality of life of the child, although non-adherence may negatively influence quality of life as well as metabolic control (176).

Children and adolescents with both type 1 diabetes and celiac disease are at increased risk for microvascular complications (177, 178). Adverse lipid profile, including low HDL levels and high LDL values is a complication in subjects with untreated celiac disease which increases cardiovascular risk (179). Monitoring of cholesterol levels and frequent supportive dietetic contacts are needed to enhance gluten-free diet adherence.

Disordered Eating and Eating disorders

A range of screening questionnaires and structured clinical interviews are available to help identify disordered eating and eating disorders (ED) in children and young people with type 1 diabetes (180, 181). The Diabetes Eating Problem Survey -Revised 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 (180).

Disordered eating and disturbed eating behavior are more common in young people with diabetes than their peers (182). 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 (183-185). Eating Disorders are usually associated with deteriorating glycemic control and may be associated with diabetic ketoacidosis. These act as warning signs and should prompt careful and urgent screening.

The risk for ED increases with diabetes duration and/or age (186, 187). This is of clinical importance as adolescents transition into adulthood and require continuity of care, often across two treating teams.

Eating Disorders in adolescents and young adults with diabetes are associated with short-term and long-term diabetic complications such as abnormal lipid profiles, ketoacidosis, retinopathy and neuropathy (186). Early identification of disordered eating is important in addressing body weight concerns and to enable timely referral for mental health support.

Interventions:

Clinicians working with young people with diabetes and eating disorders 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 individualized meal plan with supportive contacts at meals is required.

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 is required (188) 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 (189). More research is needed for interventions to prevent and treat disordered eating in diabetes.

Obesity

Obesity contributes to the challenges in optimizing glycemic control and increases the already higher risk of cardiovascular disease in the type 1 population. 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. 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.

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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