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Nutritional management in children and adolescents with diabetes

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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 weak and often anecdotal. Thus, sensitivity to individual needs, and pragmatism rather than dogmatism are most helpful for effective dietary counseling.

These consensus guidelines reflect national and international pediatric position/consensus statements (1, 2–5) and evidence derived from recommendations for adults with diabetes (6–8). Further research is required in many areas of pediatric diabetes management and education particularly in effective dietary interventions and long term outcomes.

Dietary recommendations for children with diabetes are based on healthy eating recommendations suitable for all children and adults (E) (4, 7, 9) 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 (E). 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 (A,C) (9–13). Nutrition therapy, when used in combination with other components of diabetes care, can further improve clinical and metabolic outcomes (E) (5, 6). 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, dietary and lifestyle changes

should be assisted by experienced professionals. 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 (14–16) and also have clear agreed goals with the interdisciplinary team (17).

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 (4, 5).

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 lifelong eating habits whilst preserving social, cultural and psychological well-being
- Three balanced meals a day, 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 levels
- Provide sufficient and appropriate energy intake and nutrients for optimal growth, development and good health
- 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
- Prevent and treat acute complications of diabetes such as hypoglycemia, hyperglycemic crises, illness and exercise-related problems
- Reduce the risk of micro- and macro-vascular complications
- Maintain and preserve quality of life
- Develop an enabling, trusting, empathic, supportive relationship to facilitate behavior change and consequent 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 (E) (3). Regular monitoring by the team should assess appropriate weight gain.

- ◇ Energy intake varies greatly within subjects on a daily basis due to age, growth rate, energy expenditure 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 (day by day and year by year) is necessary
- ◇ Dietary advice/meal planning should be revised regularly to meet changes in appetite and insulin regimens and to ensure optimal growth (1, 2)
- ◇ The 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 with-holding food in an effort to control blood glucose should be discouraged as this may impact adversely on growth and development (6)
- ◇ In puberty, energy intake and nutritional demands increase substantially along with significant increases in insulin dosage.

Weight maintenance.

- ◇ Although energy intake may be regulated by appetite, 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 over nutrition and insufficient physical activity. For children with diabetes other contributing factors may be over-insulinization, snacking and excess energy intake to avoid or treat hypoglycemia
- ◇ Prevention of overweight/obesity is a key strategy of care. Guidance on self-discipline, energy content of foods, appropriate portion sizes, regular meals, fat and sugar intake and physical activity is essential (E) (3)
- ◇ In general, diabetic children at all ages and in both sexes are heavier than their non-diabetic peers and pubertal girls tend to increase weight more than boys (C) (19)
- ◇ Important aspects of management in the prevention of overweight are:

- Plotting the growth curve, BMI (18) and if possible waist circumference (20) 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
 - Consistent advice on the prevention and appropriate detailed treatment of hypoglycemia (to prevent overtreatment) by all team members
 - Review of the insulin regimen to minimise hypoglycemia and the need for large snacks
- ◇ Psychological counseling should be considered for severely obese and young people with disordered eating/Eating Disorders

Weight management in young people with diabetes is often difficult and should be treated with sensitivity.

Energy intake recommendations

Total daily energy intake should be distributed as follows (C):

- Carbohydrate 50–55 % (4, 7)
- Moderate sucrose intake (up to 10% total energy) (1–3)
- Fat 30–35%
 - <10% saturated fat + trans fatty acids (8)
 - <10% polyunsaturated fat
 - >10% monounsaturated fat (up to 20 % total energy) (8)
 - n-3 fatty acids (cis configuration): 0.15 g/day
- Protein 10–15% (4)

Food components

Carbohydrates

Target: Carbohydrate (CHO) 50–55% of total daily energy intake

There is international agreement that carbohydrate should not be restricted in type 1 diabetes as it may have deleterious effects on growth (E).

- ◇ The above energy distribution is based on requirements for healthy children (3, 9)
- ◇ The proportion of carbohydrate as a percentage of total energy intake in non diabetic children varies around the world, often due to food unavailability (22)
- ◇ Encourage healthy sources of carbohydrate foods such as wholegrain breads and cereals, legumes (peas, beans, lentils), fruit, vegetables and low fat dairy products

Sucrose

Target: Sucrose can provide up to 10% of total daily energy intake (5).

Sucrose does not increase glycemia more than isocaloric amounts of starch (B) (23). 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 (E) (6).

The target is the same as that recommended for the general population (3, 5).

Not all countries have a specific recommendation on the percentage of sugar or mono/disaccharides in the diet, but only for the total amount of carbohydrate.

- ◇ Sucrose can be substituted in moderation for other carbohydrate sources without causing hyperglycemia. If added, sucrose should be appropriately balanced against insulin doses (1)
- ◇ Sucrose may be used instead of glucose to prevent or treat hypoglycemia. See guideline on Hypoglycemia for more details.
- ◇ Sucrose sweetened drinks may cause hyperglycemia and should be avoided where possible, if not being used to treat hypoglycemia
- ◇ Sucrose sweetened beverage consumption has been linked to excessive weight gain (24)
- ◇ The total denial of all sucrose containing foods may have detrimental psychological implications and is not warranted

Fiber

Target: In grams - for children above 1 year an amount of 2.8–3.4 gms per megajoule (25).

[Alternatively: for children above 2 years; age in years + 5 = grams of fiber per day (26)]

Example: if the energy-requirement is 5 megajoule per day (1190 kcal) the recommendation is ~15 grams of fiber per day.

- ◇ Estimates of dietary fiber intake in children in different countries are lower than recommended (26)
- ◇ The new recommendation (2.8–3.4 grams of fiber per megajoule) tends to give a higher amount 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 (C) (27)
- ◇ Fruit pectin may also be useful in enhancing the protection against cardiovascular disease (B) (28)
- ◇ 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

Target: Fat 30–35% of total daily energy intake.

Over recent decades surveys have shown children and young people with diabetes consume fat and saturated fat above dietary recommendations (29) and this situation has not changed (C) (30–32).

The primary goal regarding dietary fat is to decrease the intake of total fat, saturated fat, and trans fatty acids (A) (6). Monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) can be used as substitutes to keep lipid intake within recommended ranges or to improve the lipid profile (6).

If an individual's fat intake is primarily composed of MUFA and PUFA and low in trans and saturated fatty acids, a higher fat intake ($\geq 30\%$) may be justified (5).

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

Saturated fat and trans fatty acids.

- ◇ Less than 10% energy from saturated fat and trans fatty acids is recommended (8). Saturated fat is the principal dietary determinant of plasma LDL cholesterol (6). 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) (6), are found in margarines, deep-frying fat, cooking fat and manufactured products such as cookies and cakes
- ◇ Replace saturated fat with MUFA & PUFA by using lean meats, fish, low fat dairy products, low fat 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
- ◇ 10%–20% energy from MUFA is recommended (5). 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 (8). 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
- ◇ Advice for children is to eat oily fish once or twice weekly in amounts of 80–120 grams (33–35)

- ◇ 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 (36, 37)

Hyperlipidemia. Management of hyperlipidemia requires a comprehensive approach (38):

- ◇ Initial therapy should be to optimize glucose control
- ◇ Medical nutrition therapy to reduce saturated fat intake to less than 7% (38), and increase dietary sources of both soluble fiber and anti-oxidants
- ◇ Lifestyle changes (control weight, increase physical activity) and if applicable, discontinue tobacco use (39)
- ◇ 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

Target: Protein 10–15% of total daily energy intake.

- ◇ 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 (40)
- ◇ Worldwide intake of protein varies greatly depending on economy and availability
- ◇ Protein is an essential source of nitrogen
- ◇ Protein promotes growth only when sufficient total energy is available
- ◇ 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 (3)
- ◇ When persistent microalbuminuria or established nephropathy occurs excessive protein intake may be detrimental. It is prudent to advise that intake should be at the lower end of the recommended range (8). 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 (E)

Vitamins, minerals and antioxidants

- ◇ Children with diabetes have the same vitamin and mineral requirements as other healthy children (9)

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- ◇ Optimum vitamin, mineral and antioxidant intake should be maintained for general health and cardiovascular protection
- ◇ Many fresh fruits and vegetables are naturally rich in antioxidants (tocopherols, carotenoids, vitamin C, flavonoids) and are strongly recommended for young people with diabetes
- ◇ Supplements of vitamins, minerals or trace elements are not usually recommended unless nutritional assessment confirms a specific deficiency
- ◇ Supplements such as vitamin D for young children are recommended in some countries following the national guidelines for healthy children.
- ◇ 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 a 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 (4)
- ◇ Young people should be encouraged to wear identification for diabetes

Salt

Target: Salt (sodium chloride)—less than 6 g/day.

- ◇ 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
- ◇ Reduction is recommended to that of the general population. In most European countries this constitutes a reduction of 50%, to the target levels above (8)
- ◇ Dietary advice should include no added salt to cooking or meals and lower salt products/foods where practical

Alcohol

Excess alcohol is dangerous because of suppression of gluconeogenesis and may induce prolonged hypoglycemia in young people with diabetes (up to 10–12 or more hours after drinking, depending on the amount ingested) (41). Education on the following points should be emphasized when a child or young person starts to include alcohol in their lifestyle.

- ◇ 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

Specially labelled diabetic 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 (6–8), “diabetic foods” are still for sale in some countries.

Artificial and intense sweeteners

- ◇ Water should be encouraged instead of sugary drinks and cordials
- ◇ Sugary or diet fizzy drinks are not encouraged for the general population. Diet soft drinks or cordials are a better alternative
- ◇ Products such as low fat yoghurt with intense sweeteners can be useful, especially for those who are overweight
- ◇ Saccharin, 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 (42)
- ◇ There are no published scientific reports documenting harm from an intake of artificial sweeteners in doses not exceeding ADI.

Recommendations 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 (C) (16).

A dietary history should be taken including:

- Pre-existing 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. Simple advice should be given at the first meeting but reviewed by the specialist pediatric dietician within at least a month after diagnosis (E) (7).
 3. The dietician should give more detailed information, advice and education in the following weeks (E).
 4. Contacts thereafter depend on local arrangements, a minimum should include 2–4 times in the first year and annual reassessment (E). 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.
 5. There is consensus that continuation of care, support and review by a dietician is essential for optimal care (E).
 6. 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 (E).
 7. Dietary education should be individualized and appropriate for the age and maturity of the child to help engage the child in active learning (43–45).

Education tools and methods

- ◇ Education tools and methods are used to provide knowledge and skills to optimise glycemic control and cardiovascular outcomes. They vary in their complexity and therefore require a range of aptitudes to use them appropriately
- ◇ There is no international consensus on the most appropriate tools and method/s for education
- ◇ There are no high quality, long term, randomized studies to support one particular method compared with another
- ◇ The methods used should be varied, appropriate to the child, adapted to the needs of the family and staged at a pace with which the family is comfortable
- ◇ Blood glucose monitoring (pre and post-prandial) provides essential information to confirm the success of the chosen method. See guideline on Assessment and Monitoring of glycemic control

- ◇ As families become more confident with managing diabetes, education should be responsive to developmental changes and lifestyle
- ◇ As children grow and take more responsibility, regular re-education is essential (See Guideline on Diabetes Education).

The following are examples of a range of tools ranging from simple to complex. Further examples of teaching tools can be found on the International Diabetes Federation web-site (46). It is essential that dietary education tools are selected carefully for each child and family to achieve maximum understanding and adherence.

- Care should be taken not to be too dogmatic nor to inflict a method that is too difficult, resulting in confusion or failure which may cause harm, guilt and distress to the child and family (C) (15, 16).

Healthy eating education tools. Food pyramids (Fig. 1) and plate models (Fig. 2) are useful in providing basic nutritional information and healthy eating concepts. They also illustrate 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 (9).

Carbohydrate assessment and methods.

- It is a serious over-simplification to suggest that glycemic control is only affected by the amount and type of carbohydrate.



Fig. 1. Food pyramid. Copyright # 2007 American Diabetes Association. From <http://www.diabetes.org>. Reproduced with permission from The American Diabetes Association.

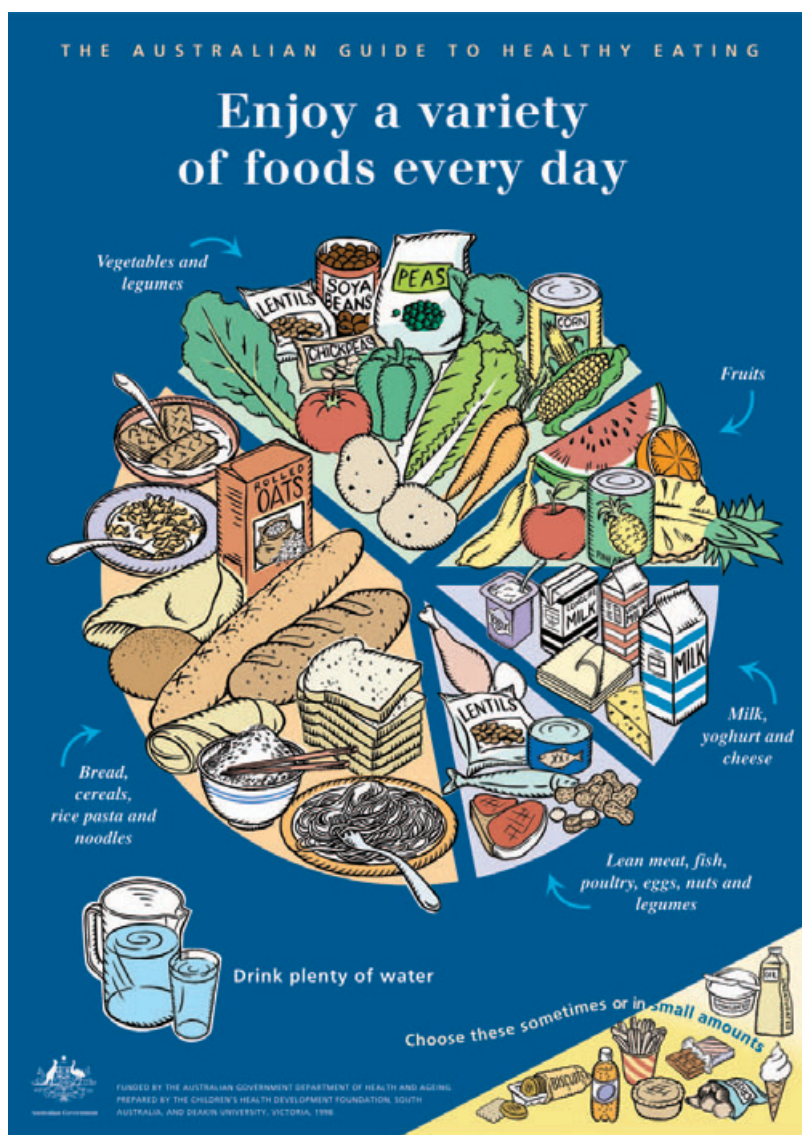


Fig. 2. Australian Guide to Healthy Eating food plate image. The Australian Guide to Healthy Eating, Commonwealth Copyright 1998 is reproduced with the permission of the Australian Government Department of Health and Ageing, 2007.

- Other variables such as endogenous and exogenous insulin levels, exercise, composition of the meal/snack (protein, fat, fiber), type of starch, cooking method of carbohydrate, gastric emptying and hormonal function are a number of variables that are difficult to measure and quantify
- Research has not demonstrated that one method of assessing the relationship between carbohydrate intake (grams/portions/exchanges), type (glycemic index and glycemic load) and blood glucose response is better than other methods (2).

However, most education tools are based upon the premise that carbohydrate amount and type is recognised as the primary determinant of the postprandial response (47) and along with distribution

of carbohydrate (48) form the basis of most education programmes.

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 circumstances, understanding, ability, motivation, personal choice and the insulin regimen.

Practical guidance on the distribution of carbohydrate intake, as part of management, is necessary for both fixed and more flexible insulin regimens. (1–3, 5)

Methods of quantifying carbohydrate in common use include:

A. Carbohydrate counting

Modern carbohydrate counting is a meal planning approach that focuses on improving glycemic control and allowing maximum flexibility of food choices.

Three levels of carbohydrate counting have been identified by the American Dietetic Association (49, 50).

Level 1: Consistent carbohydrate intake. This level introduces the basic concept of carbohydrate as the food component that raises blood glucose. A consistent intake of carbohydrate is encouraged using exchange or portion lists of measured quantities of food.

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 recognise patterns of BG response to carbohydrate (and other food) intake modified by insulin and exercise. With this understanding and team support they learn to make adjustments to their insulin dose or alter carbohydrate intake or timing of exercise to achieve blood glucose goals.

Level 3: Insulin to carbohydrate ratios. This level of carbohydrate counting is appropriate for people on Multiple Daily Injections (MDI) or insulin pump therapy. It involves the calculation of insulin to carbohydrate ratios that are individualized for each child according to age, sex, pubertal status, duration of diagnosis, time of day and activity. With the determined insulin:carbohydrate ratios, adjustment of pre-meal insulin according to the estimated carbohydrate content of the meal or snack is enabled. This has been shown to improve dietary freedom and quality of life in adults with T1DM (51). It is at present being evaluated in young people (44, 45), the results being variable showing no or some improvement in glycemic control respectively.

B. Exchange or portion system

This system teaches that it is not necessary to count precise grams. Exchanges/portions are taught as either 10 or 15 gram servings of carbohydrate.

The exchange or portion system can be used to recommend carbohydrate amounts for each meal and snack to enable a more consistent daily intake of carbohydrate. Alternatively, exchanges or portions can be used in intensive insulin therapy to enable matching of insulin dose to carbohydrate intake.

C. 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 (B) (52).

A controlled study in children using the GI of foods found flexible dietary instruction based on the food pyramid and low-GI choices achieved significantly better glycemic control after 12 months than more traditional dietary advice (B) (53).

- ◇ Low GI carbohydrate foods (GI < 55) may lower post-prandial hyperglycemia when they are chosen to replace higher GI foods (GI > 70) (B) (52).
- ◇ Examples of low GI food sources include whole-grain breads, pasta, temperate fruits and dairy products (54)

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 portion size (55). There has been no assessment of its efficacy in children.

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 (C) (2, 48)
- ◇ 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 (56, 57). Clinical experience indicates that pre-and post-prandial blood glucose testing can assist with determining the appropriateness of insulin dosage changes. Prescription of carbohydrate in a fixed meal plan

is unsuitable in a growing child 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 produce good glycemic control and to prevent excessive weight gain (56)
- ◇ Most conventional insulin regimens require carbohydrate intake before bed to prevent nocturnal hypoglycemia.

Multiple dose injection (MDI) therapy and pumps.

A more dynamic approach using individualized insulin:carbohydrate ratios, which enable insulin dose to be matched to carbohydrate intake, has been used in many centres for children and adolescents on intensive insulin therapy (personal communications ISPAD members). This approach has been endorsed by a number of international consensus guidelines (1–3, 5), although further evaluation of metabolic and quality of life outcomes are necessary.

Positive aspects of this approach are that it increases flexibility, by allowing more variable food intake at different meal times, decreasing the need for between meal snacks and enables greater insulin dose adjustments. Moreover recent research suggests that a single mealtime bolus of insulin may cover a range of carbohydrate intake without deterioration in postprandial control (58). Insulin pump therapy provides the greatest degree of flexibility with the possibility of meals being very delayed or omitted and a greater variation in carbohydrate intake. The young person with diabetes should have a greater sense of control.

- Care should be taken when a insulin:carbohydrate ratio is used in MDI and pump therapy, that the overall quality of the diet is not reduced and other important components of the diet are not compromised e.g. increased fat intake
- Increased flexibility should not mean total freedom without consideration of healthy eating principles.

The DAFNE study in adults (C) (51) was a comprehensive education package using MDI and insulin:carbohydrate ratios, and showed a modest improvement in glycemic control with improved dietary freedom and quality of life. Recent interventions of structured education programmes including insulin:carbohydrate ratios have been piloted in younger people with type 1 diabetes (43–45). Some of these showed improved glycemic control, others not, but all reported improved quality of life outcomes.

Rapid acting insulin analogues are usually given in these regimens immediately before meals to diminish the postprandial blood glucose-excursion (59) and to decrease the likelihood of being forgotten (60). In some instances, when the quantity of carbohydrate to

be consumed is uncertain the insulin may be given immediately after the meal (61). This may be useful with younger children. However this method in pump therapy has been shown to give poorer glycemic control than pre-prandial boluses (62).

- ◇ The use of MDI and pump therapy requires extra dietary education, monitoring and regular support (E). This may be offered as part of a structured education program in groups (51, 43–45) or on an individual basis as part of enhanced diabetes care
- ◇ Not all children and families may be suitable for these approaches and criteria of selection may be useful
- ◇ Intensifying management may cause psychosocial stress on the child and family
- ◇ Insulin:carbohydrate ratios must be calculated for each individual child (63)
- ◇ For those on MDI clinical experience 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). Pre- and post-prandial blood glucose testing should be used to evaluate this regimen (57)
- ◇ In pump therapy most modern pumps allow the meal bolus to be given over a prolonged period of time or part of the bolus immediately and the remainder over a longer time period. This enables the meal bolus to match the glycemic effect of the meal (low GI and/or high fat 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 (64, 65)
- ◇ Flexibility in insulin bolus dosing with pumps is useful, especially for younger children when parents are uncertain of their appetite prior to the meal.
- Further research is needed to determine appropriate teaching methods, and the validation of insulin:carbohydrate ratios. Without expert education on matching insulin to carbohydrate content and validation of this method the outcome may be the same as conventional insulin regimens (1–5, 66).

Age group specific advice

Dieticians should enable all care givers, nursery and school staff, appropriate relatives and friends to be aware of the child's diabetes, to have an understanding of nutritional principles and the recognition and dietary management of hypoglycemia.

Infants and toddlers

- ◇ Breast feeding of infants up to 12 months should be encouraged. Traditions and habits vary between

- countries and may also depend on the availability of healthy weaning diets
- ◇ Frequent small meals (“grazing” to appetite) may promote better glycemic control, depending on the insulin regimen and may also avoid food refusal issues. Care should be taken to match this type of feeding pattern with the insulin profile
 - ◇ Insulin pump therapy has been shown to be effective in infancy. It may assist with difficulties associated in persuading toddlers to eat when not hungry (C) (67)
 - ◇ Positive parental role models and early participation in family meals may promote improved cooperation regarding food and healthy food choices
 - ◇ A variety of tastes, colors and textures of foods should be encouraged
 - ◇ Episodes of food refusal or ‘sickness’ often cause distress. Discussion and reassurance to parents is required and food substitutes, such as milk, may be useful
 - ◇ 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

School children

- ◇ Focus on adapting the diabetes regimen to fit within the school timetable and school specific issues such as physical education
- ◇ Individual advice should be provided regarding carbohydrate intake to prevent hypoglycemia particularly for school events such as sports days, excursions and camps
- ◇ 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
- ◇ Continuing diabetes nutrition education with targets and problem solving may be useful

Adolescents

- ◇ Although poor growth may be a sign of delayed puberty or associated medical conditions it may also be associated with insufficient energy intake, inappropriate insulin administration, disordered eating, celiac disease and poor glycemic control
- ◇ Weight monitoring is recommended for early recognition of both weight loss or inappropriate weight gain
- ◇ Inappropriate weight gain requires careful review of insulin dosage, food intake and physical activity
- ◇ Weight loss or failure to gain weight may be associated with insulin omission for weight control (68) and may be indicative of a disordered eating behavior or an Eating Disorder (see below)

- ◇ Rebellion, binges and erratic eating behavior are not uncommon during adolescence. They need to be recognized and addressed appropriately with frequent follow-up. Some may require expert (psychological) support and counseling during this period
- ◇ 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 certain societies
- ◇ Information on the nutritional content of snacks 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 adaptation needs to be provided

Nutritional management of exercise and sport

Children and adolescents with diabetes should be encouraged to participate in regular physical activity because it promotes cardiovascular health and aids weight management (E) (69).

However, planned or unplanned physical activity is one of the commonest causes of hypoglycemia in young people with type 1 diabetes, and intense physical activity sometimes causes hyperglycemia (E) (70).

Nutritional management of physical activity aims to prevent the potential hypoglycemic and hyperglycemic effects. Advice is also necessary to meet the nutritional requirements for sports performance in those individuals wishing to train and compete.

Advice on physical activity, exercise and sport should emphasise the importance of careful planning, individual attention to detail (blood glucose monitoring, food intake and insulin management) and incorporating the personal experiences of both the young person and health professional.

Exercise should be delayed if control is poor (blood glucose >15 mmol/l or if ketones are present) until the diabetes is under better control with insulin administration (6, 70–72).

Unplanned & spontaneous activity

Hypoglycemia is the commonest problem 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.

- ◇ Particularly for unplanned exercise, young people with diabetes need to have rapidly absorbed carbohydrate readily available
- ◇ Carbohydrate will usually be in the form of high glycemic index foods consumed immediately before or during the activity. Rapidly absorbed sugar may be sufficient for sudden short duration exercise (for example, glucose or sucrose sweets)
- ◇ The amount of carbohydrate required for exercise is dependent on the blood glucose level at the start of exercise, the intensity of the exercise, the frequency of routine exercise, the prevailing insulin level at the time and the insulin regimen
- ◇ During moderate exercise, additional carbohydrate may be consumed to prevent hypoglycemia, at the rate of approximately 30g per hour of exercise or up to 1.0–1.5 g CHO per kg body weight per hour (C) (70). This will vary depending on the type of activity. See Table 2 in the Guideline on Exercise. The requirements will be lower if the premeal 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 CHO requirements are probably not dependent on the HbA1c or average glucose control, although that has been less well demonstrated (73–75)
- ◇ Additional carbohydrate is only required for more than the usual level of activity. Additional carbohydrate should not be required for an individual's normal level 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, cereal bars.

Following unplanned physical activity, blood glucose 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 the period of activity (74). Pre bed BG testing helps in the appropriate administration of additional carbohydrate to prevent nocturnal hypoglycemia (76).

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 to optimal performance (C) (70) (E) (76).

Adequate amounts of carbohydrate is vital for good sports performance. 50–60% of total energy as carbohydrate is recommended (C) (77).

- ◇ A low glycemic index, low fat meal should be eaten 1–3 hours prior to sport to ensure adequacy of glycogen stores and availability of carbohydrate for exercise (C) (78)
- ◇ Additional “quick acting carbohydrate” will be needed prior to and during strenuous exercise to maintain performance. An intake of at least 30g carbohydrate/hour of exercise or up to 1.0–1.5g carbohydrate per kg body weight per hour of exercise will usually be required (C) (77). Intakes in excess of 60g carbohydrate/hour may not confer additional performance benefits and may cause gastrointestinal upset (79)
- ◇ Pre exercise carbohydrate consumption should be related to pre exercise BG. The ideal is to distribute the carbohydrate intake throughout the activity. However if BG is 5.5 mmol/l or lower, carbohydrate should be consumed prior to the exercise (1) and/or appropriate adjustments made to insulin to prevent hypoglycemia if using MDI or pump therapy. For some high intensity strenuous/anaerobic activities, pre exercise carbohydrate may also require additional bolus insulin (70, 75, 76, 80)
- ◇ Exercise when underinsulinised may result in hyperglycemia and poor performance (70, 75, 76, 80)
- ◇ Fluid intake should be maintained at a level appropriate to the activity to maintain optimal hydration (75, 79, 80)
- ◇ Isotonic Sports drinks, which contain 6–8% carbohydrate, are useful when taken regularly during prolonged exercise to provide both the carbohydrate and fluid requirements (79)

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 (76). Carbohydrate in a readily digestible form should be available for consumption immediately or within one hour of completing exercise. Where post exercise hypoglycemia occurs, the amount of carbohydrate required to correct this may be greater than for a non exercise induced hypoglycemic event, due to the depletion of liver and muscle glycogen stores (76).

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 (81, 82).

Aims of nutritional management:

- Achieve normal glycemia and HbA1c (E) (6, 83)
- Prevent further weight gain in those with BMI at 85th–95th percentile and achieve weight loss for those with BMI > 95th percentile with normal linear growth (1, 83, 84)
- Address co morbidities, such as hypertension and dyslipidemia (83)

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 (E)
- 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 most often overweight or obese and have diabetes as well (E). Studies indicate that a family approach to treatment of overweight is most likely to be effective (C) (85). Interventions have shown improved outcomes from using parents as positive role models in 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 (24)
- Increasing energy expenditure by increasing daily physical activity is an important component of treatment (3, 83). Decreasing 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 (A) (86, 87). Physical activity may also help lower lipids in adolescents with diabetes (B) (88)

- An interdisciplinary approach including a physician, nurse practitioner or diabetes nurse educator, dietician, mental health provider and exercise physiologist (if possible) is recommended (E) (89)
- It would be sensible to consider the meal-by-meal and day-to-day consistency in carbohydrate intake to aim for stable blood sugar levels (E)
- Those on medication or insulin therapy require more in depth teaching on carbohydrate management (E)
- Children on MDI or pump therapy should be taught to adjust insulin to carbohydrate intake using a insulin:carbohydrate ratio (6, 82, 85, 88)
- 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 (90, 91)
- Regular follow-up is essential to monitor weight, glycemic control and medication (E)

Celiac disease

Celiac disease occurs in 1–10% of children with diabetes (92). It is often asymptomatic (93) although may be associated with poor growth, delayed puberty, nutritional deficiencies and hypoglycemia (94). A gluten-free diet (GFD) is the only accepted treatment for celiac disease. It is common for children with diabetes who develop celiac disease not to adhere to the GFD (94).

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

The inclusion of oats in the GFD is controversial. Short and long term studies involving children and adults suggest that oats can be safely included (A) (95–98). Concern remains about cross contamination of oats with gluten containing products and so the use of oats is not widely recommended in the US, Canada and Australia (99). Research supports the view that contamination free oats may be acceptable for the majority but not all children with celiac disease (C) (100).

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 that foods containing less than 20 parts per million gluten (=20 mg gluten/kg) are suitable for a GFD (even if gluten is detectable) (100, 101).

Wheat starch is used in some European countries as part of a GFD. This too is controversial, as wheat starch is not recommended for inclusion in North America or Australia. Some studies in adults (102, 103) have found the addition of wheat starch to an otherwise strict GFD caused no adverse effects. However, European wheat starch is intensively purified to meet the Codex

standards for gluten-free. 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 intake (99, 104).

Children with diabetes and celiac disease require more frequent review by a pediatric dietician with experience of gluten-free diets (E).

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 (105, 106).

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 12–15% of adolescents and it is increasingly recognised 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 (107).

It is well recognised 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 (106). Eating disorders (ED) in adolescents and young adults with diabetes (DM) are associated with poor metabolic control and diabetic complications (107–109). 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 (110).

Classical approaches to eating disorder diagnosis and management need to be modified to incorporate the specific demands of diabetes regimens. Clinicians need to take into account the insulin regimen and potential 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

Evidence based guidelines are available for the management of eating disorders (111). These recommend a range of psychotherapeutic approaches for treatment of anorexia and bulimia.

The value of interventions to treat or prevent ED in diabetes is largely unknown. A RCT designed to specifically address eating disorder symptoms in young people with diabetes, found that an intervention was helpful for the eating disorder symptoms but did not improve either metabolic control or insulin omission (C) (112). 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 to day management of diabetes. All members of the team should have a degree of familiarity with these therapeutic approaches.

The treatment of severe malnutrition related to an ED and diabetes may require the use of nasogastric tube feeding and advice from specialist diabetes dietician.

Behavioral approaches in diabetes dietary education

The management of diabetes in children is recognised as requiring a team approach, and parents are in need of understanding and non-judgmental support from all health care professionals (C) (16, 113), in particular dietitians.

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 (C) (114, 115). Risk taking behaviors, eating disorders and non-adherence to diabetes regimens are common (116).

The traditional medical model, based on health professionals assuming responsibility for their patient's health, often leads to frustration both for dietitians and adolescents with diabetes (16). There are few recognised and standardised interventions that specifically target children with diabetes (117). However, systematic reviews have shown that psychoeducational interventions provide an alternative model of patient care and have small to medium beneficial effects on glycemic and behavioral outcomes (A) (118–120). Further studies have shown the benefit of using behavioral techniques such as empowerment, cognitive behavioral therapy and motivational interviewing (118, 121–124). 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 (A) (122). Exploring problem-solving skills through experiential learning has been shown to lead to greater self-efficacy and improved dietary outcomes (125). Support from peers and other significant people in this process might help to substantiate this process (C) (126).

◇ Pediatric dietitians should be aware of research results and be trained in family communication

- skills, counseling, psychology, behavior modification approaches and motivational interviewing (E)
- ◇ Training in behavioral and psychological skills would enable earlier identification of those children and families who may be struggling with diabetes or with weight control and allow earlier referrals to specialist care such as, psychologists, eating disorder teams and child and family therapists.

Audit and research

- Audit and evaluation of dietary management is deficient
- Good quality research is required in all aspects of nutritional management, including the use of specific education tools, adjusting dietary intake to insulin regimens and targeted dietary outcomes
- Growth, metabolic, psychological and 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, multiple carers, often deteriorating national dietary characteristics, issues of non-compliance, 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 constantly changing physiological requirements, including growth, fluctuations in appetite associated with changes in growth velocity, varying nutritional requirements and sporadic episodes of physical activity.

Nevertheless, evidence suggests that it is possible to improve diabetes outcomes through meticulous 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 carers, which facilitates behavior change during the challenges and turbulence of childhood and adolescent development.

Recommendations

- Dietary recommendations are based on healthy eating principles suitable for all children and families with the aim of improving diabetes outcomes and reducing cardiovascular risks

- Nutritional advice should be adapted to cultural, ethnic and family traditions, as well as the cognitive and psychosocial needs of the individual child
- Specialist pediatric dieticians 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
- 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
- Total daily energy intake (TDEI) should be distributed so that carbohydrate forms >50%, Fat <35% (saturated fat <10%), and Protein 10–15% of TDEI. Sucrose can provide up 10% of TDEI
- There is no strong research evidence to demonstrate that one particular educational tool or method of quantifying carbohydrate intake (grams/portions/exchanges/glycemic index or load) is superior to another
- Successful implementation of meal planning with appropriate insulin adjustments can improve glycemic control
- Conventional insulin regimens demand some consistency in carbohydrate intake to be successful
- Intensive insulin regimens allow greater flexibility so long as the matching of insulin doses to carbohydrate intake is understood and applied. However, regularity in meal times and eating routines are still important for optimal glycemic outcomes.
- Quantification of carbohydrate intake with appropriate insulin adjustments require a higher level of structured education, monitoring and support to be successful
- Unexpected weight loss may be a sign not only of illness (infections, celiac disease etc.) but also of insulin omission or a disorder of eating
- Nutritional advice should be available on how to cope successfully with physical activity, exercise and competitive sports
- 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
- There is an urgent need for more research and rigorous evaluation of dietetic management in childhood diabetes.

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