



American Diabetes Association

13. Children and Adolescents: Standards of Medical Care in Diabetes—2020

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The American Diabetes Association (ADA) “Standards of Medical Care in Diabetes” includes the ADA’s current clinical practice recommendations and is intended to provide the components of diabetes care, general treatment goals and guidelines, and tools to evaluate quality of care. Members of the ADA Professional Practice Committee, a multidisciplinary expert committee (<https://doi.org/10.2337/dc20-SPPC>), are responsible for updating the Standards of Care annually, or more frequently as warranted. For a detailed description of ADA standards, statements, and reports, as well as the evidence-grading system for ADA’s clinical practice recommendations, please refer to the Standards of Care Introduction (<https://doi.org/10.2337/dc20-SINT>). Readers who wish to comment on the Standards of Care are invited to do so at professional.diabetes.org/SOC.

The management of diabetes in children and adolescents cannot simply be derived from care routinely provided to adults with diabetes. The epidemiology, pathophysiology, developmental considerations, and response to therapy in pediatric-onset diabetes are different from adult diabetes. There are also differences in recommended care for children and adolescents with type 1 as opposed to type 2 diabetes. This section first addresses care for children and adolescents with type 1 diabetes and next addresses care for children and adolescents with type 2 diabetes. **Figure 13.1** provides guidance on managing new-onset diabetes in youth with overweight or obesity before type 1 or type 2 diabetes is diagnosed and so applies to all youth with overweight or obesity. Lastly, guidance is provided in this section on transition of care from pediatric to adult providers to ensure that the continuum of care is appropriate as the child with diabetes develops into adulthood. Due to the nature of clinical research in children, the recommendations for children and adolescents with diabetes are less likely to be based on clinical trial evidence. However, expert opinion and a review of available and relevant experimental data are summarized in the American Diabetes Association (ADA) position statements “Type 1 Diabetes in Children and Adolescents” (1) and “Evaluation and Management of Youth-Onset Type 2 Diabetes” (2). The ADA consensus report “Youth-Onset Type 2 Diabetes Consensus Report: Current Status, Challenges, and Priorities” (3) characterizes type 2 diabetes in children and evaluates treatment options but also discusses knowledge gaps and recruitment challenges in clinical and translational research in youth-onset type 2 diabetes. Monogenic diabetes (neonatal diabetes and maturity-onset diabetes in the young [MODY]), which often present in youth, are discussed in section 2 “Classification and Diagnosis of Diabetes” (<https://doi.org/10.2337/dc20-S002>).

TYPE 1 DIABETES

Type 1 diabetes is the most common form of diabetes in youth (4), although recent data suggest that it may account for a large proportion of cases diagnosed in

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adult life (5). The provider must consider the unique aspects of care and management of children and adolescents with type 1 diabetes, such as changes in insulin sensitivity related to physical growth and sexual maturation, ability to provide self-care, supervision in the childcare and school environment, neurological vulnerability to hypoglycemia and hyperglycemia in young children, and possible adverse neurocognitive effects of diabetic ketoacidosis (DKA) (6,7). Attention to family dynamics, developmental stages, and physiologic differences related to sexual maturity is essential in developing and implementing an optimal diabetes treatment plan (8).

A multidisciplinary team of specialists trained in pediatric diabetes management and sensitive to the challenges of children and adolescents with type 1 diabetes and their families should provide care for this population. It is essential that diabetes self-management education and support, medical nutrition therapy, and psychosocial support be provided at diagnosis and regularly thereafter in a developmentally appropriate format that builds on prior knowledge by individuals experienced with the biological, educational, nutritional, behavioral, and emotional needs of the growing child and family. The appropriate balance between adult supervision and independent self-care should be defined at the first interaction and reevaluated at subsequent visits, with the expectation that it will evolve as the adolescent gradually becomes an emerging young adult.

Diabetes Self-Management Education and Support

Recommendation

13.1 Youth with type 1 diabetes and parents/caregivers (for patients aged <18 years) should receive culturally sensitive and developmentally appropriate individualized diabetes self-management education and support according to national standards at diagnosis and routinely thereafter. **B**

No matter how sound the medical regimen, it can only be effective if the family and/or affected individuals are able to implement it. Family involvement is a vital component of optimal

diabetes management throughout childhood and adolescence. Health care providers in the diabetes care team who care for children and adolescents must be capable of evaluating the educational, behavioral, emotional, and psychosocial factors that impact implementation of a treatment plan and must work with the individual and family to overcome barriers or redefine goals as appropriate. Diabetes self-management education and support requires periodic reassessment, especially as the youth grows, develops, and acquires the need for greater independent self-care skills. In addition, it is necessary to assess the educational needs and skills of day care providers, school nurses, or other school personnel who participate in the care of the child with diabetes (9).

Nutrition Therapy

Recommendations

- 13.2** Individualized medical nutrition therapy is recommended for children and adolescents with type 1 diabetes as an essential component of the overall treatment plan. **A**
- 13.3** Monitoring carbohydrate intake, whether by carbohydrate counting or experience-based estimation, is key to achieving optimal glycemic control. **B**
- 13.4** Comprehensive nutrition education at diagnosis, with annual updates, by an experienced registered dietitian nutritionist is recommended to assess caloric and nutrition intake in relation to weight status and cardiovascular disease risk factors and to inform macronutrient choices. **E**

Dietary management should be individualized: family habits, food preferences, religious or cultural needs, finances, schedules, physical activity, and the patient's and family's abilities in numeracy, literacy, and self-management should be considered. Visits with a registered dietitian nutritionist should include assessment for changes in food preferences over time, access to food, growth and development, weight status, cardiovascular risk, and potential for eating disorders. Dietary adherence is associated with better glycemic control in youth with type 1 diabetes (10).

Physical Activity and Exercise

Recommendations

- 13.5** Exercise is recommended for all youth with type 1 diabetes with the goal of 60 min of moderate-to-vigorous intensity aerobic activity daily, with vigorous muscle-strengthening and bone-strengthening activities at least 3 days per week. **C**
- 13.6** Education about frequent patterns of glycemia during and after exercise, which may include initial transient hyperglycemia followed by hypoglycemia, is essential. Families should also receive education on prevention and management of hypoglycemia during and after exercise, including ensuring patients have a preexercise glucose level of 90–250 mg/dL (5.0–13.9 mmol/L) and accessible carbohydrates before engaging in activity, individualized according to the type/intensity of the planned physical activity. **E**
- 13.7** Patients should be educated on strategies to prevent hypoglycemia during exercise, after exercise, and overnight following exercise, which may include reducing prandial insulin dosing for the meal/snack preceding (and, if needed, following) exercise, reducing basal insulin doses, increasing carbohydrate intake, eating bedtime snacks, and/or using continuous glucose monitoring. **C**
- 13.8** Frequent glucose monitoring before, during, and after exercise, with or without use of continuous glucose monitoring, is important to prevent, detect, and treat hypoglycemia and hyperglycemia with exercise. **C**

Exercise positively affects insulin sensitivity, physical fitness, strength building, weight management, social interaction, mood, self-esteem building, and creation of healthful habits for adulthood, but it also has the potential to cause both hypoglycemia and hyperglycemia.

See below for strategies to mitigate hypoglycemia risk and minimize hyperglycemia with exercise. For an in-depth discussion, see recently published reviews and guidelines (11–13).

Overall, it is recommended that youth with type 1 diabetes participate in 60 min of moderate (e.g., brisk walking, dancing) to vigorous (e.g., running, jumping rope) intensity aerobic activity daily, including resistance and flexibility training (14). Although uncommon in the pediatric population, patients should be medically evaluated for comorbid conditions or diabetes complications that may restrict participation in an exercise program. As hyperglycemia can occur before, during, and after physical activity, it is important to ensure that the elevated glucose level is not related to insulin deficiency that would lead to worsening hyperglycemia with exercise and ketosis risk. Intense activity should be postponed with marked hyperglycemia (glucose ≥ 350 mg/dL [19.4 mmol/L]), moderate to large urine ketones, and/or β -hydroxybutyrate (B-OHB) > 1.5 mmol/L. Caution may be needed when B-OHB levels are ≥ 0.6 mmol/L (10,11).

The prevention and treatment of hypoglycemia associated with physical activity include decreasing the prandial insulin for the meal/snack before exercise and/or increasing food intake. Patients on insulin pumps can lower basal rates by ~ 10 – 50% or more or suspend for 1–2 h during exercise (15). Decreasing basal rates or long-acting insulin doses by $\sim 20\%$ after exercise may reduce delayed exercise-induced hypoglycemia (16). Accessible rapid-acting carbohydrates and frequent blood glucose monitoring before, during, and after exercise, with or without continuous glucose monitoring, maximize safety with exercise.

Blood glucose targets prior to exercise should be 90–250 mg/dL (5.0–13.9 mmol/L). Consider additional carbohydrate intake during and/or after exercise, depending on the duration and intensity of physical activity, to prevent hypoglycemia. For low-to-moderate intensity aerobic activities (30–60 min), and if the patient is fasting, 10–15 g of carbohydrate may prevent hypoglycemia (17). After insulin boluses (relative hyperinsulinemia), consider 0.5–1.0 g of carbohydrates/kg per hour of exercise (~ 30 – 60 g), which is similar to carbohydrate requirements to optimize performance in athletes without type 1 diabetes (18–20).

In addition, obesity is as common in children and adolescents with type 1 diabetes as in those without diabetes. It is associated with higher frequency of cardiovascular risk factors, and it disproportionately affects racial/ethnic minorities in the U.S. (21–25). Therefore, diabetes care providers should monitor weight status and encourage a healthy diet, exercise, and healthy weight as key components of pediatric type 1 diabetes care.

School and Child Care

As a large portion of a child's day is spent in school, close communication with and the cooperation of school or day care personnel are essential for optimal diabetes management, safety, and maximal academic opportunities. Refer to the ADA position statements "Diabetes Care in the School Setting" (26) and "Care of Young Children With Diabetes in the Child Care Setting" (27) for additional details.

Psychosocial Issues

Recommendations

- 13.9** At diagnosis and during routine follow-up care, assess psychosocial issues and family stresses that could impact diabetes management and provide appropriate referrals to trained mental health professionals, preferably experienced in childhood diabetes. **E**
- 13.10** Mental health professionals should be considered integral members of the pediatric diabetes multidisciplinary team. **E**
- 13.11** Encourage developmentally appropriate family involvement in diabetes management tasks for children and adolescents, recognizing that premature transfer of diabetes care to the child can result in diabetes burnout nonadherence and deterioration in glycemic control. **A**
- 13.12** Providers should consider asking youth and their parents about social adjustment (peer relationships) and school performance to determine whether further intervention is needed. **B**

- 13.13** Assess youth with diabetes for psychosocial and diabetes-related distress, generally starting at 7–8 years of age. **B**
- 13.14** Offer adolescents time by themselves with their care provider(s) starting at age 12 years, or when developmentally appropriate. **E**
- 13.15** Starting at puberty, preconception counseling should be incorporated into routine diabetes care for all girls of child-bearing potential. **A**
- 13.16** Begin screening youth with type 1 diabetes for eating disorders between 10 and 12 years of age. The Diabetes Eating Problems Survey-Revised (DEPS-R) is a reliable, valid, and brief screening tool for identifying disturbed eating behavior. **B**

Rapid and dynamic cognitive, developmental, and emotional changes occur during childhood, adolescence, and emerging adulthood. Diabetes management during childhood and adolescence places substantial burdens on the youth and family, necessitating ongoing assessment of psychosocial status and diabetes distress in the patient and the caregiver during routine diabetes visits (28–34). It is important to consider the impact of diabetes on quality of life as well as the development of mental health problems related to diabetes distress, fear of hypoglycemia (and hyperglycemia), symptoms of anxiety, disordered eating behaviors and eating disorders, and symptoms of depression (35). Consider assessing youth for diabetes distress, generally starting at 7 or 8 years of age (36). Consider screening for depression and disordered eating behaviors using available screening tools (28,37). Early detection of depression, anxiety, eating disorders, and learning disabilities can facilitate effective treatment options and help minimize adverse effects on diabetes management and disease outcomes (33,36). There are validated tools, such as the Problem Areas in Diabetes-Teen (PAID-T) and Parent (P-PAID-Teen) (34), that can be used in assessing diabetes-specific distress in youth starting at age 12 years and in their parent

caregivers. Furthermore, the complexities of diabetes management require ongoing parental involvement in care throughout childhood with developmentally appropriate family teamwork between the growing child/teen and parent in order to maintain adherence and to prevent deterioration in glycemic control (38,39). As diabetes-specific family conflict is related to poorer adherence and glycemic control, it is appropriate to inquire about such conflict during visits and to either help to negotiate a plan for resolution or refer to an appropriate mental health specialist (40). Monitoring of social adjustment (peer relationships) and school performance can facilitate both well-being and academic achievement (41). Suboptimal glycemic control is a risk factor for underperformance at school and increased absenteeism (42).

Shared decision-making with youth regarding the adoption of regimen components and self-management behaviors can improve diabetes self-efficacy, adherence, and metabolic outcomes (22,43). Although cognitive abilities vary, the ethical position often adopted is the “mature minor rule,” whereby children after age 12 or 13 years who appear to be “mature” have the right to consent or withhold consent to general medical treatment, except in cases in which refusal would significantly endanger health (44).

Beginning at the onset of puberty or at diagnosis of diabetes, all adolescent girls and women with childbearing potential should receive education about the risks of malformations associated with poor metabolic control and the use of effective contraception to prevent unplanned pregnancy. Preconception counseling using developmentally appropriate educational tools enables adolescent girls to make well-informed decisions (45). Preconception counseling resources tailored for adolescents are available at no cost through the ADA (46). Refer to the ADA position statement “Psychosocial Care for People With Diabetes” for further details (36).

Youth with type 1 diabetes have an increased risk of disordered eating behavior as well as clinical eating disorders with serious short-term and long-term negative effects on diabetes outcomes and health in general. It is important to

recognize the unique and dangerous disordered eating behavior of insulin omission for weight control in type 1 diabetes (47) using tools such as the Diabetes Eating Problems Survey-Revised (DEPS-R) to allow for early diagnosis and intervention (37,48–50).

The presence of a mental health professional on pediatric multidisciplinary teams highlights the importance of attending to the psychosocial issues of diabetes. These psychosocial factors are significantly related to self-management difficulties, suboptimal glycemic control, reduced quality of life, and higher rates of acute and chronic diabetes complications.

Glycemic Control

Recommendations

- 13.17** The majority of children and adolescents with type 1 diabetes should be treated with intensive insulin regimens, either via multiple daily injections or continuous subcutaneous insulin infusion. **A**
- 13.18** All children and adolescents with type 1 diabetes should self-monitor glucose levels multiple times daily (up to 6–10 times/day), including premeal, prebedtime, and as needed for safety in specific situations such as exercise, driving, or the presence of symptoms of hypoglycemia. **B**
- 13.19** Continuous glucose monitoring (CGM) should be considered in all children and adolescents with type 1 diabetes, whether using injections or continuous subcutaneous insulin infusion, as an additional tool to help improve glucose control. Benefits of CGM correlate with adherence to ongoing use of the device. **B**
- 13.20** Automated insulin delivery systems appear to improve glycemic control and reduce hypoglycemia in children and should be considered in children with type 1 diabetes. **B**
- 13.21** A1C goals must be individualized and reassessed over time. An A1C of <7% (53 mmol/mol) is appropriate for many children. **B**

13.22 Less-stringent A1C goals (such as <7.5% [58 mmol/mol]) may be appropriate for patients who cannot articulate symptoms of hypoglycemia; have hypoglycemia unawareness; lack access to analog insulins, advanced insulin delivery technology, and/or continuous glucose monitors; cannot check blood glucose regularly; or have nonglycemic factors that increase A1C (e.g., high glyca-tors). **B**

13.23 Even less-stringent A1C goals (such as <8% [64 mmol/mol]) may be appropriate for patients with a history of severe hypoglycemia, limited life expectancy, or extensive comorbid conditions. **B**

13.24 Providers may reasonably suggest more-stringent A1C goals (such as <6.5% [48 mmol/mol]) for selected individual patients if they can be achieved without significant hypoglycemia, negative impacts on well-being, or undue burden of care, or in those who have nonglycemic factors that decrease A1C (e.g., lower erythrocyte life span). Lower targets may also be appropriate during the honeymoon phase. **B**

Current standards for diabetes management reflect the need to lower glucose as safely as possible. This should be done with stepwise goals. When establishing individualized glycemic targets, special consideration should be given to the risk of hypoglycemia in young children (aged <6 years) who are often unable to recognize, articulate, and/or manage hypoglycemia. However, registry data indicate that A1C targets can be achieved in children, including those <6 years, without increased risk of severe hypoglycemia (51,52). Recent data have demonstrated that the use of continuous glucose monitors lowered A1C and increased time in range in adolescents and young adults, and, in children <8 years old, was associated with lower risk of hypoglycemia (53,54). Please refer to Section 7 “Diabetes Technology” (<https://doi.org/10.2337/dc20-S007>) for more

information on the use of blood glucose meters, continuous glucose monitors, and insulin pumps. More information on insulin injection technique can be found in Section 9 “Pharmacologic Approaches to Glycemic Treatment (<https://doi.org/10.2337/dc20-S009>).”

The Diabetes Control and Complications Trial (DCCT), which did not enroll children <13 years of age, demonstrated that near normalization of blood glucose levels was more difficult to achieve in adolescents than in adults. Nevertheless, the increased use of basal-bolus regimens, insulin pumps, frequent blood glucose monitoring, goal setting, and improved patient education in youth from infancy through adolescence has been associated with more children reaching the blood glucose targets recommended by ADA (55–58), particularly in patients of families in which both the parents and the child with diabetes participate jointly to perform the required diabetes-related tasks. Furthermore, studies documenting neurocognitive imaging differences related to hyperglycemia in children provide another motivation for lowering glycemic targets (6).

Lower A1C in adolescence and young adulthood is associated with lower risk and rate of microvascular and macrovascular complications, as shown in studies in youth (59–62) and in studies that include youth and adults and demonstrate the effects of metabolic memory (63–66).

In addition, type 1 diabetes can be associated with adverse effects on cognition during childhood and adolescence (6,67,68). DKA has been shown to cause adverse effects on brain development and function. Additional factors (69–72) that contribute to adverse effects on brain development and function include young age, severe hypoglycemia at <6 years of age, and chronic hyperglycemia (73,74). However, meticulous use of new therapeutic modalities such as rapid- and long-acting insulin analogs, technological advances (e.g., continuous glucose monitors, low-glucose suspend insulin pumps, and automated insulin delivery systems), and intensive self-management education now make it more feasible to achieve excellent glycemic control while reducing the incidence of severe hypoglycemia (75–84). Intermittently scanned

continuous glucose monitors are not currently approved for use in children and adolescents. A strong relationship exists between frequency of blood glucose monitoring and glycemic stability (77–86). Recent data with newer devices and insulins indicate that the risk of hypoglycemia with lower A1C is less than it was before (52,76,87–94). Some data suggest that there could be a threshold where lower A1C is associated with more hypoglycemia (95,96); however, the confidence intervals were large, suggesting great variability.

In selecting glycemic targets, the long-term health benefits of achieving a lower A1C should be balanced against the risks of hypoglycemia and the developmental burdens of intensive regimens in children and youth. In addition, achieving lower A1C levels is likely facilitated by setting lower A1C targets (51,97). Lower goals may be possible during the “honeymoon” phase of type 1 diabetes.

Key Concepts in Setting Glycemic Targets

- Targets should be *individualized*, and lower targets may be reasonable based on a benefit-risk assessment.
- Blood glucose targets should be modified in children with frequent hypoglycemia or hypoglycemia unawareness.
- Postprandial blood glucose values should be measured when there is a discrepancy between preprandial blood glucose values and A1C levels and to assess preprandial insulin doses in those on basal-bolus or pump regimens.

Autoimmune Conditions

Recommendation

13.25 Assess for additional autoimmune conditions soon after the diagnosis of type 1 diabetes and if symptoms develop. **B**

Because of the increased frequency of other autoimmune diseases in type 1 diabetes, screening for thyroid dysfunction and celiac disease should be considered (98–102). Periodic screening in asymptomatic individuals has been recommended, but the optimal frequency of screening is unclear.

Although much less common than thyroid dysfunction and celiac disease,

other autoimmune conditions, such as Addison disease (primary adrenal insufficiency), autoimmune hepatitis, autoimmune gastritis, dermatomyositis, and myasthenia gravis, occur more commonly in the population with type 1 diabetes than in the general pediatric population and should be assessed and monitored as clinically indicated. In addition, relatives of patients should be offered testing for islet autoantibodies through research studies (e.g., TrialNet) for early diagnosis of preclinical type 1 diabetes (stages 1 and 2).

Thyroid Disease

Recommendations

13.26 Consider testing children with type 1 diabetes for antithyroid peroxidase and antithyroglobulin antibodies soon after diagnosis. **B**

13.27 Measure thyroid-stimulating hormone concentrations at diagnosis when clinically stable or soon after glycemic control has been established. If normal, suggest rechecking every 1–2 years or sooner if the patient has positive thyroid antibodies or develops symptoms or signs suggestive of thyroid dysfunction, thyromegaly, an abnormal growth rate, or unexplained glycemic variability. **B**

Autoimmune thyroid disease is the most common autoimmune disorder associated with diabetes, occurring in 17–30% of patients with type 1 diabetes (99,103,104). At the time of diagnosis, ~25% of children with type 1 diabetes have thyroid autoantibodies (105); their presence is predictive of thyroid dysfunction—most commonly hypothyroidism, although hyperthyroidism occurs in ~0.5% of patients with type 1 diabetes (106,107). For thyroid autoantibodies, a study from Sweden indicated that antithyroid peroxidase antibodies were more predictive than antithyroglobulin antibodies in multivariate analysis (108). Thyroid function tests may be misleading (euthyroid sick syndrome) if performed at the time of diagnosis owing to the effect of previous hyperglycemia, ketosis or ketoacidosis,

weight loss, etc. Therefore, if performed at diagnosis and slightly abnormal, thyroid function tests should be repeated soon after a period of metabolic stability and achievement of glycemic targets. Subclinical hypothyroidism may be associated with increased risk of symptomatic hypoglycemia (109) and reduced linear growth rate. Hyperthyroidism alters glucose metabolism and usually causes deterioration of glycemic control.

Celiac Disease

Recommendations

- 13.28** Screen children with type 1 diabetes for celiac disease by measuring IgA tissue transglutaminase (tTG) antibodies, with documentation of normal total serum IgA levels, soon after the diagnosis of diabetes, or IgG to tTG and deamidated gliadin antibodies if IgA deficient. **B**
- 13.29** Repeat screening within 2 years of diabetes diagnosis and then again after 5 years and consider more frequent screening in children who have symptoms or a first-degree relative with celiac disease. **B**
- 13.30** Individuals with biopsy-confirmed celiac disease should be placed on a gluten-free diet for treatment and to avoid complications; they should also have a consultation with a dietitian experienced in managing both diabetes and celiac disease. **B**

Celiac disease is an immune-mediated disorder that occurs with increased frequency in patients with type 1 diabetes (1.6–16.4% of individuals compared with 0.3–1% in the general population) (98,101,102,110–114). Screening patients with type 1 diabetes for celiac disease is further justified by its association with osteoporosis, iron deficiency, growth failure, and potential increased risk of retinopathy and albuminuria (115–118).

Screening for celiac disease includes measuring serum levels of IgA and tissue transglutaminase antibodies, or, with

IgA deficiency, screening can include measuring IgG tissue transglutaminase antibodies or IgG deamidated gliadin peptide antibodies. Because most cases of celiac disease are diagnosed within the first 5 years after the diagnosis of type 1 diabetes, screening should be considered at the time of diagnosis and repeated at 2 and then 5 years (112) or if clinical symptoms indicate, such as poor growth or increased hypoglycemia (113,115).

Although celiac disease can be diagnosed more than 10 years after diabetes diagnosis, there are insufficient data after 5 years to determine the optimal screening frequency. Measurement of tissue transglutaminase antibody should be considered at other times in patients with symptoms suggestive of celiac disease (112). Monitoring for symptoms should include assessment of linear growth and weight gain (113,115). A small bowel biopsy in antibody-positive children is recommended to confirm the diagnosis (119). European guidelines on screening for celiac disease in children (not specific to children with type 1 diabetes) suggest that biopsy may not be necessary in symptomatic children with high antibody titers (i.e., greater than 10 times the upper limit of normal) provided that further testing is performed (verification of endomysial antibody positivity on a separate blood sample). Whether this approach may be appropriate for asymptomatic children in high-risk groups remains an open question, though evidence is emerging (120). It is also advisable to check for celiac disease-associated HLA types in patients who are diagnosed without a small intestinal biopsy. In symptomatic children with type 1 diabetes and confirmed celiac disease, gluten-free diets reduce symptoms and rates of hypoglycemia (121). The challenging dietary restrictions associated with having both type 1 diabetes and celiac disease place a significant burden on individuals. Therefore, a biopsy to confirm the diagnosis of celiac disease is recommended, especially in asymptomatic children, before establishing a diagnosis of celiac disease (122) and endorsing significant dietary changes. A gluten-free diet was beneficial in asymptomatic adults with positive antibodies confirmed by biopsy (123).

Management of Cardiovascular Risk Factors

Hypertension Screening

Recommendations

- 13.31** Blood pressure should be measured at each routine visit. Children found to have elevated blood pressure (systolic blood pressure or diastolic blood pressure ≥ 90 th percentile for age, sex, and height or, in adolescents ≥ 13 years, systolic blood pressure 120–129 mmHg with diastolic blood pressure < 80 mmHg) or hypertension (systolic blood pressure or diastolic blood pressure ≥ 95 th percentile for age, sex, and height or, in adolescents ≥ 13 years, systolic blood pressure ≥ 130 mmHg or diastolic blood pressure ≥ 80 mmHg) should have elevated blood pressure confirmed on three separate days. **B**

Hypertension Treatment

Recommendations

- 13.32** Initial treatment of elevated blood pressure (systolic blood pressure or diastolic blood pressure consistently ≥ 90 th percentile for age, sex, and height or $\geq 120/80$ mmHg in adolescents ≥ 13 years) includes dietary modification and increased exercise, if appropriate, aimed at weight control. If target blood pressure is not reached within 3–6 months of initiating lifestyle intervention, pharmacologic treatment should be considered. **E**
- 13.33** In addition to lifestyle modification, pharmacologic treatment of hypertension (systolic blood pressure or diastolic blood pressure consistently ≥ 95 th percentile for age, sex, and height or $\geq 140/90$ mmHg in adolescents ≥ 13 years) should be considered as soon as hypertension is confirmed. **E**
- 13.34** ACE inhibitors or angiotensin receptor blockers should be considered for the initial pharmacologic treatment of

hypertension **E** in children and adolescents, following reproductive counseling due to the potential teratogenic effects of both drug classes. **E**

13.35 The goal of treatment is blood pressure consistently <90th percentile for age, sex, and height or <120/<80 mmHg in children ≥ 13 years. **E**

Blood pressure measurements should be performed using the appropriate size cuff with the child seated and relaxed. Hypertension should be confirmed on at least three separate days. Evaluation should proceed as clinically indicated (124). Treatment is generally initiated with an ACE inhibitor, but an angiotensin receptor blocker can be used if the ACE inhibitor is not tolerated (e.g., due to cough) (125).

Dyslipidemia Testing

Recommendations

13.36 Initial lipid testing should be performed when initial glycemic control has been achieved and age is ≥ 2 years. If initial LDL cholesterol is ≤ 100 mg/dL (2.6 mmol/L), subsequent testing should be performed at 9–11 years of age. **B** Initial testing may be done with a nonfasting non-HDL cholesterol level with confirmatory testing with a fasting lipid panel.

13.37 If LDL cholesterol values are within the accepted risk level (<100 mg/dL [2.6 mmol/L]), a lipid profile repeated every 3 years is reasonable. **E**

Dyslipidemia Treatment

Recommendations

13.38 If lipids are abnormal, initial therapy should consist of optimizing glucose control and medical nutrition therapy to limit the amount of calories from fat to 25–30%, saturated fat to <7%, cholesterol <200 mg/day, avoidance of *trans* fats, and aim for $\sim 10\%$ calories from monounsaturated fats. **A**

13.39 After the age of 10 years, addition of a statin may be considered in patients who, despite medical nutrition therapy and lifestyle changes, continue to have LDL cholesterol >160 mg/dL (4.1 mmol/L) or LDL cholesterol >130 mg/dL (3.4 mmol/L) and one or more cardiovascular disease risk factors, following reproductive counseling because of the potential teratogenic effects of statins. **E**

13.40 The goal of therapy is an LDL cholesterol value <100 mg/dL (2.6 mmol/L). **E**

Population-based studies estimate that 14–45% of children with type 1 diabetes have two or more atherosclerotic cardiovascular disease (ASCVD) risk factors (126–128), and the prevalence of cardiovascular disease (CVD) risk factors increases with age (128) and among racial/ethnic minorities (21), with girls having a higher risk burden than boys (127).

Pathophysiology. The atherosclerotic process begins in childhood, and although ASCVD events are not expected to occur during childhood, observations using a variety of methodologies show that youth with type 1 diabetes may have subclinical CVD within the first decade of diagnosis (129–131). Studies of carotid intima-media thickness have yielded inconsistent results (124,125).

Screening. Diabetes predisposes to development of accelerated arteriosclerosis. Lipid evaluation for these patients contributes to risk assessment and identifies an important proportion of those with dyslipidemia. Therefore, initial screening should be done soon after diagnosis. If the initial screen is normal, subsequent screening may be done at 9–11 years of age, which is a stable time for lipid assessment in children (132). Non-HDL cholesterol level has been identified as a significant predictor of the presence of atherosclerosis—as powerful as any other lipoprotein cholesterol measure in children and adolescents. For both children and adults, non-HDL cholesterol level seems to be more predictive of persistent dyslipidemia and, therefore, atherosclerosis and future events than total cholesterol, LDL cholesterol, or HDL cholesterol levels alone. A major advantage of non-HDL cholesterol is that it can

be accurately calculated in a nonfasting state and is therefore practical to obtain in clinical practice as a screening test (133). Youth with type 1 diabetes have a high prevalence of lipid abnormalities (126,134).

Even if normal, screening should be repeated within 3 years, as glycemic control and other cardiovascular risk factors can change dramatically during adolescence (135).

Treatment. Pediatric lipid guidelines provide some guidance relevant to children with type 1 diabetes (124,132,136,137); however, there are few studies on modifying lipid levels in children with type 1 diabetes. A 6-month trial of dietary counseling produced a significant improvement in lipid levels (138); likewise, a lifestyle intervention trial with 6 months of exercise in adolescents demonstrated improvement in lipid levels (139). Data from the SEARCH for Diabetes in Youth (SEARCH) study show that improved glucose over a 2-year period is associated with a more favorable lipid profile; however, improved glycemia alone will not normalize lipids in youth with type 1 diabetes and dyslipidemia (135).

Although intervention data are sparse, the American Heart Association categorizes children with type 1 diabetes in the highest tier for cardiovascular risk and recommends both lifestyle and pharmacologic treatment for those with elevated LDL cholesterol levels (137,140). Initial therapy should be with a nutrition plan that restricts saturated fat to 7% of total calories and dietary cholesterol to 200 mg/day. Data from randomized clinical trials in children as young as 7 months of age indicate that this diet is safe and does not interfere with normal growth and development (141).

Neither long-term safety nor cardiovascular outcome efficacy of statin therapy has been established for children; however, studies have shown short-term safety equivalent to that seen in adults and efficacy in lowering LDL cholesterol levels in familial hypercholesterolemia or severe hyperlipidemia, improving endothelial function and causing regression of carotid intimal thickening (142,143). Statins are not approved for patients aged <10 years, and statin treatment should generally not be used in children with type 1 diabetes before this age. Statins are contraindicated in

pregnancy; therefore, prevention of unplanned pregnancies is of paramount importance for postpubertal girls (see Section 14 “Management of Diabetes in Pregnancy,” <https://doi.org/10.2337/dc20-S014>, for more information). The multicenter, randomized, placebo-controlled Adolescent Type 1 Diabetes Cardio-Renal Intervention Trial (AddIT) provides safety data on pharmacologic treatment with an ACE inhibitor and statin in adolescents with type 1 diabetes.

Smoking

Recommendations

- 13.41** Elicit a smoking history at initial and follow-up diabetes visits; discourage smoking in youth who do not smoke and encourage smoking cessation in those who do smoke. **A**
- 13.42** E-cigarette use should be discouraged. **A**

The adverse health effects of smoking are well recognized with respect to future cancer and CVD risk. Despite this, smoking rates are significantly higher among youth with diabetes than among youth without diabetes (144,145). In youth with diabetes, it is important to avoid additional CVD risk factors. Smoking increases the risk of onset of albuminuria; therefore, smoking avoidance is important to prevent both microvascular and macrovascular complications (132,146). Discouraging cigarette smoking, including e-cigarettes (147,148), is an important part of routine diabetes care. In light of recent Centers for Disease Control and Prevention evidence of deaths related to e-cigarette use (149,150), no persons should be advised to use e-cigarettes, either as a way to stop smoking tobacco or as a recreational drug. In younger children, it is important to assess exposure to cigarette smoke in the home because of the adverse effects of secondhand smoke and to discourage youth from ever smoking if exposed to smokers in childhood.

Microvascular Complications

Nephropathy Screening

Recommendations

- 13.43** Annual screening for albuminuria with a random (morning sample preferred to avoid

effects of exercise) spot urine sample for albumin-to-creatinine ratio should be considered at puberty or at age >10 years, whichever is earlier, once the child has had diabetes for 5 years. **B**

Nephropathy Treatment

Recommendations

- 13.44** An ACE inhibitor or an angiotensin receptor blocker, titrated to normalization of albumin excretion, may be considered when elevated urinary albumin-to-creatinine ratio (>30 mg/g) is documented (two of three urine samples obtained over a 6-month interval following efforts to improve glycemic control and normalize blood pressure). **E**

Data from 7,549 participants <20 years of age in the T1D Exchange clinic registry emphasize the importance of good glycemic and blood pressure control, particularly as diabetes duration increases, in order to reduce the risk of diabetic kidney disease. The data also underscore the importance of routine screening to ensure early diagnosis and timely treatment of albuminuria (151). An estimation of glomerular filtration rate (GFR), calculated using GFR estimating equations from the serum creatinine, height, age, and sex (152), should be considered at baseline and repeated as indicated based on clinical status, age, diabetes duration, and therapies. Improved methods are needed to screen for early GFR loss, since estimated GFR is inaccurate at GFR >60 mL/min/1.73 m² (152,153). The AddIT study in adolescents with type 1 diabetes demonstrated safety of ACE inhibitor treatment, but the treatment did not change the albumin-to-creatinine ratio over the course of the study (124).

Retinopathy

Recommendations

- 13.45** An initial dilated and comprehensive eye examination is recommended once youth have had type 1 diabetes for 3–5 years, provided they are aged

≥11 years or puberty has started, whichever is earlier. **B**

- 13.46** After the initial examination, repeat dilated and comprehensive eye examination every 2 years. Less frequent examinations, every 4 years, may be acceptable on the advice of an eye care professional and based on risk factor assessment, including a history of glycemic control with A1C <8%. **B**

Retinopathy (like albuminuria) most commonly occurs after the onset of puberty and after 5–10 years of diabetes duration (154). It is currently recognized that there is low risk of development of vision-threatening retinal lesions prior to 12 years of age (155,156). A 2019 publication based on the follow-up of the DCCT adolescent cohort supports lower frequency of eye examinations than previously recommended, in particular in adolescents with A1C closer to the target range (157,158). Referrals should be made to eye care professionals with expertise in diabetic retinopathy and experience in counseling pediatric patients and families on the importance of prevention, early detection, and intervention.

Neuropathy

Recommendation

- 13.47** Consider an annual comprehensive foot exam at the start of puberty or at age ≥10 years, whichever is earlier, once the youth has had type 1 diabetes for 5 years. **B**

Diabetic neuropathy rarely occurs in prepubertal children or after only 1–2 years of diabetes (154), although data suggest a prevalence of distal peripheral neuropathy of 7% in 1,734 youth with type 1 diabetes and associated with the presence of CVD risk factors (159,160). A comprehensive foot exam, including inspection, palpation of dorsalis pedis and posterior tibial pulses, and determination of proprioception, vibration, and monofilament sensation, should be performed annually along with an assessment of symptoms of neuropathic pain (160). Foot inspection can be performed at each visit to educate youth regarding

the importance of foot care (see Section 11 “Microvascular Complications and Foot Care,” <https://doi.org/10.2337/dc20-S011>).

TYPE 2 DIABETES

For information on testing for type 2 diabetes and prediabetes in children and adolescents, please refer to Section 2 “Classification and Diagnosis of Diabetes” (<https://doi.org/10.2337/dc20-S002>). For additional support for these recommendations, see the ADA position statement “Evaluation and Management of Youth-Onset Type 2 Diabetes” (2).

Type 2 diabetes in youth has increased over the past 20 years, and recent estimates suggest an incidence of ~5,000 new cases per year in the U.S. (161). The Centers for Disease Control and Prevention published projections for type 2 diabetes prevalence using the SEARCH database; assuming a 2.3% annual increase, the prevalence in those under 20 years of age will quadruple in 40 years (162,163).

Evidence suggests that type 2 diabetes in youth is different not only from type 1 diabetes but also from type 2 diabetes in adults and has unique features, such as a more rapidly progressive decline in β -cell function and accelerated development of diabetes complications (2,164). Type 2 diabetes disproportionately impacts youth of ethnic and racial minorities and can occur in complex psychosocial and cultural environments, which may make it difficult to sustain healthy lifestyle changes and self-management behaviors (22,165–168). Additional risk factors associated with type 2 diabetes in youth include adiposity, family history of diabetes, female sex, and low socioeconomic status (164).

As with type 1 diabetes, youth with type 2 diabetes spend much of the day in school. Therefore, close communication with and the cooperation of school personnel are essential for optimal diabetes management, safety, and maximal academic opportunities.

Screening and Diagnosis

Recommendations

13.48 Risk-based screening for prediabetes and/or type 2 diabetes should be considered in

children and adolescents after the onset of puberty or ≥ 10 years of age, whichever occurs earlier, with overweight (BMI ≥ 85 th percentile) or obesity (BMI ≥ 95 th percentile) and who have one or more additional risk factors for diabetes (see **Table 2.4** for evidence grading of other risk factors).

13.49 If tests are normal, repeat testing at a minimum of 3-year intervals **E**, or more frequently if BMI is increasing. **C**

13.50 Fasting plasma glucose, 2-h plasma glucose during a 75-g oral glucose tolerance test, and A1C can be used to test for prediabetes or diabetes in children and adolescents. **B**

13.51 Children and adolescents with overweight or obesity in whom the diagnosis of type 2 diabetes is being considered should have a panel of pancreatic autoantibodies tested to exclude the possibility of autoimmune type 1 diabetes. **B**

In the last decade, the incidence and prevalence of type 2 diabetes in adolescents has increased dramatically, especially in racial and ethnic minority populations (132,169). A few recent studies suggest oral glucose tolerance tests or fasting plasma glucose values as more suitable diagnostic tests than A1C in the pediatric population, especially among certain ethnicities (170), although fasting glucose alone may overdiagnose diabetes in children (171,172). In addition, many of these studies do not recognize that diabetes diagnostic criteria are based on long-term health outcomes, and validations are not currently available in the pediatric population (173). ADA acknowledges the limited data supporting A1C for diagnosing type 2 diabetes in children and adolescents. Although A1C is not recommended for diagnosis of diabetes in children with cystic fibrosis or symptoms suggestive of acute onset of type 1 diabetes, and only A1C assays without interference are appropriate for children with hemoglobinopathies, ADA continues to recommend A1C for diagnosis of type 2 diabetes in this population (174,175).

Diagnostic Challenges

Given the current obesity epidemic, distinguishing between type 1 and type 2 diabetes in children can be difficult. Overweight and obesity are common in children with type 1 diabetes (23), and diabetes-associated autoantibodies and ketosis may be present in pediatric patients with features of type 2 diabetes (including obesity and acanthosis nigricans) (171). The presence of islet autoantibodies has been associated with faster progression to insulin deficiency (171). At onset, DKA occurs in ~6% of youth aged 10–19 years with type 2 diabetes (176). Although uncommon, type 2 diabetes has been observed in prepubertal children under the age of 10, and thus it should be part of the differential in children with suggestive symptoms (177). Finally, obesity (178) contributes to the development of type 1 diabetes in some individuals, which further blurs the lines between diabetes types. However, accurate diagnosis is critical, as treatment regimens, educational approaches, dietary advice, and outcomes differ markedly between patients with the two diagnoses. The significant diagnostic difficulties posed by MODY are discussed in section 2 “Classification and Diagnosis of Diabetes” (<https://doi.org/10.2337/dc20-S002>). In addition, there are rare and atypical diabetes cases that represent a challenge for clinicians and researchers.

Management

Lifestyle Management

Recommendations

13.52 All youth with type 2 diabetes and their families should receive comprehensive diabetes self-management education and support that is specific to youth with type 2 diabetes and is culturally competent. **B**

13.53 Youth with overweight/obesity and type 2 diabetes and their families should be provided with developmentally and culturally appropriate comprehensive lifestyle programs that are integrated with diabetes management to achieve 7–10% decrease in excess weight. **C**

13.54 Given the necessity of long-term weight management for children and adolescents with

type 2 diabetes, lifestyle intervention should be based on a chronic care model and offered in the context of diabetes care. **E**

- 13.55** Youth with diabetes, like all children, should be encouraged to participate in at least 30–60 min of moderate-to-vigorous physical activity at least 5 days per week (and strength training on at least 3 days/week) **B** and to decrease sedentary behavior. **C**
- 13.56** Nutrition for youth with type 2 diabetes, like for all children, should focus on healthy eating patterns that emphasize consumption of nutrient-dense, high-quality foods and decreased consumption of calorie-dense, nutrient-poor foods, particularly sugar-added beverages. **B**

Glycemic Targets

Recommendations

- 13.57** Home self-monitoring of blood glucose regimens should be individualized, taking into consideration the pharmacologic treatment of the patient. **E**
- 13.58** A1C should be measured every 3 months. **E**
- 13.59** A reasonable A1C target for most children and adolescents with type 2 diabetes treated with oral agents alone is <7% (53 mmol/mol). More stringent A1C targets (such as <6.5% [48 mmol/mol]) may be appropriate for selected individual patients if they can be achieved without significant hypoglycemia or other adverse effects of treatment. Appropriate patients might include those with short duration of diabetes and lesser degrees of β -cell dysfunction and patients treated with lifestyle or metformin only who achieve significant weight improvement. **E**
- 13.60** Less-stringent A1C goals (such as 7.5% [58 mmol/mol]) may be appropriate if there is increased risk of hypoglycemia. **E**

- 13.61** A1C targets for patients on insulin should be individualized, taking into account the relatively low rates of hypoglycemia in youth-onset type 2 diabetes. **E**

Pharmacologic Management

Recommendations

- 13.62** Initiate pharmacologic therapy, in addition to lifestyle therapy, at diagnosis of type 2 diabetes. **A**
- 13.63** In incidentally diagnosed or metabolically stable patients (A1C <8.5% [69 mmol/mol] and asymptomatic), metformin is the initial pharmacologic treatment of choice if renal function is normal. **A**
- 13.64** Youth with marked hyperglycemia (blood glucose \geq 250 mg/dL [13.9 mmol/L], A1C \geq 8.5% [69 mmol/mol]) without acidosis at diagnosis who are symptomatic with polyuria, polydipsia, nocturia, and/or weight loss should be treated initially with basal insulin while metformin is initiated and titrated. **B**
- 13.65** In patients with ketosis/ketoacidosis, treatment with subcutaneous or intravenous insulin should be initiated to rapidly correct the hyperglycemia and the metabolic derangement. Once acidosis is resolved, metformin should be initiated while subcutaneous insulin therapy is continued. **A**
- 13.66** In individuals presenting with severe hyperglycemia (blood glucose \geq 600 mg/dL [33.3 mmol/L]), consider assessment for hyperglycemic hyperosmolar nonketotic syndrome. **A**
- 13.67** If glycemic targets are no longer met with metformin (with or without basal insulin), liraglutide (a glucagon-like peptide 1 receptor agonist) therapy should be considered in children 10 years of age or older if they have no past medical history or family history of medullary thyroid

carcinoma or multiple endocrine neoplasia type 2. **A**

- 13.68** Patients treated with basal insulin up to 1.5 units/kg/day who do not meet A1C target should be moved to multiple daily injections with basal and premeal bolus insulins. **E**
- 13.69** In patients initially treated with insulin and metformin who are meeting glucose targets based on home blood glucose monitoring, insulin can be tapered over 2–6 weeks by decreasing the insulin dose 10–30% every few days. **B**
- 13.70** Use of medications not approved by the U.S. Food and Drug Administration for youth with type 2 diabetes is not recommended outside of research trials. **B**

Treatment of youth-onset type 2 diabetes should include lifestyle management, diabetes self-management education, and pharmacologic treatment. Initial treatment of youth with obesity and diabetes must take into account that diabetes type is often uncertain in the first few weeks of treatment, due to overlap in presentation, and that a substantial percentage of youth with type 2 diabetes will present with clinically significant ketoacidosis (180). Therefore, initial therapy should address the hyperglycemia and associated metabolic derangements irrespective of ultimate diabetes type, with adjustment of therapy once metabolic compensation has been established and subsequent information, such as islet autoantibody results, becomes available. **Figure 13.1** provides an approach to initial treatment of new-onset diabetes in youth with overweight or obesity.

Glycemic targets should be individualized, taking into consideration long-term health benefits of more stringent targets and risk for adverse effects, such as hypoglycemia. A lower target A1C in youth with type 2 diabetes when compared with those recommended in type 1 diabetes is justified by lower risk of hypoglycemia and higher risk of complications (181–184).

Patients and their families must prioritize lifestyle modifications such as eating a balanced diet, achieving

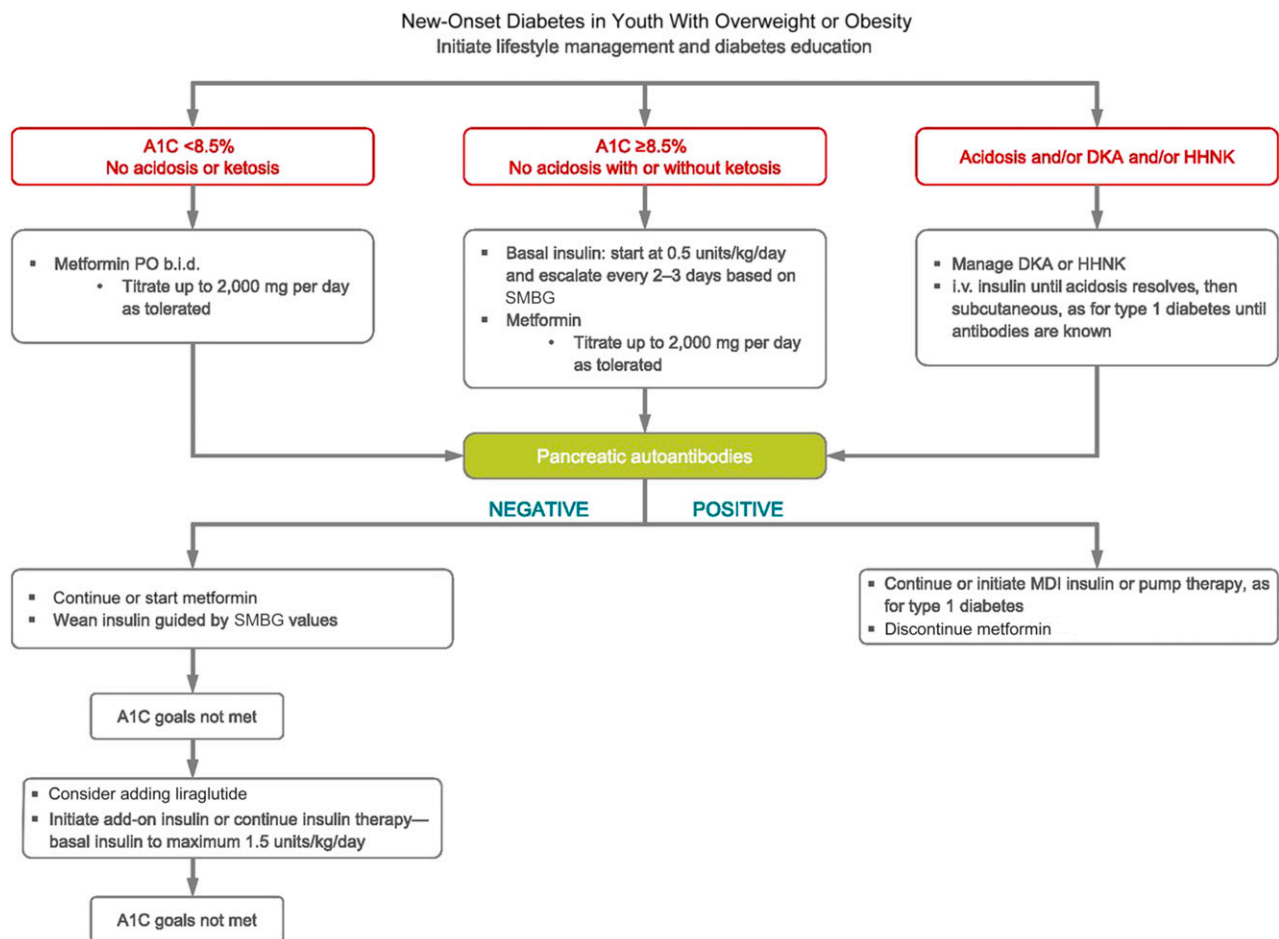


Figure 13.1—Management of new-onset diabetes in youth with overweight or obesity. A1C 8.5% = 69 mmol/mol. Adapted from the ADA position statement “Evaluation and Management of Youth-Onset Type 2 Diabetes” (2). DKA, diabetic ketoacidosis; HHNK, hyperosmolar hyperglycemic nonketotic syndrome; MDI, multiple daily injections.

and maintaining a healthy weight, and exercising regularly. A family-centered approach to nutrition and lifestyle modification is essential in children with type 2 diabetes, and nutrition recommendations should be culturally appropriate and sensitive to family resources (see Section 5 “Facilitating Behavior Change and Well-being to Improve Health Outcomes,” <https://doi.org/10.2337/dc20-S005>). Given the complex social and environmental context surrounding youth with type 2 diabetes, individual-level lifestyle interventions may not be sufficient to target the complex interplay of family dynamics, mental health, community readiness, and the broader environmental system (2).

A multidisciplinary diabetes team, including a physician, diabetes nurse educator, registered dietitian, and psychologist or social worker, is essential. In addition to achieving glycemic targets and self-management education

(185–187), initial treatment must include management of comorbidities such as obesity, dyslipidemia, hypertension, and microvascular complications.

Current pharmacologic treatment options for youth-onset type 2 diabetes are limited to three approved drugs—insulin, metformin, and liraglutide (2). Presentation with ketoacidosis or marked ketosis requires a period of insulin therapy until fasting and postprandial glycemia have been restored to normal or near-normal levels. Metformin therapy may be used as an adjunct after resolution of ketosis/ketoacidosis. Initial treatment should also be with insulin when the distinction between type 1 diabetes and type 2 diabetes is unclear and in patients who have random blood glucose concentrations ≥ 250 mg/dL (13.9 mmol/L) and/or A1C $\geq 8.5\%$ (69 mmol/mol) (188).

When insulin treatment is not required, initiation of metformin is

recommended. The Treatment Options for Type 2 Diabetes in Adolescents and Youth (TODAY) study found that metformin alone provided durable glycemic control (A1C $\leq 8\%$ [64 mmol/mol]) for 6 months) in approximately half of the subjects (189). The RISE Consortium study did not demonstrate differences in measures of glucose or β -cell function preservation between metformin and insulin, but there was more weight gain with insulin (190).

To date, the TODAY study is the only trial combining lifestyle and metformin therapy in youth with type 2 diabetes; the combination did not perform better than metformin alone in achieving durable glycemic control (189).

A recent randomized clinical trial in children aged 10–17 years with type 2 diabetes demonstrated the addition of subcutaneous liraglutide (up to 1.8 mg daily) to metformin (with or without basal insulin) as safe and effective to

decrease A1C (estimated decrease of 1.06 percentage points at 26 weeks and 1.30 at 52 weeks), although it did increase the frequency of gastrointestinal side effects (191). In June 2019, the U.S. Food and Drug Administration approved liraglutide injection for treatment of pediatric patients aged 10 years or older with type 2 diabetes (192).

Metabolic Surgery

Recommendations

- 13.71** Metabolic surgery may be considered for the treatment of adolescents with type 2 diabetes who are markedly obese (BMI >35 kg/m²) and who have uncontrolled glycemia and/or serious comorbidities despite lifestyle and pharmacologic intervention. **A**
- 13.72** Metabolic surgery should be performed only by an experienced surgeon working as part of a well-organized and engaged multidisciplinary team including a surgeon, endocrinologist, nutritionist, behavioral health specialist, and nurse. **A**

The results of weight-loss and lifestyle interventions for obesity in children and adolescents have been disappointing, and no effective and safe pharmacologic intervention is available or approved by the U.S. Food and Drug Administration in youth. Over the last decade, weight-loss surgery has been increasingly performed in adolescents with obesity. Small retrospective analyses and a recent prospective multicenter nonrandomized study suggest that bariatric or metabolic surgery may have benefits in obese adolescents with type 2 diabetes similar to those observed in adults. Teenagers experience similar degrees of weight loss, diabetes remission, and improvement of cardiometabolic risk factors for at least 3 years after surgery (193). No randomized trials, however, have yet compared the effectiveness and safety of surgery to those of conventional treatment options in adolescents (194). The guidelines used as an indication for metabolic surgery in adolescents generally include BMI >35 kg/m² with comorbidities or BMI >40 kg/m² with or without comorbidities (195–206). A number of groups, including the Pediatric Bariatric Study Group and the Teen Longitudinal

Assessment of Bariatric Surgery (Teen-LABS) Study, have demonstrated the effectiveness of metabolic surgery in adolescents (199–205).

Prevention and Management of Diabetes Complications

Nephropathy

Recommendations

- 13.73** Blood pressure should be measured at every visit. **A**
- 13.74** Blood pressure should be optimized to reduce risk and/or slow the progression of diabetic kidney disease. **A**
- 13.75** If blood pressure is ≥90th percentile for age, sex, and height or, in adolescents ≥13 years, blood pressure is ≥120/80 mmHg, increased emphasis should be placed on lifestyle management to promote weight loss. If blood pressure remains above the 90th percentile or, in adolescents ≥13 years, blood pressure is ≥120/80 after 6 months, antihypertensive therapy should be initiated. **C**
- 13.76** In addition to lifestyle modification, pharmacologic treatment of hypertension (systolic blood pressure or diastolic blood pressure consistently ≥95th percentile for age, sex, and height or ≥140/90 mmHg in adolescents ≥13 years) should be considered as soon as hypertension is confirmed. **E**
- 13.77** Initial therapeutic options include ACE inhibitors or angiotensin receptor blockers. Other blood pressure-lowering agents may be added as needed. **C**
- 13.78** Protein intake should be at the recommended daily allowance of 0.8 g/kg/day. **E**
- 13.79** Urine albumin-to-creatinine ratio should be obtained at the time of diagnosis and annually thereafter. An elevated urine albumin-to-creatinine ratio (>30 mg/g creatinine) should be confirmed on two of three samples. **B**
- 13.80** Estimated glomerular filtration rate should be determined at the time of diagnosis and annually thereafter. **E**

- 13.81** In nonpregnant patients with diabetes and hypertension, either an ACE inhibitor or an angiotensin receptor blocker is recommended for those with modestly elevated urinary albumin-to-creatinine ratio (30–299 mg/g creatinine) and is strongly recommended for those with urinary albumin-to-creatinine ratio >300 mg/g creatinine and/or estimated glomerular filtration rate <60 mL/min/1.73 m². **E**
- 13.82** For those with nephropathy, continued monitoring (yearly urinary albumin-to-creatinine ratio, estimated glomerular filtration rate, and serum potassium) may aid in assessing adherence and detecting progression of disease. **E**
- 13.83** Referral to nephrology is recommended in case of uncertainty of etiology, worsening urinary albumin-to-creatinine ratio, or decrease in estimated glomerular filtration rate. **E**

Neuropathy

Recommendations

- 13.84** Youth with type 2 diabetes should be screened for the presence of neuropathy by foot examination at diagnosis and annually. The examination should include inspection, assessment of foot pulses, pinprick and 10-g monofilament sensation tests, testing of vibration sensation using a 128-Hz tuning fork, and ankle reflex tests. **C**
- 13.85** Prevention should focus on achieving glycemic targets. **C**

Retinopathy

Recommendations

- 13.86** Screening for retinopathy should be performed by dilated funduscopy or retinal photography at or soon after diagnosis and annually thereafter. **C**
- 13.87** Optimizing glycemia is recommended to decrease the risk or slow the progression of retinopathy. **B**

- 13.88** Less frequent examination (every 2 years) may be considered if there is adequate glycemic control and a normal eye exam. **C**

Nonalcoholic Fatty Liver Disease

Recommendations

- 13.89** Evaluation for nonalcoholic fatty liver disease (by measuring AST and ALT) should be done at diagnosis and annually thereafter. **B**
- 13.90** Referral to gastroenterology should be considered for persistently elevated or worsening transaminases. **B**

Obstructive Sleep Apnea

Recommendation

- 13.91** Screening for symptoms of sleep apnea should be done at each visit, and referral to a pediatric sleep specialist for evaluation and a polysomnogram, if indicated, is recommended. Obstructive sleep apnea should be treated when documented. **B**

Polycystic Ovary Syndrome

Recommendations

- 13.92** Evaluate for polycystic ovary syndrome in female adolescents with type 2 diabetes, including laboratory studies when indicated. **B**
- 13.93** Oral contraceptive pills for treatment of polycystic ovary syndrome are not contraindicated for girls with type 2 diabetes. **C**
- 13.94** Metformin in addition to lifestyle modification is likely to improve the menstrual cyclicity and hyperandrogenism in girls with type 2 diabetes. **E**

Cardiovascular Disease

Recommendation

- 13.95** Intensive lifestyle interventions focusing on weight loss, dyslipidemia, hypertension, and dysglycemia are important to prevent overt macrovascular disease in early adulthood. **E**

Dyslipidemia

Recommendations

- 13.96** Lipid testing should be performed when initial glycemic control has been achieved and annually thereafter. **B**
- 13.97** Optimal goals are LDL cholesterol <100 mg/dL (2.6 mmol/L), HDL cholesterol >35 mg/dL (0.91 mmol/L), and triglycerides <150 mg/dL (1.7 mmol/L). **E**
- 13.98** If lipids are abnormal, initial therapy should consist of optimizing glucose control and medical nutritional therapy to limit the amount of calories from fat to 25–30%, saturated fat to <7%, cholesterol <200 mg/day, avoid *trans* fats, and aim for ~10% calories from monounsaturated fats for elevated LDL. For elevated triglycerides, medical nutrition therapy should also focus on decreasing simple sugar intake and increasing dietary n-3 fatty acids in addition to the above changes. **A**
- 13.99** If LDL cholesterol remains >130 mg/dL after 6 months of dietary intervention, initiate therapy with statin, with a goal of LDL <100 mg/dL. **B**
- 13.100** If triglycerides are >400 mg/dL (4.7 mmol/L) fasting or >1,000 mg/dL (11.6 mmol/L) nonfasting, optimize glycemia and begin fibrate, with a goal of <400 mg/dL (4.7 mmol/L) fasting (to reduce risk for pancreatitis). **C**

Cardiac Function Testing

Recommendation

- 13.101** Routine screening for heart disease with electrocardiogram, echocardiogram, or stress testing is not recommended in asymptomatic youth with type 2 diabetes. **B**

Comorbidities may already be present at the time of diagnosis of type 2 diabetes in youth (164,207). Therefore, blood pressure measurement, a fasting lipid panel, assessment of random urine albumin-to-creatinine ratio, and

a dilated eye examination should be performed at diagnosis. Thereafter, screening guidelines and treatment recommendations for hypertension, dyslipidemia, urine albumin excretion, and retinopathy are similar to those for youth with type 1 diabetes. Additional problems that may need to be addressed include polycystic ovary disease and other comorbidities associated with pediatric obesity, such as sleep apnea, hepatic steatosis, orthopedic complications, and psychosocial concerns. The ADA position statement “Evaluation and Management of Youth-Onset Type 2 Diabetes” (2) provides guidance on the prevention, screening, and treatment of type 2 diabetes and its comorbidities in children and adolescents.

Youth-onset type 2 diabetes is associated with significant microvascular and macrovascular risk burden and a substantial increase in the risk of cardiovascular morbidity and mortality at an earlier age than those diagnosed later in life (208). The higher complication risk in earlier-onset type 2 diabetes is likely related to prolonged lifetime exposure to hyperglycemia and other atherogenic risk factors, including insulin resistance, dyslipidemia, hypertension, and chronic inflammation. There is low risk of hypoglycemia in youth with type 2 diabetes, even if they are being treated with insulin (209), and there are high rates of complications (181–184). These diabetes comorbidities also appear to be higher than in youth with type 1 diabetes despite shorter diabetes duration and lower A1C (207). In addition, the progression of vascular abnormalities appears to be more pronounced in youth-onset type 2 diabetes compared with type 1 diabetes of similar duration, including ischemic heart disease and stroke (210).

Psychosocial Factors

Recommendations

- 13.102** Providers should assess social context, including potential food insecurity, housing stability, and financial barriers, and apply that information to treatment decisions. **E**
- 13.103** Use patient-appropriate standardized and validated tools to assess for diabetes distress

and mental/behavioral health in youth with type 2 diabetes, with attention to symptoms of depression and eating disorders, and refer to specialty care when indicated. **B**

13.104 When choosing glucose-lowering or other medications for youth with overweight or obesity and type 2 diabetes, consider medication-taking behavior and their effect on weight. **E**

13.105 Starting at puberty, preconception counseling should be incorporated into routine diabetes clinic visits for all females of childbearing potential because of the adverse pregnancy outcomes in this population. **A**

13.106 Patients should be screened for smoking and alcohol use at diagnosis and regularly thereafter. **C**

a miscarriage, stillbirth, or intrauterine death, and 20.5% of the liveborn infants had a major congenital anomaly.

TRANSITION FROM PEDIATRIC TO ADULT CARE

Recommendations

13.107 Pediatric diabetes providers should begin to prepare youth for transition to adult health care in early adolescence and, at the latest, at least 1 year before the transition. **E**

13.108 Both pediatric and adult diabetes care providers should provide support and resources for transitioning young adults. **E**

13.109 Youth with type 2 diabetes should be transferred to an adult-oriented diabetes specialist when deemed appropriate by the patient and provider. **E**

Most youth with type 2 diabetes come from racial/ethnic minority groups, have low socioeconomic status, and often experience multiple psychosocial stressors (22,36,165–168). Consideration of the sociocultural context and efforts to personalize diabetes management are of critical importance to minimize barriers to care, enhance adherence, and maximize response to treatment.

Evidence about psychiatric disorders and symptoms in youth with type 2 diabetes is limited (211–215), but given the sociocultural context for many youth and the medical burden and obesity associated with type 2 diabetes, ongoing surveillance of mental health/behavioral health is indicated. Symptoms of depression and disordered eating are common and associated with poorer glycemic control (212,216,217).

Many of the drugs prescribed for diabetes and psychiatric disorders are associated with weight gain and can increase patients' concerns about eating, body shape, and weight (218,219).

The TODAY study documented (220) that despite disease- and age-specific counseling, 10.2% of the females in the cohort became pregnant over an average of 3.8 years of study participation. Of note, 26.4% of pregnancies ended in

Care and close supervision of diabetes management are increasingly shifted from parents and other adults to the youth with type 1 or type 2 diabetes throughout childhood and adolescence. The shift from pediatric to adult health care providers, however, often occurs abruptly as the older teen enters the next developmental stage, referred to as emerging adulthood (221), which is a critical period for young people who have diabetes. During this period of major life transitions, youth begin to move out of their parents' homes and must become fully responsible for their diabetes care. Their new responsibilities include self-management of their diabetes, making medical appointments, and financing health care, once they are no longer covered by their parents' health insurance plans (ongoing coverage until age 26 years is currently available under provisions of the U.S. Affordable Care Act). In addition to lapses in health care, this is also a period associated with deterioration in glycemic stability; increased occurrence of acute complications; psychosocial, emotional, and behavioral challenges; and the emergence of chronic complications (222–225). The transition period from pediatric to adult care is prone to fragmentation in health care delivery, which may adversely impact

health care quality, cost, and outcomes (226). Worsening diabetes health outcomes during transition to adult care and early adulthood have been documented (227,228).

Although scientific evidence is limited, it is clear that comprehensive and coordinated planning that begins in early adolescence is necessary to facilitate a seamless transition from pediatric to adult health care (222,223,229,230). New technologies and other interventions are being tried to support transition to adult care in young adulthood (231–235). A comprehensive discussion regarding the challenges faced during this period, including specific recommendations, is found in the ADA position statement "Diabetes Care for Emerging Adults: Recommendations for Transition From Pediatric to Adult Diabetes Care Systems" (223).

The Endocrine Society in collaboration with the ADA and other organizations has developed transition tools for clinicians and youth and families (230).

References

- Chiang JL, Maahs DM, Garvey KC, et al. Type 1 diabetes in children and adolescents: a position statement by the American Diabetes Association. *Diabetes Care* 2018;41:2026–2044
- Arslanian S, Bacha F, Grey M, Marcus MD, White NH, Zeitler P. Evaluation and management of youth-onset type 2 diabetes: a position statement by the American Diabetes Association. *Diabetes Care* 2018;41:2648–2668
- Nadeau KJ, Anderson BJ, Berg EG, et al. Youth-onset type 2 diabetes consensus report: current status, challenges, and priorities. *Diabetes Care* 2016;39:1635–1642
- Mayer-Davis EJ, Lawrence JM, Dabelea D, et al.; SEARCH for Diabetes in Youth Study. Incidence trends of type 1 and type 2 diabetes among youths, 2002–2012. *N Engl J Med* 2017; 376:1419–1429
- Thomas NJ, Jones SE, Weedon MN, Shields BM, Oram RA, Hattersley AT. Frequency and phenotype of type 1 diabetes in the first six decades of life: a cross-sectional, genetically stratified survival analysis from UK Biobank. *Lancet Diabetes Endocrinol* 2018;6:122–129
- Barnea-Goraly N, Raman M, Mazaika P, et al.; Diabetes Research in Children Network (DirecNet). Alterations in white matter structure in young children with type 1 diabetes. *Diabetes Care* 2014;37:332–340
- Cameron FJ, Scratch SE, Nadebaum C, et al.; DKA Brain Injury Study Group. Neurological consequences of diabetic ketoacidosis at initial presentation of type 1 diabetes in a prospective cohort study of children. *Diabetes Care* 2014;37: 1554–1562

8. Markowitz JT, Garvey KC, Laffel LMB. Developmental changes in the roles of patients and families in type 1 diabetes management. *Curr Diabetes Rev* 2015;11:231–238
9. Driscoll KA, Volkening LK, Haro H, et al. Are children with type 1 diabetes safe at school? Examining parent perceptions. *Pediatr Diabetes* 2015;16:613–620
10. Mehta SN, Volkening LK, Anderson BJ, et al.; Family Management of Childhood Diabetes Study Steering Committee. Dietary behaviors predict glycemic control in youth with type 1 diabetes. *Diabetes Care* 2008;31:1318–1320
11. Riddell MC, Gallen IW, Smart CE, et al. Exercise management in type 1 diabetes: a consensus statement. *Lancet Diabetes Endocrinol* 2017;5:377–390
12. Colberg SR, Sigal RJ, Yardley JE, et al. Physical activity/exercise and diabetes: a position statement of the American Diabetes Association. *Diabetes Care* 2016;39:2065–2079
13. Robertson K, Adolfsson P, Scheiner G, Hanas R, Riddell MC. Exercise in children and adolescents with diabetes. *Pediatr Diabetes* 2009;10(Suppl. 12):154–168
14. U.S. Department of Health and Human Services. 2008 physical activity guidelines for Americans: index. Accessed 29 October 2019. Available from <https://health.gov/paguidelines/guidelines/default.aspx>
15. Tsalikian E, Kollman C, Tamborlane WB, et al.; Diabetes Research in Children Network (DirecNet) Study Group. Prevention of hypoglycemia during exercise in children with type 1 diabetes by suspending basal insulin. *Diabetes Care* 2006;29:2200–2204
16. Taplin CE, Cobry E, Messer L, McFann K, Chase HP, Fiallo-Scharer R. Preventing post-exercise nocturnal hypoglycemia in children with type 1 diabetes. *J Pediatr* 2010;157:784–788.e1
17. Riddell MC, Milliken J. Preventing exercise-induced hypoglycemia in type 1 diabetes using real-time continuous glucose monitoring and a new carbohydrate intake algorithm: an observational field study. *Diabetes Technol Ther* 2011;13:819–825
18. Francescato MP, Stel G, Stenner E, Geat M. Prolonged exercise in type 1 diabetes: performance of a customizable algorithm to estimate the carbohydrate supplements to minimize glycemic imbalances. *PLoS One* 2015;10:e0125220
19. Adolfsson P, Mattsson S, Jendle J. Evaluation of glucose control when a new strategy of increased carbohydrate supply is implemented during prolonged physical exercise in type 1 diabetes. *Eur J Appl Physiol* 2015;115:2599–2607
20. Baker LB, Rollo I, Stein KW, Jeukendrup AE. Acute effects of carbohydrate supplementation on intermittent sports performance. *Nutrients* 2015;7:5733–5763
21. Redondo MJ, Libman I, Cheng P, et al.; Pediatric Diabetes Consortium. Racial/ethnic minority youth with recent-onset type 1 diabetes have poor prognostic factors. *Diabetes Care* 2018;41:1017–1024
22. Liu LL, Lawrence JM, Davis C, et al.; SEARCH for Diabetes in Youth Study Group. Prevalence of overweight and obesity in youth with diabetes in USA: the SEARCH for Diabetes in Youth study. *Pediatr Diabetes* 2010;11:4–11
23. DuBose SN, Hermann JM, Tamborlane WV, et al.; Type 1 Diabetes Exchange Clinic Network and Diabetes Prospective Follow-up Registry. Obesity in youth with type 1 diabetes in Germany, Austria, and the United States. *J Pediatr* 2015;167:627–632.e4
24. Corbin KD, Driscoll KA, Pratley RE, Smith SR, Maahs DM, Mayer-Davis EJ; Advancing Care for Type 1 Diabetes and Obesity Network (ACT1ON). Obesity in type 1 diabetes: pathophysiology, clinical impact, and mechanisms. *Endocr Rev* 2018;39:629–663
25. Redondo MJ, Foster NC, Libman IM, et al. Prevalence of cardiovascular risk factors in youth with type 1 diabetes and elevated body mass index. *Acta Diabetol* 2016;53:271–277
26. Jackson CC, Albanese-O'Neill A, Butler KL, et al. Diabetes care in the school setting: a position statement of the American Diabetes Association. *Diabetes Care* 2015;38:1958–1963
27. Siminerio LM, Albanese-O'Neill A, Chiang JL, et al.; American Diabetes Association. Care of young children with diabetes in the child care setting: a position statement of the American Diabetes Association. *Diabetes Care* 2014;37:2834–2842
28. Corathers SD, Kichler J, Jones N-HY, et al. Improving depression screening for adolescents with type 1 diabetes. *Pediatrics* 2013;132:e1395–e1402journal
29. Hood KK, Beavers DP, Yi-Frazier J, et al. Psychosocial burden and glycemic control during the first 6 years of diabetes: results from the SEARCH for Diabetes in Youth study. *J Adolesc Health* 2014;55:498–504
30. Ducat L, Philipson LH, Anderson BJ. The mental health comorbidities of diabetes. *JAMA* 2014;312:691–692
31. Hagger V, Hendrieckx C, Sturt J, Skinner TC, Speight J. Diabetes distress among adolescents with type 1 diabetes: a systematic review. *Curr Diab Rep* 2016;16:9
32. Anderson BJ, Laffel LM, Domenger C, et al. Factors associated with diabetes-specific health-related quality of life in youth with type 1 diabetes: the global TEENS study [published correction appears in *Diabetes Care* 2018;41:640]. *Diabetes Care* 2017;40:1002–1009
33. Hilliard ME, De Wit M, Wasserman RM, et al. Screening and support for emotional burdens of youth with type 1 diabetes: strategies for diabetes care providers. *Pediatr Diabetes* 2018;19:534–543
34. Shapiro JB, Vesco AT, Weil LEG, Evans MA, Hood KK, Weissberg-Benchell J. Psychometric properties of the Problem Areas in Diabetes: Teen and Parent of Teen versions. *J Pediatr Psychol* 2018;43:561–571
35. Lawrence JM, Yi-Frazier JP, Black MH, et al.; SEARCH for Diabetes in Youth Study Group. Demographic and clinical correlates of diabetes-related quality of life among youth with type 1 diabetes. *J Pediatr* 2012;161:201–207.e2
36. Young-Hyman D, de Groot M, Hill-Briggs F, Gonzalez JS, Hood K, Peyrot M. Psychosocial care for people with diabetes: a position statement of the American Diabetes Association. *Diabetes Care* 2016;39:2126–2140
37. Markowitz JT, Butler DA, Volkening LK, Antisdell JE, Anderson BJ, Laffel LMB. Brief screening tool for disordered eating in diabetes: internal consistency and external validity in a contemporary sample of pediatric patients with type 1 diabetes. *Diabetes Care* 2010;33:495–500
38. Katz ML, Volkening LK, Butler DA, Anderson BJ, Laffel LM. Family-based psychoeducation and Care Ambassador intervention to improve glycemic control in youth with type 1 diabetes: a randomized trial. *Pediatr Diabetes* 2014;15:142–150
39. Laffel LMB, Vangsness L, Connell A, Goebel-Fabbri A, Butler D, Anderson BJ. Impact of ambulatory, family-focused teamwork intervention on glycemic control in youth with type 1 diabetes. *J Pediatr* 2003;142:409–416
40. Anderson BJ, Vangsness L, Connell A, Butler D, Goebel-Fabbri A, Laffel LMB. Family conflict, adherence, and glycaemic control in youth with short duration type 1 diabetes. *Diabet Med* 2002;19:635–642
41. Helgeson VS, Palladino DK. Implications of psychosocial factors for diabetes outcomes among children with type 1 diabetes: a review. *Soc Personal Psychol Compass* 2012;6:228–242
42. McCarthy AM, Lindgren S, Mengeling MA, Tsalikian E, Engvall J. Factors associated with academic achievement in children with type 1 diabetes. *Diabetes Care* 2003;26:112–117
43. Kuther TL. Medical decision-making and minors: issues of consent and assent. *Adolescence* 2003;38:343–358
44. Coleman DL, Rosoff PM. The legal authority of mature minors to consent to general medical treatment. *Pediatrics* 2013;131:786–793
45. Charron-Prochownik D, Sereika SM, Becker D, et al. Long-term effects of the booster-enhanced READY-Girls preconception counseling program on intentions and behaviors for family planning in teens with diabetes. *Diabetes Care* 2013;36:3870–3874
46. Charron-Prochownik D, Downs J. *Diabetes and Reproductive Health for Girls*. Alexandria, VA, American Diabetes Association, 2016
47. Wisting L, Frøisland DH, Skriverhaug T, Dahl-Jørgensen K, Rø O. Disturbed eating behavior and omission of insulin in adolescents receiving intensified insulin treatment: a nationwide population-based study. *Diabetes Care* 2013;36:3382–3387
48. Goebel-Fabbri AE. Disturbed eating behaviors and eating disorders in type 1 diabetes: clinical significance and treatment recommendations. *Curr Diab Rep* 2009;9:133–139
49. Atik Altınok Y, Özgür S, Meseri R, Özen S, Darcan Ş, Gökşen D. Reliability and validity of the diabetes eating problem survey in Turkish children and adolescents with type 1 diabetes mellitus. *J Clin Res Pediatr Endocrinol* 2017;9:323–328
50. Saßmann H, Albrecht C, Busse-Widmann P, et al. Psychometric properties of the German version of the Diabetes Eating Problem Survey-Revised: additional benefit of disease-specific screening in adolescents with Type 1 diabetes. *Diabet Med* 2015;32:1641–1647
51. Maahs DM, Hermann JM, DuBose SN, et al.; DPV Initiative; T1D Exchange Clinic Network. Contrasting the clinical care and outcomes of 2,622 children with type 1 diabetes less than 6 years of age in the United States T1D Exchange and German/Austrian DPV registries. *Diabetologia* 2014;57:1578–1585
52. Haynes A, Hermann JM, Miller KM, et al.; T1D Exchange, WACDD and DPV registries. Severe hypoglycemia rates are not associated with HbA1c: a cross-sectional analysis of 3 contemporary

- pediatric diabetes registry databases. *Pediatr Diabetes* 2017;18:643–650
53. Jaeb Center for Health Research. CGM Intervention in Teens and Young Adults With Type 1 Diabetes (T1D) (CITY). In: *ClinicalTrials.gov*. Bethesda, MD, National Library of Medicine. Accessed 3 October 2019. Available from <https://clinicaltrials.gov/ct2/show/NCT03263494>
54. Jaeb Center for Health Research. Strategies to Enhance New CGM Use in Early Childhood (SENCE). In: *ClinicalTrials.gov*. Accessed 3 October 2019. Available from <https://clinicaltrials.gov/ct2/show/NCT02912728>
55. Rosenbauer J, Dost A, Karges B, et al.; DPV Initiative and the German BMBF Competence Network Diabetes Mellitus. Improved metabolic control in children and adolescents with type 1 diabetes: a trend analysis using prospective multicenter data from Germany and Austria. *Diabetes Care* 2012;35:80–86
56. Cameron FJ, de Beaufort C, Aanstoot HJ, et al.; Hvidoere International Study Group. Lessons from the Hvidoere International Study Group on childhood diabetes: be dogmatic about outcome and flexible in approach. *Pediatr Diabetes* 2013;14:473–480
57. Nimri R, Weintrob N, Benzaquen H, Ofan R, Fayman G, Phillip M. Insulin pump therapy in youth with type 1 diabetes: a retrospective paired study. *Pediatrics* 2006;117:2126–2131
58. Doyle EA, Weinzimer SA, Steffen AT, Ahern JAH, Vincent M, Tamborlane WVA. A randomized, prospective trial comparing the efficacy of continuous subcutaneous insulin infusion with multiple daily injections using insulin glargine. *Diabetes Care* 2004;27:1554–1558
59. Diabetes Control and Complications Trial Research Group. Effect of intensive diabetes treatment on the development and progression of long-term complications in adolescents with insulin-dependent diabetes mellitus: Diabetes Control and Complications Trial. *J Pediatr* 1994;125:177–188
60. White NH, Cleary PA, Dahms W, Goldstein D, Malone J, Tamborlane WV; Diabetes Control and Complications Trial (DCCT)/Epidemiology of Diabetes Interventions and Complications (EDIC) Research Group. Beneficial effects of intensive therapy of diabetes during adolescence: outcomes after the conclusion of the Diabetes Control and Complications Trial (DCCT). *J Pediatr* 2001;139:804–812
61. Samuelsson U, Steineck I, Gubbjornsdottir S. A high mean-HbA_{1c} value 3-15 months after diagnosis of type 1 diabetes in childhood is related to metabolic control, macroalbuminuria, and retinopathy in early adulthood—a pilot study using two nation-wide population based quality registries. *Pediatr Diabetes* 2014;15:229–235
62. Carlsen S, Skriverhaug T, Thue G, et al. Glycemic control and complications in patients with type 1 diabetes - a registry-based longitudinal study of adolescents and young adults. *Pediatr Diabetes* 2017;18:188–195
63. Genuth SM, Backlund J-YC, Bayless M, et al.; DCCT/EDIC Research Group. Effects of prior intensive versus conventional therapy and history of glycemia on cardiac function in type 1 diabetes in the DCCT/EDIC. *Diabetes* 2013;62:3561–3569
64. Writing Team for the Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications Research Group. Sustained effect of intensive treatment of type 1 diabetes mellitus on development and progression of diabetic nephropathy: the Epidemiology of Diabetes Interventions and Complications (EDIC) study. *JAMA* 2003;290:2159–2167
65. Writing Team for the DCCT/EDIC Research Group, Gubitosi-Klug RA, Sun W, et al. Effects of prior intensive insulin therapy and risk factors on patient-reported visual function outcomes in the Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications (DCCT/EDIC) cohort. *JAMA Ophthalmol* 2016;134:137–145
66. Orchard TJ, Nathan DM, Zinman B, et al.; Writing Group for the DCCT/EDIC Research Group. Association between 7 years of intensive treatment of type 1 diabetes and long-term mortality. *JAMA* 2015;313:45–53
67. Foland-Ross LC, Reiss AL, Mazaika PK, et al.; Diabetes Research in Children Network (DirecNet). Longitudinal assessment of hippocampus structure in children with type 1 diabetes. *Pediatr Diabetes* 2018;19:1116–1123
68. Maura N, Mazaika P, Buckingham B, et al.; Diabetes Research in Children Network (DirecNet). Longitudinal assessment of neuroanatomical and cognitive differences in young children with type 1 diabetes: association with hyperglycemia. *Diabetes* 2015;64:1770–1779
69. Pourabbasi A, Tehrani-Doost M, Qavam SE, Arzaghi SM, Larijani B. Association of diabetes mellitus and structural changes in the central nervous system in children and adolescents: a systematic review. *J Diabetes Metab Disord* 2017;16:10
70. Perantie DC, Wu J, Koller JM, et al. Regional brain volume differences associated with hyperglycemia and severe hypoglycemia in youth with type 1 diabetes. *Diabetes Care* 2007;30:2331–2337
71. Arbelaez AM, Semenkovich K, Hershey T. Glycemic extremes in youth with T1DM: the structural and functional integrity of the developing brain. *Pediatr Diabetes* 2013;14:541–553journal
72. Broadley MM, White MJ, Andrew B. A systematic review and meta-analysis of executive function performance in type 1 diabetes mellitus. *Psychosom Med* 2017;79:684–696
73. Ryan CM. Why is cognitive dysfunction associated with the development of diabetes early in life? The diathesis hypothesis. *Pediatr Diabetes* 2006;7:289–297
74. Cameron FJ. The impact of diabetes on brain function in childhood and adolescence. *Pediatr Clin North Am* 2015;62:911–927
75. Campbell MS, Schatz DA, Chen V, et al.; T1D Exchange Clinic Network. A contrast between children and adolescents with excellent and poor control: the T1D Exchange clinic registry experience. *Pediatr Diabetes* 2014;15:110–117
76. Cooper MN, O'Connell SM, Davis EA, Jones TW. A population-based study of risk factors for severe hypoglycaemia in a contemporary cohort of childhood-onset type 1 diabetes. *Diabetologia* 2013;56:2164–2170
77. Bergenstal RM, Klonoff DC, Garg SK, et al.; ASPIRE In-Home Study Group. Threshold-based insulin-pump interruption for reduction of hypoglycemia. *N Engl J Med* 2013;369:224–232
78. Abraham MB, Davey R, O'Grady MJ, et al. Effectiveness of a predictive algorithm in the prevention of exercise-induced hypoglycemia in type 1 diabetes. *Diabetes Technol Ther* 2016;18:543–550
79. Buckingham BA, Bailey TS, Christiansen M, et al. Evaluation of a predictive low-glucose management system in-clinic. *Diabetes Technol Ther* 2017;19:288–292
80. Nimri R, Muller I, Atlas E, et al. MD-Logic overnight control for 6 weeks of home use in patients with type 1 diabetes: randomized crossover trial. *Diabetes Care* 2014;37:3025–3032
81. Thabit H, Tauschmann M, Allen JM, et al. Home use of an artificial beta cell in type 1 diabetes. *N Engl J Med* 2015;373:2129–2140
82. Bergenstal RM, Garg S, Weinzimer SA, et al. Safety of a hybrid closed-loop insulin delivery system in patients with type 1 diabetes. *JAMA* 2016;316:1407–1408
83. Kovatchev B, Cheng P, Anderson SM, et al. Feasibility of long-term closed-loop control: a multicenter 6-month trial of 24/7 automated insulin delivery. *Diabetes Technol Ther* 2017;19:18–24
84. El-Khatib FH, Balliro C, Hillard MA, et al. Home use of a bihormonal bionic pancreas versus insulin pump therapy in adults with type 1 diabetes: a multicentre randomised crossover trial. *Lancet* 2017;389:369–380
85. Levine BS, Anderson BJ, Butler DA, Antisdel JE, Brackett J, Laffel LM. Predictors of glycemic control and short-term adverse outcomes in youth with type 1 diabetes. *J Pediatr* 2001;139:197–203
86. Miller KM, Beck RW, Bergenstal RM, et al.; T1D Exchange Clinic Network. Evidence of a strong association between frequency of self-monitoring of blood glucose and hemoglobin A_{1c} levels in T1D Exchange clinic registry participants. *Diabetes Care* 2013;36:2009–2014
87. Haynes A, Hermann JM, Clapin H, et al.; WACDD and DPV registries. Decreasing trends in mean HbA_{1c} are not associated with increasing rates of severe hypoglycemia in children: a longitudinal analysis of two contemporary population-based pediatric type 1 diabetes registries from Australia and Germany/Austria between 1995 and 2016. *Diabetes Care* 2019;42:1630–1636
88. Fredheim S, Johansen A, Thorsen SU, et al.; Danish Society for Diabetes in Childhood and Adolescence. Nationwide reduction in the frequency of severe hypoglycemia by half. *Acta Diabetol* 2015;52:591–599
89. Birkebaek NH, Drivvoll AK, Aakeson K, et al. Incidence of severe hypoglycemia in children with type 1 diabetes in the Nordic countries in the period 2008-2012: association with hemoglobin A_{1c} and treatment modality. *BMJ Open Diabetes Res Care* 2017;5:e000377
90. Ly TT, Nicholas JA, Retterath A, Lim EM, Davis EA, Jones TW. Effect of sensor-augmented insulin pump therapy and automated insulin suspension vs standard insulin pump therapy on hypoglycemia in patients with type 1 diabetes: a randomized clinical trial. *JAMA* 2013;310:1240–1247
91. Downie E, Craig ME, Hing S, Cusumano J, Chan AKF, Donaghue KC. Continued reduction in the prevalence of retinopathy in adolescents with type 1 diabetes: role of insulin therapy

- and glycemic control. *Diabetes Care* 2011;34:2368–2373
92. Karges B, Rosenbauer J, Kapellen T, et al. Hemoglobin A1c levels and risk of severe hypoglycemia in children and young adults with type 1 diabetes from Germany and Austria: a trend analysis in a cohort of 37,539 patients between 1995 and 2012. *PLoS Med* 2014;11:e1001742
93. Johnson SR, Cooper MN, Jones TW, Davis EA. Long-term outcome of insulin pump therapy in children with type 1 diabetes assessed in a large population-based case-control study. *Diabetologia* 2013;56:2392–2400
94. Karges B, Kapellen T, Wagner VM, et al.; DPV Initiative. Glycated hemoglobin A1c as a risk factor for severe hypoglycemia in pediatric type 1 diabetes. *Pediatr Diabetes* 2017;18:51–58
95. Saydah S, Imperatore G, Divers J, et al. Occurrence of severe hypoglycaemic events among US youth and young adults with type 1 or type 2 diabetes. *Endocrinol Diabetes Metab* 2019;2:e00057
96. Ishiak-Ahmed K, Carstensen B, Pedersen-Bjergaard U, Jørgensen ME. Incidence trends and predictors of hospitalization for hypoglycemia in 17,230 adult patients with type 1 diabetes: a Danish Register linkage cohort study. *Diabetes Care* 2017;40:226–232
97. Swift PGF, Skinner TC, de Beaufort CE, et al.; Hvidoere Study Group on Childhood Diabetes. Target setting in intensive insulin management is associated with metabolic control: the Hvidoere childhood diabetes study group centre differences study 2005. *Pediatr Diabetes* 2010;11:271–278
98. Warncke K, Fröhlich-Reiterer EE, Thon A, Hofer SE, Wiemann D, Holl RW; DPV Initiative of the German Working Group for Pediatric Diabetology; German BMBF Competence Network for Diabetes Mellitus. Polyendocrinopathy in children, adolescents, and young adults with type 1 diabetes: a multicenter analysis of 28,671 patients from the German/Austrian DPV-Wiss database. *Diabetes Care* 2010;33:2010–2012
99. Nderstigt C, Uitbeijerse BS, Janssen LGM, Corssmit EPM, de Koning EJP, Dekkers OM. Associated auto-immune disease in type 1 diabetes patients: a systematic review and meta-analysis. *Eur J Endocrinol* 2019;180:135–144
100. Kozhakhmetova A, Wyatt RC, Caygill C, et al. A quarter of patients with type 1 diabetes have co-existing non-islet autoimmunity: the findings of a UK population-based family study. *Clin Exp Immunol* 2018;192:251–258
101. Hughes JW, Riddlesworth TD, DiMeglio LA, Miller KM, Rickels MR, McGill JB. Autoimmune diseases in children and adults with type 1 diabetes from the T1D Exchange Clinic Registry. *J Clin Endocrinol Metab* 2016;101:4931–4937
102. Kahaly GJ, Hansen MP. Type 1 diabetes associated autoimmunity. *Autoimmun Rev* 2016;15:644–648
103. Roldán MB, Alonso M, Barrio R. Thyroid autoimmunity in children and adolescents with type 1 diabetes mellitus. *Diabetes Nutr Metab* 1999;12:27–31
104. Shun CB, Donaghue KC, Phelan H, Twigg SM, Craig ME. Thyroid autoimmunity in type 1 diabetes: systematic review and meta-analysis. *Diabet Med* 2014;31:126–135
105. Triolo TM, Armstrong TK, McFann K, et al. Additional autoimmune disease found in 33% of patients at type 1 diabetes onset. *Diabetes Care* 2011;34:1211–1213
106. Kordonouri O, Deiss D, Danne T, Dorow A, Bassir C, Grüters-Kieslich A. Predictivity of thyroid autoantibodies for the development of thyroid disorders in children and adolescents with type 1 diabetes. *Diabet Med* 2002;19:518–521
107. Dost A, Rohrer TR, Fröhlich-Reiterer E, et al.; DPV Initiative and the German Competence Network Diabetes Mellitus. Hyperthyroidism in 276 children and adolescents with type 1 diabetes from Germany and Austria. *Horm Res Paediatr* 2015;84:190–198
108. Jonsdottir B, Larsson C, Carlsson A, et al.; Better Diabetes Diagnosis Study Group. Thyroid and islet autoantibodies predict autoimmune thyroid disease at type 1 diabetes diagnosis. *J Clin Endocrinol Metab* 2017;102:1277–1285
109. Mohn A, Di Michele S, Di Luzio R, Tumini S, Chiarelli F. The effect of subclinical hypothyroidism on metabolic control in children and adolescents with type 1 diabetes mellitus. *Diabet Med* 2002;19:70–73
110. Holmes GKT. Screening for coeliac disease in type 1 diabetes. *Arch Dis Child* 2002;87:495–498
111. Rewers M, Liu E, Simmons J, Redondo MJ, Hoffenberg EJ. Celiac disease associated with type 1 diabetes mellitus. *Endocrinol Metab Clin North Am* 2004;33:197–214, xi
112. Pham-Short A, Donaghue KC, Ambler G, Phelan H, Twigg S, Craig ME. Screening for celiac disease in type 1 diabetes: a systematic review. *Pediatrics* 2015;136:e170–e176
113. Craig ME, Prinz N, Boyle CT, et al.; Australasian Diabetes Data Network (ADDN); T1D Exchange Clinic Network (T1DX); National Paediatric Diabetes Audit (NPDA) and the Royal College of Paediatrics and Child Health; Prospective Diabetes Follow-up Registry (DPV) initiative. Prevalence of celiac disease in 52,721 youth with type 1 diabetes: international comparison across three continents. *Diabetes Care* 2017;40:1034–1040
114. Cerutti F, Bruno G, Chiarelli F, Lorini R, Meschi F, Sacchetti C; Diabetes Study Group of the Italian Society of Pediatric Endocrinology and Diabetology. Younger age at onset and sex predict celiac disease in children and adolescents with type 1 diabetes: an Italian multicenter study. *Diabetes Care* 2004;27:1294–1298
115. Simmons JH, Foster NC, Riddlesworth TD, et al.; T1D Exchange Clinic Network. Sex- and age-dependent effects of celiac disease on growth and weight gain in children with type 1 diabetes: analysis of the Type 1 Diabetes Exchange Clinic Registry. *Pediatr Diabetes* 2018;19:741–748
116. Margoni D, Chouliaras G, Ducas G, et al. Bone health in children with celiac disease assessed by dual x-ray absorptiometry: effect of gluten-free diet and predictive value of serum biochemical indices. *J Pediatr Gastroenterol Nutr* 2012;54:680–684
117. Rohrer TR, Wolf J, Liptay S, et al.; DPV Initiative and the German BMBF Competence Network Diabetes Mellitus. Microvascular complications in childhood-onset type 1 diabetes and celiac disease: a multicenter longitudinal analysis of 56,514 patients from the German-Austrian DPV database. *Diabetes Care* 2015;38:801–807
118. Mollazadegan K, Kugelberg M, Montgomery SM, Sanders DS, Ludvigsson J, Ludvigsson JF. A population-based study of the risk of diabetic retinopathy in patients with type 1 diabetes and celiac disease. *Diabetes Care* 2013;36:316–321
119. Rubio-Tapia A, Hill ID, Kelly CP, Calderwood AH, Murray JA; American College of Gastroenterology. ACG clinical guidelines: diagnosis and management of celiac disease. *Am J Gastroenterol* 2013;108:656–676; quiz 677
120. Paul SP, Sandhu BK, Spray CH, Basude D, Ramani P. Evidence supporting serology-based pathway for diagnosing celiac disease in asymptomatic children from high-risk groups. *J Pediatr Gastroenterol Nutr* 2018;66:641–644
121. Abid N, McGlone O, Cardwell C, McCallion W, Carson D. Clinical and metabolic effects of gluten free diet in children with type 1 diabetes and coeliac disease. *Pediatr Diabetes* 2011;12:322–325
122. Husby S, Koletzko S, Korponay-Szabó IR, et al.; ESPGHAN Working Group on Coeliac Disease Diagnosis; ESPGHAN Gastroenterology Committee; European Society for Pediatric Gastroenterology, Hepatology, and Nutrition. European Society for Pediatric Gastroenterology, Hepatology, and Nutrition guidelines for the diagnosis of coeliac disease. *J Pediatr Gastroenterol Nutr* 2012;54:136–160
123. Kurppa K, Paavola A, Collin P, et al. Benefits of a gluten-free diet for asymptomatic patients with serologic markers of celiac disease. *Gastroenterology* 2014;147:610–617.e1
124. Marcovecchio ML, Chiesa ST, Bond S, et al.; AddIT Study Group. ACE inhibitors and statins in adolescents with type 1 diabetes. *N Engl J Med* 2017;377:1733–1745
125. de Ferranti SD, de Boer IH, Fonseca V, et al. Type 1 diabetes mellitus and cardiovascular disease: a scientific statement from the American Heart Association and American Diabetes Association. *Circulation* 2014;130:1110–1130
126. Rodriguez BL, Fujimoto WY, Mayer-Davis EJ, et al. Prevalence of cardiovascular disease risk factors in U.S. children and adolescents with diabetes: the SEARCH for Diabetes in Youth study. *Diabetes Care* 2006;29:1891–1896
127. Margeisdottir HD, Larsen JR, Brunborg C, Overby NC, Dahl-Jørgensen K; Norwegian Study Group for Childhood Diabetes. High prevalence of cardiovascular risk factors in children and adolescents with type 1 diabetes: a population-based study. *Diabetologia* 2008;51:554–561
128. Schwab KO, Doerfer J, Hecker W, et al.; DPV Initiative of the German Working Group for Pediatric Diabetology. Spectrum and prevalence of atherogenic risk factors in 27,358 children, adolescents, and young adults with type 1 diabetes: cross-sectional data from the German diabetes documentation and quality management system (DPV). *Diabetes Care* 2006;29:218–225
129. Singh TP, Groehn H, Kazmers A. Vascular function and carotid intimal-medial thickness in children with insulin-dependent diabetes mellitus. *J Am Coll Cardiol* 2003;41:661–665
130. Haller MJ, Stein J, Shuster J, et al. Peripheral artery tonometry demonstrates altered endothelial

- function in children with type 1 diabetes. *Pediatr Diabetes* 2007;8:193–198
131. Urbina EM, Wadwa RP, Davis C, et al. Prevalence of increased arterial stiffness in children with type 1 diabetes mellitus differs by measurement site and sex: the SEARCH for Diabetes in Youth Study. *J Pediatr* 2010;156:731–737.e1
132. Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents; National Heart, Lung, and Blood Institute. Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents: summary report. *Pediatrics* 2011;128(Suppl. 5):S213–S256
133. Blaha MJ, Blumenthal RS, Brinton EA, Jacobson TA; National Lipid Association Taskforce on Non-HDL Cholesterol. The importance of non-HDL cholesterol reporting in lipid management. *J Clin Lipidol* 2008;2:267–273
134. Kershner AK, Daniels SR, Imperatore G, et al. Lipid abnormalities are prevalent in youth with type 1 and type 2 diabetes: the SEARCH for Diabetes in Youth Study. *J Pediatr* 2006;149:314–319
135. Maahs DM, Dabelea D, D'Agostino RB Jr, et al.; SEARCH for Diabetes in Youth Study. Glucose control predicts 2-year change in lipid profile in youth with type 1 diabetes. *J Pediatr* 2013;162:101–107.e1
136. Daniels SR, Greer FR; Committee on Nutrition. Lipid screening and cardiovascular health in childhood. *Pediatrics* 2008;122:198–208
137. Kavey R-EW, Allada V, Daniels SR, et al.; American Heart Association Expert Panel on Population and Prevention Science; American Heart Association Council on Cardiovascular Disease in the Young; American Heart Association Council on Epidemiology and Prevention; American Heart Association Council on Nutrition, Physical Activity and Metabolism; American Heart Association Council on High Blood Pressure Research; American Heart Association Council on Cardiovascular Nursing; American Heart Association Council on the Kidney in Heart Disease; Interdisciplinary Working Group on Quality of Care and Outcomes Research. Cardiovascular risk reduction in high-risk pediatric patients: a scientific statement from the American Heart Association Expert Panel on Population and Prevention Science; the Councils on Cardiovascular Disease in the Young, Epidemiology and Prevention, Nutrition, Physical Activity and Metabolism, High Blood Pressure Research, Cardiovascular Nursing, and the Kidney in Heart Disease; and the Interdisciplinary Working Group on Quality of Care and Outcomes Research: endorsed by the American Academy of Pediatrics. *Circulation* 2006;114:2710–2738
138. Cadario F, Prod'homme F, Pasqualicchio S, et al. Lipid profile and nutritional intake in children and adolescents with Type 1 diabetes improve after a structured dietician training to a Mediterranean-style diet. *J Endocrinol Invest* 2012;35:160–168
139. Salem MA, AboElAsrar MA, Elbarbary NS, Elhilaly RA, Refaat YM. Is exercise a therapeutic tool for improvement of cardiovascular risk factors in adolescents with type 1 diabetes mellitus? A randomised controlled trial. *Diabetol Metab Syndr* 2010;2:47
140. McCrindle BW, Urbina EM, Dennison BA, et al.; American Heart Association Atherosclerosis, Hypertension, and Obesity in Youth Committee; American Heart Association Council of Cardiovascular Disease in the Young; American Heart Association Council on Cardiovascular Nursing. Drug therapy of high-risk lipid abnormalities in children and adolescents: a scientific statement from the American Heart Association Atherosclerosis, Hypertension, and Obesity in Youth Committee, Council of Cardiovascular Disease in the Young, with the Council on Cardiovascular Nursing. *Circulation* 2007;115:1948–1967
141. Salo P, Viikari J, Hämläinen M, et al. Serum cholesterol ester fatty acids in 7- and 13-month-old children in a prospective randomized trial of a low-saturated fat, low-cholesterol diet: the STRIP baby project: Special Turku coronary Risk factor Intervention Project for children. *Acta Paediatr* 1999;88:505–512
142. McCrindle BW, Ose L, Marais AD. Efficacy and safety of atorvastatin in children and adolescents with familial hypercholesterolemia or severe hyperlipidemia: a multicenter, randomized, placebo-controlled trial. *J Pediatr* 2003;143:74–80
143. Wiegman A, Hutten BA, de Groot E, et al. Efficacy and safety of statin therapy in children with familial hypercholesterolemia: a randomized controlled trial. *JAMA* 2004;292:331–337
144. Karter AJ, Stevens MR, Gregg EW, et al. Educational disparities in rates of smoking among diabetic adults: the translating research into action for diabetes study. *Am J Public Health* 2008;98:365–370
145. Reynolds K, Liese AD, Anderson AM, et al. Prevalence of tobacco use and association between cardiometabolic risk factors and cigarette smoking in youth with type 1 or type 2 diabetes mellitus. *J Pediatr* 2011;158:594–601.e1
146. Scott LJ, Warram JH, Hanna LS, Laffel LM, Ryan L, Krolewski AS. A nonlinear effect of hyperglycemia and current cigarette smoking are major determinants of the onset of microalbuminuria in type 1 diabetes. *Diabetes* 2001;50:2842–2849
147. Chaffee BW, Watkins SL, Glantz SA. Electronic cigarette use and progression from experimentation to established smoking. *Pediatrics* 2018;141:e20173594
148. Audrain-McGovern J, Stone MD, Barrington-Trimis J, Unger JB, Leventhal AM. Adolescent e-cigarette, hookah, and conventional cigarette use and subsequent marijuana use. *Pediatrics* 2018;142:e20173616
149. Centers for Disease Control and Prevention. Outbreak of lung injury associated with e-cigarette use, or vaping. Accessed 27 September 2019. Available from https://www.cdc.gov/tobacco/basic_information/e-cigarettes/severe-lung-disease.html
150. Miech R, Johnston L, O'Malley PM, Bachman JG, Patrick ME. Trends in adolescent vaping, 2017–2019. *N Engl J Med* 2019;381:1490–1491
151. Daniels M, DuBose SN, Maahs DM, et al.; T1D Exchange Clinic Network. Factors associated with microalbuminuria in 7,549 children and adolescents with type 1 diabetes in the T1D Exchange clinic registry. *Diabetes Care* 2013;36:2639–2645
152. Schwartz GJ, Work DF. Measurement and estimation of GFR in children and adolescents. *Clin J Am Soc Nephrol* 2009;4:1832–1843
153. Inker LA, Schmid CH, Tighiouart H, et al.; CKD-EPI Investigators. Estimating glomerular filtration rate from serum creatinine and cystatin C. *N Engl J Med* 2012;367:20–29
154. Cho YH, Craig ME, Hing S, et al. Microvascular complications assessment in adolescents with 2- to 5-yr duration of type 1 diabetes from 1990 to 2006. *Pediatr Diabetes* 2011;12:682–689
155. Scanlon PH, Stratton IM, Bachmann MO, Jones C, Leese GP; Four Nations Diabetic Retinopathy Screening Study Group. Risk of diabetic retinopathy at first screen in children at 12 and 13 years of age. *Diabet Med* 2016;33:1655–1658
156. Beauchamp G, Boyle CT, Tamborlane WV, et al.; T1D Exchange Clinic Network. Treatable diabetic retinopathy is extremely rare among pediatric T1D Exchange clinic registry participants. *Diabetes Care* 2016;39:e218–e219
157. Nathan DM, Bebu I, Hainsworth D, et al.; DCCT/EDIC Research Group. Frequency of evidence-based screening for retinopathy in type 1 diabetes. *N Engl J Med* 2017;376:1507–1516
158. Gubitosi-Klug RA, Bebu I, White NH, et al.; Diabetes Control and Complications Trial (DCCT)/Epidemiology of Diabetes Interventions and Complications (EDIC) Research Group*. Screening eye exams in youth with type 1 diabetes under 18 years of age: once may be enough? *Pediatr Diabetes* 2019;20:743–749
159. Jaiswal M, Divers J, Dabelea D, et al. Prevalence of and risk factors for diabetic peripheral neuropathy in youth with type 1 and type 2 diabetes: SEARCH for Diabetes in Youth Study. *Diabetes Care* 2017;40:1226–1232
160. Pop-Busui R, Boulton AJM, Feldman EL, et al. Diabetic neuropathy: a position statement by the American Diabetes Association. *Diabetes Care* 2017;40:136–154
161. Lawrence JM, Imperatore G, Pettitt DJ, et al. Incidence of diabetes in United States youth by diabetes type, race/ethnicity, and age, 2008–2009 (Abstract). *Diabetes* 2014;63(Suppl. 1):A407
162. Imperatore G, Boyle JP, Thompson TJ, et al.; SEARCH for Diabetes in Youth Study Group. Projections of type 1 and type 2 diabetes burden in the U.S. population aged <20 years through 2050: dynamic modeling of incidence, mortality, and population growth. *Diabetes Care* 2012;35:2515–2520
163. Pettitt DJ, Talton J, Dabelea D, et al.; SEARCH for Diabetes in Youth Study Group. Prevalence of diabetes in U.S. youth in 2009: the SEARCH for diabetes in youth study. *Diabetes Care* 2014;37:402–408
164. Copeland KC, Zeitler P, Geffner M, et al.; TODAY Study Group. Characteristics of adolescents and youth with recent-onset type 2 diabetes: the TODAY cohort at baseline. *J Clin Endocrinol Metab* 2011;96:159–167
165. Arslanian SA. Metabolic differences between Caucasian and African-American children and the relationship to type 2 diabetes mellitus. *J Pediatr Endocrinol Metab* 2002;15(Suppl. 1):509–517
166. Naughton MJ, Ruggiero AM, Lawrence JM, et al.; SEARCH for Diabetes in Youth Study Group. Health-related quality of life of children and adolescents with type 1 or type 2 diabetes

- mellitus: SEARCH for Diabetes in Youth Study. *Arch Pediatr Adolesc Med* 2008;162:649–657
167. Wadden TA, Webb VL, Moran CH, Bailer BA. Lifestyle modification for obesity: new developments in diet, physical activity, and behavior therapy. *Circulation* 2012;125:1157–1170
168. Whalen DJ, Belden AC, Tillman R, Barch DM, Luby JL. Early adversity, psychopathology, and latent class profiles of global physical health from preschool through early adolescence. *Psychosom Med* 2016;78:1008–1018
169. Dabelea D, Mayer-Davis EJ, Saydah S, et al.; SEARCH for Diabetes in Youth Study. Prevalence of type 1 and type 2 diabetes among children and adolescents from 2001 to 2009. *JAMA* 2014;311:1778–1786
170. Buse JB, Kaufman FR, Linder B, Hirst K, El Ghormli L, Willi S; HEALTHY Study Group. Diabetes screening with hemoglobin A(1c) versus fasting plasma glucose in a multiethnic middle-school cohort. *Diabetes Care* 2013;36:429–435
171. Klingensmith GJ, Pyle L, Arslanian S, et al.; TODAY Study Group. The presence of GAD and IA-2 antibodies in youth with a type 2 diabetes phenotype: results from the TODAY study. *Diabetes Care* 2010;33:1970–1975
172. Hannon TS, Arslanian SA. The changing face of diabetes in youth: lessons learned from studies of type 2 diabetes. *Ann N Y Acad Sci* 2015;1353:113–137
173. Kapadia C, Zeitler P; Drugs and Therapeutics Committee of the Pediatric Endocrine Society. Hemoglobin A1c measurement for the diagnosis of type 2 diabetes in children. *Int J Pediatr Endocrinol* 2012;2012:31
174. Kester LM, Hey H, Hannon TS. Using hemoglobin A1c for prediabetes and diabetes diagnosis in adolescents: can adult recommendations be upheld for pediatric use? *J Adolesc Health* 2012;50:321–323
175. Wu E-L, Kazzi NG, Lee JM. Cost-effectiveness of screening strategies for identifying pediatric diabetes mellitus and dysglycemia. *JAMA Pediatr* 2013;167:32–39
176. Dabelea D, Rewers A, Stafford JM, et al.; SEARCH for Diabetes in Youth Study Group. Trends in the prevalence of ketoacidosis at diabetes diagnosis: the SEARCH for Diabetes in Youth Study. *Pediatrics* 2014;133:e938–e945
177. Hutchins J, Barajas RA, Hale D, Escaname E, Lynch J. Type 2 diabetes in a 5-year-old and single center experience of type 2 diabetes in youth under 10. *Pediatr Diabetes* 2017;18:674–677
178. Ferrara CT, Geyer SM, Liu Y-F, et al.; Type 1 Diabetes TrialNet Study Group. Excess BMI in childhood: a modifiable risk factor for type 1 diabetes development? *Diabetes Care* 2017;40:698–701
179. Reference removed during proofreading
180. Pinhas-Hamiel O, Dolan LM, Zeitler PS. Diabetic ketoacidosis among obese African-American adolescents with NIDDM. *Diabetes Care* 1997;20:484–486
181. TODAY Study Group. Safety and tolerability of the treatment of youth-onset type 2 diabetes: the TODAY experience. *Diabetes Care* 2013;36:1765–1771
182. TODAY Study Group. Retinopathy in youth with type 2 diabetes participating in the TODAY clinical trial. *Diabetes Care* 2013;36:1772–1774
183. TODAY Study Group. Lipid and inflammatory cardiovascular risk worsens over 3 years in youth with type 2 diabetes: the TODAY clinical trial. *Diabetes Care* 2013;36:1758–1764
184. TODAY Study Group. Rapid rise in hypertension and nephropathy in youth with type 2 diabetes: the TODAY clinical trial. *Diabetes Care* 2013;36:1735–1741
185. Grey M, Schreiner B, Pyle L. Development of a diabetes education program for youth with type 2 diabetes. *Diabetes Educ* 2009;35:108–116
186. American Diabetes Association. *Be Healthy Today; Be Healthy For Life*. Accessed 29 October 2019. Available from <http://main.diabetes.org/dorg/PDFs/Type-2-Diabetes-in-Youth/Type-2-Diabetes-in-Youth.pdf>
187. Atkinson A, Radjenovic D. Meeting quality standards for self-management education in pediatric type 2 diabetes. *Diabetes Spectr* 2007;20:40–46
188. Copeland KC, Silverstein J, Moore KR, et al. Management of newly diagnosed type 2 diabetes mellitus (T2DM) in children and adolescents. *Pediatrics* 2013;131:364–382
189. Zeitler P, Hirst K, Pyle L, et al.; TODAY Study Group. A clinical trial to maintain glycemic control in youth with type 2 diabetes. *N Engl J Med* 2012;366:2247–2256
190. RISE Consortium. Impact of insulin and metformin versus metformin alone on β -cell function in youth with impaired glucose tolerance or recently diagnosed type 2 diabetes. *Diabetes Care* 2018;41:1717–1725
191. Tamborlane WV, Barrientos-Pérez M, Fainberg U, et al.; Ellipse Trial Investigators. Liraglutide in children and adolescents with type 2 diabetes. *N Engl J Med* 2019;381:637–646journal
192. U.S. Food and Drug Administration. FDA approves new treatment for pediatric patients with type 2 diabetes. Accessed 20 September 2019. Available from <http://www.fda.gov/news-events/press-announcements/fda-approves-new-treatment-pediatric-patients-type-2-diabetes>
193. Inge TH, Courcoulas AP, Jenkins TM, et al.; Teen-LABS Consortium. Weight Loss and Health Status 3 Years after Bariatric Surgery in Adolescents. *N Engl J Med* 2016;374:113–123
194. Rubino F, Nathan DM, Eckel RH, et al.; Delegates of the 2nd Diabetes Surgery Summit. Metabolic surgery in the treatment algorithm for type 2 diabetes: a joint statement by international diabetes organizations. *Diabetes Care* 2016;39:861–877
195. Pratt JSA, Lenders CM, Dionne EA, et al. Best practice updates for pediatric/adolescent weight loss surgery. *Obesity (Silver Spring)* 2009;17:901–910
196. Dolan K, Creighton L, Hopkins G, Fielding G. Laparoscopic gastric banding in morbidly obese adolescents. *Obes Surg* 2003;13:101–104
197. Sugerman HJ, Sugerman EL, DeMaria EJ, et al. Bariatric surgery for severely obese adolescents. *J Gastrointest Surg* 2003;7:102–108
198. Inge TH, Garcia V, Daniels S, et al. A multidisciplinary approach to the adolescent bariatric surgical patient. *J Pediatr Surg* 2004;39:442–447; discussion 446–447
199. Lawson ML, Kirk S, Mitchell T, et al.; Pediatric Bariatric Study Group. One-year outcomes of Roux-en-Y gastric bypass for morbidly obese adolescents: a multicenter study from the Pediatric Bariatric Study Group. *J Pediatr Surg* 2006;41:137–143; discussion 137–143
200. Inge TH, Zeller M, Harmon C, et al. Teen-Longitudinal Assessment of Bariatric Surgery: methodological features of the first prospective multicenter study of adolescent bariatric surgery. *J Pediatr Surg* 2007;42:1969–1971
201. Ells LJ, Mead E, Atkinson G, et al. Surgery for the treatment of obesity in children and adolescents. *Cochrane Database Syst Rev* 2015;6:CD011740
202. Michalsky MP, Inge TH, Simmons M, et al.; Teen-LABS Consortium. Cardiovascular risk factors in severely obese adolescents: the Teen Longitudinal Assessment of Bariatric Surgery (Teen-LABS) study. *JAMA Pediatr* 2015;169:438–444
203. Zeinoddini A, Heidari R, Talebpour M. Laparoscopic gastric plication in morbidly obese adolescents: a prospective study. *Surg Obes Relat Dis* 2014;10:1135–1139
204. Göthberg G, Gronowitz E, Flodmark C-E, et al. Laparoscopic Roux-en-Y gastric bypass in adolescents with morbid obesity—surgical aspects and clinical outcome. *Semin Pediatr Surg* 2014;23:11–16
205. Inge TH, Prigeon RL, Elder DA, et al. Insulin sensitivity and β -cell function improve after gastric bypass in severely obese adolescents. *J Pediatr* 2015;167:1042–1048.e1
206. Styne DM, Arslanian SA, Connor EL, et al. Pediatric obesity-assessment, treatment, and prevention: an Endocrine Society clinical practice guideline. *J Clin Endocrinol Metab* 2017;102:709–757
207. Eppens MC, Craig ME, Cusumano J, et al. Prevalence of diabetes complications in adolescents with type 2 compared with type 1 diabetes. *Diabetes Care* 2006;29:1300–1306
208. Song SH, Hardisty CA. Early onset type 2 diabetes mellitus: a harbinger for complications in later years—clinical observation from a secondary care cohort. *QJM* 2009;102:799–806
209. Zeitler P, Fu J, Tandon N, et al.; International Society for Pediatric and Adolescent Diabetes. ISPAD Clinical Practice Consensus Guidelines 2014. Type 2 diabetes in the child and adolescent. *Pediatr Diabetes* 2014;15(Suppl. 20):26–46
210. Song SH. Complication characteristics between young-onset type 2 versus type 1 diabetes in a UK population. *BMJ Open Diabetes Res Care* 2015;3:e000044
211. Cefalu WT. “TODAY” reflects on the changing “faces” of type 2 diabetes. *Diabetes Care* 2013;36:1732–1734
212. Lawrence JM, Standiford DA, Loots B, et al.; SEARCH for Diabetes in Youth Study. Prevalence and correlates of depressed mood among youth with diabetes: the SEARCH for Diabetes in Youth study. *Pediatrics* 2006;117:1348–1358
213. Levitt Katz LE, Swami S, Abraham M, et al. Neuropsychiatric disorders at the presentation of type 2 diabetes mellitus in children. *Pediatr Diabetes* 2005;6:84–89
214. Lewis-Fernández R, Rotheram-Borus MJ, Betts VT, et al. Rethinking funding priorities in mental health research. *Br J Psychiatry* 2016;208:507–509
215. Reinehr T. Type 2 diabetes mellitus in children and adolescents. *World J Diabetes* 2013;4:270–281
216. Pinhas-Hamiel O, Hamiel U, Levy-Shraga Y. Eating disorders in adolescents with type 1

- diabetes: challenges in diagnosis and treatment. *World J Diabetes* 2015;6:517–526
217. Wilfley D, Berkowitz R, Goebel-Fabbri A, et al.; TODAY Study Group. Binge eating, mood, and quality of life in youth with type 2 diabetes: baseline data from the today study. *Diabetes Care* 2011;34:858–860
218. Shelton RC. Depression, antidepressants, and weight gain in children. *Obesity (Silver Spring)* 2016;24: 2450–2450
219. Baeza I, Vigo L, de la Serna E, et al. The effects of antipsychotics on weight gain, weight-related hormones and homocysteine in children and adolescents: a 1-year follow-up study. *Eur Child Adolesc Psychiatry* 2017;26:35–46
220. Klingensmith GJ, Pyle L, Nadeau KJ, et al.; TODAY Study Group. Pregnancy outcomes in youth with type 2 diabetes: the TODAY study experience. *Diabetes Care* 2016;39:122–129
221. Arnett JJ. Emerging adulthood: a theory of development from the late teens through the twenties. *Am Psychol* 2000;55:469–480
222. Weissberg-Benchell J, Wolpert H, Anderson BJ. Transitioning from pediatric to adult care: a new approach to the post-adolescent young person with type 1 diabetes. *Diabetes Care* 2007;30:2441–2446
223. Peters A, Laffel L; American Diabetes Association Transitions Working Group. Diabetes care for emerging adults: recommendations for transition from pediatric to adult diabetes care systems: a position statement of the American Diabetes Association, with representation by the American College of Osteopathic Family Physicians, the American Academy of Pediatrics, the American Association of Clinical Endocrinologists, the American Osteopathic Association, the Centers for Disease Control and Prevention, Children with Diabetes, The Endocrine Society, the International Society for Pediatric and Adolescent Diabetes, Juvenile Diabetes Research Foundation International, the National Diabetes Education Program, and the Pediatric Endocrine Society (formerly Lawson Wilkins Pediatric Endocrine Society). *Diabetes Care* 2011;34:2477–2485
224. Bryden KS, Peveler RC, Stein A, Neil A, Mayou RA, Dunger DB. Clinical and psychological course of diabetes from adolescence to young adulthood: a longitudinal cohort study. *Diabetes Care* 2001;24:1536–1540
225. Laing SP, Jones ME, Swerdlow AJ, Burden AC, Gatling W. Psychosocial and socioeconomic risk factors for premature death in young people with type 1 diabetes. *Diabetes Care* 2005;28: 1618–1623
226. Mays JA, Jackson KL, Derby TA, et al. An evaluation of recurrent diabetic ketoacidosis, fragmentation of care, and mortality across Chicago, Illinois. *Diabetes Care* 2016;39:1671–1676
227. Lotstein DS, Seid M, Klingensmith G, et al.; SEARCH for Diabetes in Youth Study Group. Transition from pediatric to adult care for youth diagnosed with type 1 diabetes in adolescence. *Pediatrics* 2013;131:e1062–e1070
228. Lyons SK, Becker DJ, Helgeson VS. Transfer from pediatric to adult health care: effects on diabetes outcomes. *Pediatr Diabetes* 2014;15: 10–17
229. Garvey KC, Foster NC, Agarwal S, et al. Health care transition preparation and experiences in a U.S. national sample of young adults with type 1 diabetes. *Diabetes Care* 2017;40:317–324
230. The Endocrine Society. Managing the transition of care for patients with type 1 diabetes. Accessed 29 October 2019. Available from <https://www.endocrine.org/guidelines-and-clinical-practice/quality-improvement-resources/clinical-practice-resources/transition-of-care>
231. Reid MW, Krishnan S, Berget C, et al. CoYoT1 Clinic: home telemedicine increases young adult engagement in diabetes care. *Diabetes Technol Ther* 2018;20:370–379
232. Spaic T, Robinson T, Goldbloom E, et al.; JDRF Canadian Clinical Trial CCTN1102 Study Group. Closing the gap: results of the multi-center canadian randomized controlled trial of structured transition in young adults with type 1 diabetes. *Diabetes Care* 2019;42:1018–1026
233. White M, O’Connell MA, Cameron FJ. Clinic attendance and disengagement of young adults with type 1 diabetes after transition of care from paediatric to adult services (TrACeD): a randomised, open-label, controlled trial. *Lancet Child Adolesc Health* 2017;1:274–283
234. Schultz AT, Smaldone A. Components of interventions that improve transitions to adult care for adolescents with type 1 diabetes. *J Adolesc Health* 2017;60:133–146
235. Sequeira PA, Pyatak EA, Weigensberg MJ, et al. Let’s Empower and Prepare (LEAP): evaluation of a structured transition program for young adults with type 1 diabetes. *Diabetes Care* 2015;38:1412–1419