



Ensuring Safe Physical Activity in Children and Adolescents With Type 1 Diabetes

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INTRODUCTION

Physical activity offers multiple benefits to children and adolescents with type 1 diabetes (T1D), including positive effects on blood glucose (BG) control, body composition, cardiorespiratory fitness, blood lipid profiles, and endothelial function.^{1,2} It is recommended that children with diabetes get the same amount of exercise as those without diabetes.³ Unfortunately, for a variety of reasons, most children with T1D don't get enough exercise to meet goals set by national organizations such as the American Diabetes Association (ADA) and the American Academy of Pediatrics (AAP) (see sidebar).²⁻⁴ Physical activity can be difficult or worrisome for individuals with T1D and their caregivers because they must pay special attention to glucose levels, insulin dose, and diet before, during, and after exercise to avoid potentially dangerous glucose excursions.⁵⁻⁷ These issues are even more difficult for children and adolescents to navigate successfully in school and sports settings.⁷

This handout will discuss basic strategies for glucose monitoring, insulin adjustments, and nutritional adjustments to help ensure that your pediatric patients with T1D can safely engage in and reap the benefits of physical activity.

Recommendations for Physical Activity in Children and Young People With T1D

ADA

- Children with T1D should engage in **60 MINUTES OR MORE PER DAY** of moderate- to vigorous-intensity aerobic activity
- They should engage in vigorous muscle- and bone-strengthening activities **AT LEAST 3 DAYS PER WEEK**

AAP

- **UNLIMITED** active playtime for children ages 1-4
- Children older than 4 years of age should get **A MINIMUM OF 60 MINUTES PER DAY** of moderate- to vigorous-intensity physical activity, with vigorous activity on **3 DAYS PER WEEK**

KEY ELEMENTS OF SAFE PHYSICAL ACTIVITY

For children and adolescents with T1D, 4 key components are central to safely participating in physical activity^{3,7}:

Pre-Participation Examination (PPE)



Glucose Monitoring



Insulin Adjustments (to help reduce BG excursions)



Nutritional Adjustments (to maintain optimal BG)



Pre-Participation Examination



To begin low- to moderate-intensity exercise (such as brisk walking), a PPE may not be necessary in children and adolescents with T1D who are asymptomatic, have well-controlled diabetes, and receive care from a multidisciplinary diabetes team.³ Many children with T1D, however, would like to participate in vigorous sports or other more challenging activities.^{3,8} In these circumstances, a PPE is warranted and also often required by the sporting organization or school, regardless of whether the child has diabetes.⁸ Although there is no expert consensus on the elements that should be included in a PPE for children with T1D and comorbid conditions or diabetes-related complications are uncommon in pediatric populations, it is prudent to obtain a thorough review that

includes a metabolic and cardiovascular history and examination in addition to routine sports clearance (bone health, etc.) before beginning vigorous activities. This assessment should^{2,7,8}:

- Review glycemic control, previous history of hypoglycemia, or diabetic ketoacidosis
- Evaluate for diabetes-related cardiovascular risk factors and microvascular complications (eg, hypertension, retinopathy, nephropathy) that may affect participation in some physical activities
- Check for other cardiovascular “red flags” (eg, syncope, heart murmurs, exertional chest pain, hereditary cardiac conditions) that may warrant a more detailed cardiovascular work-up or referral to a cardiologist

GLUCOSE MONITORING



The glycemic response to exercise in T1D can be highly variable and depends on: (1) insulin and glucose concentrations before and during exercise, (2) exercise intensity and duration, and (3) composition of food consumed before exercise.⁶ General responses to different types of exercise are summarized in [Table 1](#).⁶

TABLE 1. Glycemic Response to Various Exercise Types

EXERCISE TYPE	GLYCEMIC RESPONSE
Aerobic exercise	<ul style="list-style-type: none"> • Usually results in a decrease in glucose levels because circulating exogenous free basal or rapid-acting insulin does not decrease at a comparable rate to glucose uptake during exercise • Most individuals will develop hypoglycemia within 45 minutes of starting aerobic activity if they do not increase carbohydrate intake or decrease insulin in advance of the aerobic activity • Intense activity can also increase the risk of hypoglycemia 6 to 12 hours after exercise (ie, the “lag effect”)
Resistance training	<ul style="list-style-type: none"> • Glucose stability or possibly an increase in glucose levels
Brief, intense anaerobic exercise (eg, powerlifting, sprinting)	<ul style="list-style-type: none"> • Glucose levels frequently rise • Hyperglycemia may occur, especially if glucose levels are elevated before engaging in the activity
High-intensity interval training	<ul style="list-style-type: none"> • Glucose levels frequently rise • Hyperglycemia may occur, especially if glucose levels are elevated before engaging in the activity

Adapted from Riddell MC, Gallen IW, Smart CE, et al. Exercise management in type 1 diabetes: a consensus statement. *Lancet Diabetes Endocrinol.* 2017;5(5):377-390; 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(9):2026-2044.

Spontaneous play and most sports are characterized by repeated bouts of intensive activity interspersed with moderate-to-intense activity.⁵ Under these circumstances, glucose levels are likely to fall less profoundly than during continuous moderate activity.⁵

IMPORTANT

Aerobic, resistance, and high-intensity exercise that last 40 minutes or longer can increase the risk of hypoglycemia 6 to 12 hours after exercise (ie, the “lag effect”).^{2,3} Be sure to remind children and adolescents with T1D and their caregivers that after-school sports activities or other afternoon exercise performed between the hours of 4 pm and 6 pm, or even later into the evening, may increase the risk of nocturnal hypoglycemia.^{1,3,7}

Overnight glucose monitoring is especially critical in such situations, and many individuals find it helpful to use continuous glucose monitoring (CGM) technology and the associated alarms rather than rely solely on episodic BG monitoring.²

Glucose target levels should always be tailored to the individual.⁶ However, general recommendations for glucose levels and monitoring of glucose levels in T1D before, during, and after exercise are as follows^{2,3,5-7,9,10}:

BEFORE



- Always check glucose level about 15 minutes before starting exercise; should be at least 90 mg/dL (5 mmol/L), but less than 250 mg/dL (13.9 mmol/L)
- For aerobic exercise, the ADA recommends a starting BG level of > 126 mg/dL (7 mmol/L)
- If < 90 mg/dL (5 mmol/L), consume sufficient carbohydrate to achieve euglycemia before exercising
- If > 250 mg/dL (13.9 mmol/L), check ketone levels and do not exercise until glucose level returns to target range and ketones are not elevated (urine ketones negative, trace, or small or blood ketones [B-OHB] < 0.6 mmol/L)

DURING



- The glycemic target during exercise is approximately 120 to 180 mg/dL (6.7 to 10 mmol/L), although individualized goals are best
- Glucose should be monitored approximately every 30 minutes during periods of continuous physical activity; because BG monitoring can be inconvenient, CGM can be a valuable tool in children and adolescents

AFTER



- Post-exercise glucose monitoring can be less frequent than during-exercise monitoring; conduct shortly after completion of exercise, then every 1 to 3 hours and before bedtime and/or overnight
- More frequent monitoring over the next 24 hours may be warranted because of the risk of post-exercise hypoglycemia, especially after strenuous exercise

Insulin Adjustments

Reductions in basal and prandial insulin before exercise are often needed to reduce the risk of hypoglycemia during and after exercise and must be individualized.^{3,6} In those using multiple daily insulin injections (MDIIs), a 20% reduction in basal insulin may be attempted on days with prolonged activity.⁶ In those on continuous subcutaneous insulin infusion (CSII), basal insulin reductions of 50% to 80% up to 90 minutes before the start of exercise and for the duration of the activity (or even pump suspension at the start of exercise, for no longer than 60 minutes) are also an option. In those using mealtime bolus insulin either by MDII or CSII, a 25% to 75% reduction in insulin at the meal or snack consumed within 2 hours of the exercise (both before and after) may attenuate hypoglycemia; start with a 50% reduction and assess response.⁶

IMPORTANT

Children and adolescents, and their caregivers, should be aware that reductions in insulin dosages may result in hyperglycemia at other times during the day.⁶ It is critically important that, whenever insulin adjustments are made, glucose be monitored frequently.⁷

Insulin therapy with CSII is associated with lower rates of severe hypoglycemia and is one option for children who experience difficulty managing activity-associated glucose excursions, assuming the child and family members have a desire to use pump therapy.¹ Studies have shown that, in children using an insulin pump, suspending the basal insulin rate during exercise followed by a basal rate reduction of 20% between 9 pm and 3 am can reduce the risk of nocturnal hypoglycemia.¹¹ The use of CSII can also help limit post-exercise hyperglycemia compared with MDII.¹⁰

Activity multiplier charts, such as the one in [Table 2](#), are tools that can help children and their parents calculate insulin dose reductions, depending on activity type and duration. A more detailed chart is available online at the Seattle Children's Hospital Endocrinology and Diabetes program website (www.seattlechildrens.org/clinics-programs/endocrinology/resources/).

TABLE 2. Activity Multiplier Chart for Bolus Insulin Reduction Before Exercise
(for Exercise Started Within 90-120 Minutes of Meal Consumption)

ACTIVITY INTENSITY	EXERCISE DURATION	
	30 MINUTES	60 MINUTES
Mild aerobic exercise	0.75 (25% dose reduction)	0.50 (50% dose reduction)
Moderate aerobic exercise	0.50 (50% dose reduction)	0.25 (75% dose reduction)
Heavy aerobic exercise	0.25 (75% dose reduction)	N/A (this intensity not expected for 60 minutes)
Intense aerobic or anaerobic exercise	No reduction recommended	N/A (this intensity not expected for 60 minutes)

Adapted from Riddell MC, Gallen IW, Smart CE, et al. Exercise management in type 1 diabetes: a consensus statement. *Lancet Diabetes Endocrinol.* 2017;5(5):377-390; Seattle Children's Hospital. Exercise and activity guidelines for children and teens with diabetes. Last updated April 2015. Seattle Children's Hospital, Seattle, WA, 2015.

Nutritional Adjustments



Food choices before, during, and after exercise are important to maximize physical performance and maintain glycemic control. As a general rule, people with T1D should have a well-balanced meal containing carbohydrate, protein, and fat 3 to 4 hours before engaging in sports or physical activity.⁵

Carbohydrate replacement is critically important in people with T1D who are engaging in physical activity.⁷ In children with T1D, the amount of carbohydrate needed depends on the activity performed, body mass of the child, and glucose level.⁷ Consider these helpful suggestions:

- Within about 1 to 2 hours before starting planned activity with longer duration (about 1 hour), children with T1D should have a snack containing approximately 1 g of carbohydrate/kg of body weight without insulin coverage if a recently given insulin dose has not been reduced^{5,6}
- As mentioned above, pre-exercise glucose should be checked before the start of exercise to determine whether the glucose is in the appropriate range; if < 90 mg/dL (5 mmol/L), a pre-exercise carbohydrate snack should be eaten without insulin coverage, and intense physical exercise should be avoided until glucose levels rise⁷
- During exercise, the goal is to maintain a glucose level between 120 and 180 mg/dL (6.7 mmol/L and 10 mmol/L)¹⁰; the amount of carbohydrate intake without insulin coverage should equal the amount of carbohydrate being used; this can range from 1.0 g to 1.5 g of carbohydrate/kg body weight for every hour of aerobic exercise, depending on the intensity of the activity and the timing of peak insulin activity^{5,6}
- Eating a bedtime snack that includes about 15 g of carbohydrate without insulin coverage can be an additional strategy that may help prevent overnight hypoglycemia^{2,5}
- If children engage in unplanned exercise/activity, a carbohydrate snack/meal should be consumed to prevent hypoglycemia during peak insulin activity (usually within 3 hours of an injection/bolus); the amount needed depends on the glucose levels pre-activity and when insulin was last administered⁹

Various charts, such as the one published by Seattle Children's (www.seattlechildrens.org/pdf/PE1973.pdf), are available for general guidance on carbohydrate replacement based on specific activities, exercise duration, and body mass.^{5,6,10} Consuming carbohydrate during activity also depends on the amount of insulin on board and time to peak activity.⁹

Insulin sensitivity may be increased for 24 to 48 hours after exercise, and carbohydrate stores must be replenished to lower the risk of late-onset hypoglycemia.⁶ As mentioned above, glucose monitoring after exercise can help to guide carbohydrate amounts needed and detect hypoglycemic trends. At bedtime, if glucose is < 120 mg/dL, a small snack/meal containing both protein and 15 g of carbohydrate should be consumed without insulin coverage; some sources recommend that (in the absence of CGM use with preset alerts) glucose should be checked again between 12 am and 2 am to assess for nocturnal hypoglycemia.^{2,3,7,9}

ADDITIONAL RESOURCES



We hope you found this to be a helpful summary of information to provide to your young patients with T1D. For additional information on this topic, please visit the JDRF PEAK website: www.jdrf.org/t1d-resources/peak/.

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Developed in Collaboration



Funded in part by The Leona M. and Harry B. Helmsley Charitable Trust and Whitlock and supported by an educational grant from Novo Nordisk, Inc.

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