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National Athletic Trainers' Association Position Statement: Management of the Athlete With Type 1 Diabetes Mellitus

Carolyn C. Jimenez
West Chester University of Pennsylvania, cjimenez@wcupa.edu

Matthew H. Corcoran
Lehigh Valley Hospital, Allentown, PA

James T. Crawley
Dominican College, Orangeburg, NY

W. Guyton Hornsby, Jr.
West Virginia University

Kimberly S. Peer
Kent State University - Kent Campus

See next page for additional authors

Authors
Carolyn C. Jimenez; Matthew H. Corcoran; James T. Crawley; W. Guyton Hornsby, Jr.; Kimberly S. Peer; Rick D. Philbin; and Michael C. Riddell

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National Athletic Trainers' Association Position Statement: Management of the Athlete With Type 1 Diabetes Mellitus

Carolyn C. Jimenez, PhD, ATC*; Matthew H. Corcoran, MD, CDE†; James T. Crawley, MEd, PT, ATC‡; W. Guyton Hornsby, Jr, PhD, CDE‖; Kimberly S. Peer, EdD, LATC¶; Rick D. Philbin, MBA, MEd, ATC#; Michael C. Riddell, PhD**

*West Chester University, West Chester, PA; †Lehigh Valley Hospital, Allentown, PA; ‡Dominican College, Orangeburg, NY; ‖West Virginia University, Morgantown, WV; ¶Kent State University, Kent, OH; #Animas Corp, West Chester, PA; **York University, Toronto, ON

Objective: To present recommendations for the certified athletic trainer in the management of type 1 diabetes in the athlete.

Background: In managing diabetes, the most important goal is to keep blood glucose levels at or as close to normal levels as possible without causing hypoglycemia. This goal requires the maintenance of a delicate balance among hypoglycemia, euglycemia, and hyperglycemia, which is often more challenging in the athlete due to the demands of physical activity and competition. However, effectively managing blood glucose, lipid, and blood pressure levels is necessary to ensuring the long-term health and well-being of the athlete with diabetes.

Recommendations: These recommendations are intended to provide the certified athletic trainer participating in the management of an athlete with type 1 diabetes mellitus with the specific knowledge and problem-solving skills needed. Athletic trainers have more contact with the athlete with diabetes than most members of the diabetes management team do and so must be prepared to assist the athlete as required.

Key Words: hypoglycemia, hyperglycemia, insulin replacement therapy

Effective management of glycemic, lipid, and blood pressure control plays an important role in the health outcomes of persons with diabetes mellitus. The primary goal of diabetes management is to consistently maintain blood glucose levels in a normal or near-normal range without provoking undue hypoglycemia.[1–5] Although several exercise guidelines for persons with diabetes have been published (American Diabetes Association's ''Physical Activity/Exercise and Type 2 Diabetes,''[6] American College of Sports Medicine's ''Exercise and Type 2 Diabetes,''[7] and the joint statement of the American College of Sports Medicine and the American Diabetes Association, ''Diabetes Mellitus and Exercise''[8]), none address issues of concern for athletic trainers (eg, blood glucose management strategies during injury or the effect of therapeutic modalities on blood glucose control). The following position statement and recommendations provide relevant information on type 1 diabetes mellitus and specific recommendations for athletic trainers who work with patients with diabetes.

RECOMMENDATIONS

Based on current research and literature, the National Athletic Trainers' Association (NATA) suggests the following guidelines for management of athletes with type 1 diabetes mellitus. These recommendations have been organized into the following categories: diabetes care plan; supplies for athletic training kits; preparticipation physical examination (PPE); recognition, treatment, and prevention of hypoglycemia; recognition, treatment, and prevention of hyperglycemia; insulin administration; travel recommendations; and athletic injury and glycemic control.

Diabetes Care Plan

1. Each athlete with diabetes should have a diabetes care plan for practices and games. The plan should include the following:
   a. Blood glucose monitoring guidelines. Address frequency of monitoring and pre-exercise exclusion values.
   b. Insulin therapy guidelines. Should include the type of insulin used, dosages and adjustment strategies for planned activities types, as well as insulin correction dosages for high blood glucose levels.
   c. List of other medications. Include those used to assist with glycemic control and/or to treat other diabetes-related conditions.
   d. Guidelines for hypoglycemia recognition and treatment. Include prevention, signs, symptoms, and treatment of hypoglycemia, including instructions on the use of glucagon.
   e. Guidelines for hyperglycemia recognition and treatment. Include prevention, signs, symptoms, and treatment of hyperglycemia and ketosis.

f. Emergency contact information. Include parents' and/or other family member's telephone numbers, physician's telephone number, and consent for medical treatment (for minors).
g. Athletes with diabetes should have a medic alert tag with them at all times.

Supplies for Athletic Training Kits

2. Supplies to treat diabetes-related emergencies should be available at all practices and games. The athlete (or athlete's parents/guardians, in the case of minors) provides the following items:
   a. A copy of the diabetes care plan.
   b. Blood glucose monitoring equipment and supplies. The athletic trainer should check the expiration dates of supplies, such as blood glucose testing strips and insulin, on a regular basis. Blood glucose testing strips have a code number located on the outside of the test strip vial. The code number on the blood glucose meter and test strip vial must match.
   c. Supplies to treat hypoglycemia, including sugary foods (eg, glucose tablets, sugar packets) or sugary fluids (eg, orange juice, non-diet soda) and a glucagon injection kit.
   d. Supplies for urine or blood ketone testing.
   e. A ''sharps'' container to ensure proper disposal of syringes and lancets.
   f. Spare batteries (for blood glucose meter and/or insulin pump) and, if applicable, spare infusion sets and reservoirs for insulin pumps.

Preparticipation Physical Examination

3. Athletes with type 1 diabetes should have a glycosylated hemoglobin (HbA1c) assay every 3 to 4 months to assess overall long-term glycemic control. However, the HbA1c value is not used to make day-to-day decisions concerning participation.
4. An annual examination for retinopathy, nephropathy, and neuropathy is recommended along with an annual foot examination to check sensory function and ankle reflexes. Screening for cardiovascular disease should occur at intervals recommended by the athlete's endocrinologist or cardiologist. Exercise limitations or restrictions for athletes with diabetes-related complications should be determined by the athlete's physician.[9–11]

Recognition, Treatment, and Prevention of Hypoglycemia

5. Strategies to recognize, treat, and prevent hypoglycemia typically include blood glucose monitoring, carbohydrate supplementation, and/or insulin adjustments. Athletes with diabetes should discuss with their physicians specific carbohydrate qualities and quantities as well as the use of an insulin reduction plan for activity (Appendix 1).
6. Athletic trainers should know the signs, symptoms, and treatment guidelines for mild and severe hypoglycemia. Hypoglycemia is defined as mild if the athlete is conscious and able to swallow and follow directions or severe if the athlete is unable to swallow, follow directions, or eat as directed or is unconscious. Treatment of severe hypoglycemia requires a glucagon injection, and athletic trainers should be trained in mixing and administering glucagon. The athlete, athlete's family, or physician can provide appropriate training (Appendix 2).

Recognition, Treatment, and Prevention of Hyperglycemia

7. Athletes with type 1 diabetes and athletic trainers are advised to follow the American Diabetes Association (ADA) guidelines for avoiding exercise during periods of hyperglycemia (Appendix 3).
8. Athletes with type 1 diabetes who experience hyperglycemia during short-term, intense, and stressful periods of exercise should consult with their physicians concerning an increased basal rate or the use of small insulin boluses to counteract this phenomenon.[30]
9. Athletes should drink noncarbohydrate fluids when blood glucose levels exceed the renal glucose threshold (180 mg/dL, or 10 mmol/L), which may lead to increased urination, fluid loss, and dehydration.

Insulin Administration

10. Insulin should be administered into the subcutaneous tissue. The abdomen, upper thigh, and upper arms are common sites for injection. Intramuscular injections of insulin should always be avoided as muscle contractions may accelerate insulin absorption.[12]
11. Depending on the type of insulin used by the athlete, heat and cold should be avoided for 1 to 3 hours after an injection of rapid-acting insulin (eg, lispro, aspart, or glulisine) and up to 4 hours for fast-acting (eg, regular) insulin.[31,32] Heat may increase insulin absorption rates. Thus, athletes with type 1 diabetes should avoid warm whirlpools, saunas, showers, hot tubs, and baths after injection. Local heat-producing modalities such as moist hot packs, diathermy, and thermal ultrasound should not be applied directly over an infusion or injection site. By contrast, cold may decrease insulin absorption rates. Therefore, athletes with type 1 diabetes should avoid using ice and cold sprays directly over the injection or infusion site after insulin administration. Similarly, cold whirlpools should be avoided after insulin injection.
12. Insulin pump users should replace insulin infusion sets every 2 to 3 days to reduce skin and infusion site irritation.
13. Extreme ambient temperature (<36°F or >86°F [<2.2°C or >30°C]) can reduce insulin action. Athletes with type 1 diabetes are advised to check blood glucose levels frequently and replace the entire insulin-filled cartridge and infusion set if any signs of unusual hyperglycemia occur in extreme environmental conditions.

Travel Recommendations

14. Athletic trainers should review the advice provided by the Transportation Security Administration (TSA) in conjunction with the ADA for airline passengers with diabetes traveling within the United States.[33] In addition, athletes are advised to carry diabetes supplies with them and have prescriptions available in the event that medication or supplies need to be replaced. Due to extreme temperature

fluctuations that could affect insulin action, insulin should not be stored in the cargo hold of the airplane.

15. When traveling, athletes with type 1 diabetes are advised to carry prepackaged meals and snacks in case food availability is interrupted. If travel occurs over several time zones, insulin therapy may need to be adjusted to coordinate with changes in eating and activity patterns.

Athletic Injury and Glycemic Control

16. Trauma, even in persons without diabetes, often causes a hyperglycemic state. Hyperglycemia is known to impair the wound healing process; thus, for athletes with type 1 diabetes, an individualized blood glucose management protocol should be developed for use during injury recovery, including frequency of blood glucose monitoring.

BACKGROUND

Diabetes mellitus is a chronic endocrine disorder characterized by hyperglycemia. Persons with diabetes are at risk for macrovascular, microvascular, and neuropathic complications. For those without diabetes, normal fasting blood glucose levels are 60 to 100 mg/dL (3.3 to 5.5 mmol/L); normal postprandial levels are less than 140 mg/dL (7.8 mmol/L) 2 hours after a meal. Chronic hyperglycemia leads to long-term damage, dysfunction, and failure of various organs, especially the eyes, kidneys, nerves, and heart.[34] The literature supports the importance of a consistent, near-normal blood glucose level, as well as blood pressure and lipid control, for preventing diabetes-related complications and improving quality of life.[2–5]

Currently, approximately 20.8 million persons are living with diabetes in the United States.[35] It is estimated that approximately 90% have type 2 diabetes and approximately 10% have type 1 diabetes.[35] Type 2 diabetes typically occurs in adults 40 years of age and older; however, the incidence of type 2 diabetes in children is increasing, especially among American Indian, African American, and Hispanic/Latino populations. Type 1 diabetes typically occurs in children and young adults.[35,36]

Type 1 diabetes is the rarer form of the disease, but athletic trainers working in middle schools, secondary schools, colleges, and many professional settings are more likely to encounter athletes with type 1 than type 2 diabetes. This position statement focuses on recommendations for the athlete with type 1 diabetes, although athletic trainers can also play a crucial role in the diabetes-management plan of a person with type 2 diabetes.

Type 1 diabetes is characterized by absolute insulin deficiency. It is considered an autoimmune disorder resulting from a combination of genetic and unknown environmental factors. The signs and symptoms of type 1 diabetes develop rapidly and are related to hyperglycemia. Symptoms include frequent urination, thirst, hunger and polyphagia, weight loss, visual disturbances, fatigue, and ketosis.[37] Usually, athletes are able to resume exercise and sports within weeks of starting insulin treatment as long as a treatment plan is developed and a support team exists. The treatment plan for persons with type 1 diabetes focuses on a self-care plan predicated on exogenous insulin, monitoring of blood glucose, healthy nutrition, and exercise.

DIABETES MANAGEMENT TEAM AND THE DIABETES CARE PLAN

Proper management of blood glucose levels during practices and games allows the athlete with diabetes to compete in a safe and effective manner. Maintaining a near-normal blood glucose level (100 to 180 mg/dL, or 5.5 mmol/L to 10 mmol/L) reduces the risk of dehydration, lethargy, hypoglycemia, and autonomic counterregulatory failure. This goal is best achieved through a team approach. The team-management approach to providing support for patients with diabetes is well established in the allied health literature.[38–46] In school-aged athletes, the team should include the school nurse, coach, and school administrators. In adult athletes, diabetes is best managed by a team that includes several health professionals.[39,41–43,47,48] Creating this team requires a deliberate, well-designed plan, which defines the role of each individual in the supervision and care of the athlete with diabetes. All members of the team should be trained and willing to assist an athlete who is experiencing a diabetes-related emergency.

Critical roles for the athletic trainer include prevention, recognition, and immediate care of hypoglycemia and hyperglycemia (with and without ketoacidosis); exercise nutrition; hydration counseling; and helping the athlete to recognize the intensity of the exercise session in order to adjust glucose and insulin levels accordingly.[41,49–51] The athletic trainer also facilitates communication among the other members of the diabetes management team.

Athletes with type 1 diabetes should have a diabetes care plan for practices and games.[40] The plan should identify blood glucose targets for practices and games, including exclusion thresholds; strategies to prevent exercise-associated hypoglycemia, hyperglycemia, and ketosis; a list of medications used for glycemic control or other diabetes-related conditions; signs, symptoms, and treatment protocols for hypoglycemia, hyperglycemia, and ketosis; and emergency contact information. The athlete must have access to supplies for managing glycemic emergencies at all times. When the athlete requires assistance, the athletic trainer and/or other members of the diabetes management team (eg, coach) must have immediate access to these supplies. The athlete or parent/guardian should provide the necessary supplies and equipment.

PREPARTICIPATION PHYSICAL EXAMINATION FOR ATHLETES WITH TYPE 1 DIABETES

A thorough PPE should begin with the team or primary care physician. This examination should include a sports history, assessment of the level of diabetes self-care skills and knowledge, general physical examination emphasizing screening of diabetes-related complications, and discussion of how sports participation will affect blood glucose and blood pressure control. As part of the PPE, the athlete's endocrinologist or primary care physician should provide an assessment of the current level of glycemic control, information concerning the presence and status of diabetes-related complications, and blood glucose management strategies. Completion of the PPE may require consultation with other specialists (eg, cardiologist, ophthalmologist), especially in the case of diabetes-related complications.[52] Athletic trainers are referred to the *Handbook of Exercise in Diabetes*,[53] published by the American Diabetes Association, for further readings on prescreening of the active individual with type 1 diabetes.

Preparticipation Physical Examination and Glycemic Control

The athlete's level of long-term glycemic control should be listed on the PPE. Long-term glycemic control is assessed by an HbA1c test every 3 to 4 months.[54] Normal HbA1c levels, depending on the laboratory assay, are generally between 4.0% and 6.0%. The ADA recommends a target HbA1c level of 7% or less for adults on intensive insulin therapy and 7.5% or less for teens and adolescents.[55] An HbA1c level of 7% correlates with an average blood glucose level of approximately 150 mg/dL (8.3 mmol/L). Other organizations, such as the American Association of Clinical Endocrinologists, set more stringent recommendations, such as 6.5% (approximately 135 mg/dL [7.5 mmol/L]) or less in adults.[56] In general, a lower HbA1c level correlates with a lower risk of diabetes-related complications at the expense of an increased risk of hypoglycemia.[2] The athletic trainer should understand that although the HbA1c level provides a long-term perspective of glycemic control, it is not used to make day-to-day participation decisions.

Preparticipation Physical Examination and Screening for Diabetes-Related Complications

Athletic trainers should be aware that an athlete with type 1 diabetes may be chronologically young but may have had the disease for many years and, as such, may experience diabetes-related complications. Common diabetes-related complications are retinopathy, nephropathy, neuropathy, and cardiovascular disease.

The ADA recommends an initial dilated and comprehensive ophthalmologic examination 3 to 5 years after the diagnosis of type 1 diabetes and an annual screening thereafter for retinopathy, glaucoma, and cataracts.[11,57] Decisions regarding activity limitations for the athlete are based on the presence and degree of retinopathy and are made by the athlete's physician.

Diabetic nephropathy is characterized by increased urinary protein excretion. An initial examination is recommended 5 years after the diagnosis of type 1 diabetes and annually thereafter.[9,58] The athlete's physician may limit exercise based upon the presence and degree of nephropathy.

Peripheral neuropathy is characterized by bilateral sensory involvement with dull perception of vibration, pain, and temperature, particularly in the lower extremities. This is of particular concern for the athlete performing weight-bearing activities. Athletic trainers should instruct the athlete with diabetes to inspect the feet on a daily basis for any reddened areas, blisters, abrasions, or lacerations. Cutting toenails straight across, not walking barefoot, and avoiding poor-fitting or tight shoes are all recommendations the athletic trainer should provide.[53] Initial screening for peripheral neuropathy is recommended 5 years after diagnosis.[10] Thereafter, an annual examination for peripheral neuropathy (ie, examining sensory function of the feet and checking the ankle reflexes) is recommended.[10] The athlete's physician may limit certain physical activities in the presence of peripheral neuropathy.

Autonomic neuropathy may affect the cardiovascular, gastrointestinal, and neuroendocrine systems. This may predispose the athlete with diabetes to exercise intolerance, orthostatic hypotension, and hypoglycemic unawareness (a failure to effectively recognize the signs and symptoms of low blood sugar). The ADA recommends an initial screening for autonomic neuropathy 5 years after the diagnosis of type 1 diabetes and annually thereafter.[10] Suspected autonomic neuropathy should be evaluated by the athlete's endocrinologist and/or cardiologist for exercise recommendations.[59]

Cardiovascular complications include myocardial infarction, stroke, and peripheral arterial disease. The ADA recommends that persons who have had type 1 diabetes for more than 15 years or have any other risk factor for coronary artery disease, microvascular disease, peripheral vascular disease, or autonomic neuropathy undergo a graded exercise stress test to evaluate cardiovascular function.[59] For those athletes with, or suspected of having, cardiovascular disease, referral to an endocrinologist and/or cardiologist for further assessment and treatment is warranted.

INSULIN REPLACEMENT THERAPY

The objective of insulin replacement therapy is the near-normalization of blood glucose levels while minimizing the risks of hypoglycemia and weight gain. The standard of care is ''intensive insulin therapy.''[2] Intensive insulin therapy uses basal and bolus insulin doses to regulate blood glucose levels during fasting, feeding, and hyperglycemic periods. Basal insulin is used to maintain glycemic stability during fasting periods and delivers a steady, low dose of insulin 24 hours a day. Bolus insulin is used to control elevations in blood glucose levels that occur after eating or to lower blood glucose levels during hyperglycemia. Bolus insulin doses are determined by several factors, including the prevailing blood glucose level, carbohydrate content of the meal, and anticipated exercise.

Insulin pumps and multiple daily injections (MDI) are the primary methods used to deliver basal and bolus therapy. Insulin pump therapy uses novel technology to deliver rapid-acting or fast-acting insulin to provide both basal and bolus doses (see Appendix 4 for examples of fast-acting and rapid-acting insulins). However, rapid-acting insulins are considered the standard of care in insulin pump therapy because of their physiologic profile. In insulin pump therapy, basal insulin is continuously administered via preset basal infusion rates (ie, 1.2 units of insulin per hour) over a 24-hour period. At meals or to correct hyperglycemia, the athlete uses a bolus-dosing menu on the insulin pump to dispense insulin dosages (ie, 5 units of insulin).

The MDI plans require patients with diabetes to inject both basal and bolus insulins. Typically, basal insulin is injected 1 or 2 times a day. Unlike insulin pump basal infusion rates, basal therapy with MDI consists of injecting a fixed amount of long-acting insulin, such as 6.5 units. Optimal basal insulin use with MDI has a long biological activity (18 to 24 hours) and a relatively peakless profile. Patients with diabetes may use 2 to 4 injections of rapid-acting or fast-acting insulin to provide bolus coverage at mealtimes or to correct hyperglycemia. Bolus dosing with MDI is similar to that with insulin pump therapy in that a fixed amount of insulin (ie, 5 units of insulin) is administered based upon the current blood glucose level, carbohydrate content of the meal, and any anticipated exercise.

The choice to use an insulin pump or MDI is made by the athlete in consultation with the physician. Each method of delivery has distinct advantages and disadvantages. Advantages of insulin pump therapy include the use of a single rapid-acting insulin to achieve a more physiologic insulin profile; the ability to alter the basal rate before or during exercise; the ability to suspend or disconnect the pump; ''smart pumps'' that use internal calculators to determine an estimated amount of insulin in circulation, which may help to prevent excessive

insulin dosing; allowance for flexible meal schedules; and avoiding the regular use of needles for insulin administration. Disadvantages of insulin pump therapy include possible damage during contact sports; risk of hyperglycemia and ketosis if the insulin pump malfunctions or is inadvertently disconnected from the athlete; infusion set displacement, as heavy sweating or water contact may reduce the ability of adhesives to hold the infusion set in place; movement or contact leading to irritation at the infusion site, especially in those using metal needle infusion sets; and extreme ambient temperatures (<36°F [2.22°C] or >86°F [30°C]), which can affect insulin housed within the pump and interfere with insulin action.[65]

The advantages of MDI include a lower cost of operation compared with insulin pumps and the absence of a connection to a device. Disadvantages include the inability to manipulate basal insulin levels during exercise, the need for regular injections, and the lack of flexibility regarding meal timing and unplanned exercise.

Insulin absorption is the rate-limiting step in insulin activity for both the insulin pump and MDI, and many factors may affect the absorption rate.[66] Athletes should use consistent sites for injections to eliminate absorption differences among body regions (ie, abdomen versus triceps). Appendix 5 lists some of the variables that can affect absorption rates.

The athlete and diabetes management team should be aware of insulin-specific pharmacokinetic and pharmacodynamic properties. For example, rapid-acting insulin analogs (lispro, aspart, glulisine) all reach peak circulating levels within 90 minutes of administration. This peak represents the maximal glucose-lowering effect and greatest risk for hypoglycemia. See Appendix 4 for pharmacokinetic properties of commonly used basal and bolus insulins.

HYPOGLYCEMIA

Hypoglycemia is the most severe acute complication of intensive insulin therapy in diabetes, and exercise is its most frequent cause.[1,68] Intensive insulin therapy is associated with a 2-fold to 3-fold increase in severe hypoglycemia (ie, the person with diabetes requires assistance).[2] The risk of severe hypoglycemia is higher in males, adolescents, and those who have already had a severe episode.[2] Although responses are individualized, signs and symptoms of hypoglycemia typically occur when blood glucose levels fall below 70 mg/dL (3.9 mmol/L).

Under most circumstances, hypoglycemia is the result of overinsulinization, both during and after exercise. Several factors contribute to overinsulinization. First, the rate at which subcutaneously injected insulin is absorbed increases with exercise due to increases in body temperature and in subcutaneous and skeletal muscle blood flow.[69] Second, exogenously administered insulin levels do not decrease during exercise in persons with type 1 diabetes. This is in contrast to exercise in persons without diabetes, in whom insulin levels decrease during exercise to prevent hypoglycemia. The inability to decrease plasma insulin levels during exercise in type 1 diabetes causes relative hyperinsulinemia, which impairs hepatic glucose production and initiates hypoglycemia, usually within 20 to 60 minutes after the onset of exercise.[13,14,70] Third, hypoglycemia during exercise can result from impaired release of glucose-counterregulatory hormones (ie, glucagon and catecholamines) caused by either a previous bout of exercise or hypoglycemic episode.[68] As a result, athletes with type 1 diabetes who experience hypoglycemia on the days preceding competition may be at risk for exercise-associated hypoglycemia.[68] Finally, exercise improves insulin sensitivity in skeletal muscle. Exercise-associated improvements in insulin sensitivity may last for several hours to days after exercise. Thus, some athletes experience a phenomenon known as postexercise late-onset hypoglycemia, which may occur while the athlete is sleeping. Athletes who experience nighttime hypoglycemia require additional blood glucose monitoring in addition to a snack.[15,71]

Managing blood glucose levels during practices and games and preventing hypoglycemia are challenges. Typically, hypoglycemia prevention uses a 3-pronged approach of blood glucose monitoring, carbohydrate supplementation, and insulin adjustments. Appendix 1 lists strategies to prevent hypoglycemia during and after practices and games. The athlete and the diabetes management team should work together to determine which strategies to employ.

Hypoglycemia normally produces noticeable autonomic or neurogenic symptoms. Autonomic symptoms include tachycardia, sweating, palpitations, hunger, nervousness, headache, trembling, and dizziness. These symptoms typically occur at blood glucose levels <70 mg/dL (<3.9 mmol/L) in persons with diabetes and are related to the release of epinephrine and acetylcholine.[26,27] As glucose continues to fall, symptoms of brain neuronal glucose deprivation (neurogenic symptoms) occur and may cause blurred vision, fatigue, difficulty thinking, loss of motor control, aggressive behavior, seizures, convulsions, and loss of consciousness; if hypoglycemia is prolonged and severe, brain damage and even death can result. Symptoms of hypoglycemia can be unique to a person with diabetes.[72] Thus, the athletic training staff should be familiar with athlete-specific symptoms of hypoglycemia and be prepared to act appropriately. Hypoglycemia can cause some athletes to be especially aggressive and unwilling to cooperate with instructions. Treatment guidelines for mild and severe cases of hypoglycemia are presented in Appendix 2.

ACUTE HYPERGLYCEMIA AND KETOSIS

Hyperglycemia with or without ketosis can occur during exercise in athletes with type 1 diabetes. Hyperglycemia during exercise is related to several factors. First, exercise (especially high-intensity exercise at 70% V_{O_2} max or >85% of maximal heart rate) can cause additional increases in blood glucose concentrations and possible ketoacidosis in athletes with poor glycemic control and those who are underinsulinized. Without adequate insulin levels, blood glucose levels continue to rise due to exaggerated hepatic glucose production and impairments in exercise-induced glucose utilization.[73] Second, even in well-controlled athletes with type 1 diabetes, high-intensity exercise may result in hyperglycemia. High-intensity exercise may lead to significant increases in catecholamines, free fatty acids, and ketone bodies, all of which impair muscle glucose utilization and increase blood glucose levels.[74] This exercise-associated rise in glucose levels is usually transient in the well-controlled diabetic athlete, declining as counterregulatory hormone levels decrease, typically within 30 to 60 minutes.[15] Third, the psychological stress of competition is frequently associated with increases in blood glucose levels before competition. Although data do not exist for those with type 1 diabetes, it is likely that excessive increases in counterregulatory hormones occur before exercise, when anticipatory stress is high.[75] Athletes may find that blood glucose

management strategies that work on practice days actually result in hyperglycemia on game days due to psychological stress. Frequent blood glucose monitoring and either small boluses of rapid-acting insulin or a temporary increase in basal rate insulin may be required to recover from these hyperglycemic episodes. Finally, limited data exist regarding competition and training in hot and humid environments by athletes with type 1 diabetes. Athletes may find that training or competing in these environments elevates blood glucose levels, likely because of exaggerated increases in glucose counterregulatory hormones.[76]

Effects vary from one athlete to another, but hyperglycemic signs and symptoms include nausea, dehydration, reduced cognitive performance, slowing of visual reaction time, and feelings of sluggishness and fatigue.[16] The symptoms of hyperglycemia with ketoacidosis may include those listed above as well as rapid breathing (also known as Kussmaul breathing), fruity odor to the breath, unusual fatigue, sleepiness, inattentiveness, loss of appetite, increased thirst, and frequent urination. Athletic trainers should also be aware that some athletes with type 1 diabetes may intentionally train and compete in a hyperglycemic state (>180 mg/dL [10 mmol/L]) to avoid hypoglycemia. Competing in a hyperglycemic state places the athlete at risk for dehydration, reduced athletic performance, and possibly ketosis.[77]

The ADA provides guidelines for exercise during hyperglycemic periods (Appendix 3). Athletes should work with their physicians to determine the need for insulin adjustments for periods of hyperglycemia before, during, and after exercise. In addition, dehydration is possible when blood glucose levels exceed the renal glucose threshold (180 mg/dL [10 mmol/L]) as urinary output increases to excrete excess glucose. During these periods, athletes may need to increase consumption of noncarbohydrate fluids.

TRAVEL FOR THE ATHLETE WITH TYPE 1 DIABETES

The athlete with diabetes must take special precautions to ensure that blood glucose management is not disrupted by travel. If travel is by airplane, the athlete is advised to study and be prepared for all current regulations and advice from the TSA of the United States Department of Homeland Security before departure. The following advice has been provided by the TSA in conjunction with the ADA for airline passengers with diabetes traveling within the 50 United States[78]:

> Athletes with diabetes should notify airport security screeners of their medical condition and need to carry on board all diabetes equipment and supplies. The TSA allows the following diabetes materials through the checkpoint:
>
> 1. Clearly identified and labeled, with pharmaceutical labels, insulin and insulin-loaded dispensing products, including vials or a box of individual vials, jet injectors, pens, infusers, and preloaded syringes.
> 2. An unlimited number of unused syringes when accompanied by insulin or other injectable medication.
> 3. Lancets, blood glucose meters, test strips, alcohol swabs, and meter-testing solutions.
> 4. Insulin pump and supplies such as cleaning agents, batteries, plastic tubing, and infusion kit catheter and needle.
> 5. Glucagon emergency kit, clearly identified and labeled.
> 6. Ketone testing supplies.
> 7. An unlimited number of used syringes as long as they are transported in a ''sharps'' disposable container or other similar hard-surface container.[79]

Before travel, the athlete should obtain prescriptions for insulin and other medications along with a letter from the physician, on letterhead, explaining the need for diabetes medications, equipment, and supplies. Travel may result in medications, equipment, and supplies becoming lost, damaged, or destroyed. Thus, it is advisable for the athlete to travel with twice the amount of medications and supplies needed for the trip. The athlete should also carry a health insurance card that has the insurance company name, policy number, and emergency phone numbers.

Travel may affect the accessibility to meals and snacks, as well as when and where food may be eaten. Athletes with diabetes should carry prepackaged meals and/or snacks in the event that meals are delayed. If travel occurs over several time zones, insulin therapy may need to be adjusted to coordinate with changes in eating and activity patterns. The athlete should be instructed to discuss the travel plans with his or her diabetes health care team before departure.

It is advisable that everyone with diabetes wear or carry some form of medical identification, especially when traveling. If the trip includes stops in non–English-speaking countries, the ADA can provide identification cards translated into almost any language.[80] However, it may be helpful to learn phrases for requesting medical attention, such as ''I need a doctor,'' ''I need sugar,'' or ''I have diabetes.''[81–88]

INJURY AND GLYCEMIC CONTROL

Trauma is associated with dramatic increases in the secretion of stress hormones (adrenocorticotropic hormone, cortisol, growth hormone, catecholamines, and glucagon) and an increase in blood glucose levels. In persons without diabetes, these changes ensure a steady supply of fuel that assists with the recovery process. Patients with type 1 diabetes appear to have an exaggerated hyperglycemic response to trauma, especially with preexisting hyperglycemia and/or hypoinsulinemia. Numerous authors[87,88] have demonstrated that poor blood glucose control is associated with an increased risk of infection, as well as poor wound and fracture healing. These deficits can be corrected by the administration of insulin and proper blood glucose management.[89,90] Athletes with diabetes should strive to maintain near-normal blood glucose levels via proper insulin administration during the injury process.[91]

Athletes with diabetes should strive for tight blood glucose control in order to minimize the deleterious effects of trauma on glycemic control. Although no researchers have directly addressed the issue of blood glucose control and insulin therapy for common athletic injuries (eg, sprains, strains), the guidelines developed by the ADA for blood glucose control in noncritical patients could be applied to injured athletes with diabetes.[91] The guidelines recommend a premeal blood glucose target of 110 mg/dL (6.1 mmol/L) and a postmeal blood glucose level of <180 mg/dL (10 mmol/L) in noncritical patients. The ADA guidelines listed above can serve as a starting point to assist the diabetes care team in developing glycemic goals.

SUMMARY

Although the literature supports the benefits of physical activity for persons with type 1 diabetes, exercise training and

competition can cause major disturbances to blood glucose management. Maintaining the delicate balance among hypoglycemia-euglycemia-hyperglycemia is best achieved through a team approach. Special considerations for glycemic control, medication, travel, and recovery from injury are needed for the athlete with type 1 diabetes. The certified athletic trainer, who has more contact with the athlete with diabetes than most members of the diabetes management team, is an integral component of the team. Athletes with diabetes can benefit from a well-organized plan that may allow them to compete on equal ground with their teammates and competitors without diabetes.

DISCLAIMER

The NATA publishes its position statements as a service to promote the awareness of certain issues to its members. The information contained in the position statement is neither exhaustive nor exclusive to all circumstances or individuals. Variables such as institutional human resource guidelines, state or federal statutes, rules, or regulations, as well as regional environmental conditions, may impact the relevance and implementation of these recommendations. The NATA advises its members and others to carefully and independently consider each of the recommendations (including the applicability to any particular circumstance or individual). The position statement should not be relied upon as an independent basis for care but rather as a resource available to NATA members or others. Moreover, no opinion is expressed herein regarding the quality of care that adheres to or differs from NATA's position statements. The NATA reserves the right to rescind or modify its position statements at any time.

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Carolyn C. Jimenez, PhD, ATC; Matthew H. Corcoran, MD, CDE; James T. Crawley, MEd, PT, ATC; W. Guyton Hornsby, Jr, PhD, CDE; Kimberly S. Peer, EdD, LATC; Rick D. Philbin, MBA, MEd, ATC; and Michael C. Riddell, PhD, contributed to conception and design; acquisition and analysis and interpretation of the data; and drafting, critical revision, and final approval of the article.

Address correspondence to National Athletic Trainers' Association, Communications Department, 2952 Stemmons Freeway, Dallas, TX 75247. Address e-mail to cjimenez@wcupa.edu.

Appendix 1. Strategies to Prevent Hypoglycemia[1,12–25]

Strategy	Comment
Blood glucose monitoring	Athletes should measure blood glucose levels before, during, and after exercise. Athletes who exercise in extreme heat or cold or at high altitude or experience postexercise late-onset hypoglycemia, which may lead to nighttime hypoglycemia, require additional monitoring. 1. Measure blood glucose levels 2 to 3 times before exercise at 30-min intervals to determine directional glucose movement. 2. Measure glucose levels every 30 min during exercise if possible. 3. Athletes who experience postexercise late-onset hypoglycemia should measure glucose levels every 2 h up to 4 h postexercise. Athletes who experience nighttime hypoglycemia should measure blood glucose values before going to sleep, once during the night, and immediately upon waking.
Carbohydrate supplementation (Note: The athlete should discuss specific carbohydrate quantities and types with his or her physician.)	Before exercise Consumption of carbohydrates before exercise depends on the prevailing blood glucose level. In general, when the blood glucose level is $<$100 mg/dL (5.5 mmol/L), carbohydrates should be consumed.[26,27] During exercise 1. Additional carbohydrate supplementation may be needed for practices or games lasting $>$60 min when the pre-exercise insulin dosage has not been reduced by at least 50%. 2. Athletes who are exercising at the peak of insulin activity may require additional carbohydrates. Postexercise Athletes should eat a snack and/or meal shortly after exercise.
Insulin adjustments (Note: These are very important for moderate-intensity to high-intensity exercise sessions of $\geq$30 min.)	Physician determines insulin reduction strategies. 1. Insulin pump (may use one or more of the following strategies) a. Reduce basal rate by 20% to 50% 1 to 2 h before exercise. b. Reduce bolus dose up to 50% at the meal preceding exercise. c. Suspend or disconnect the insulin pump at the start of exercise. Note: Athletes should not suspend or disconnect from pump longer than 60 min without supplemental insulin. 2. Multiple daily injection Reduce bolus dose up to 50% at the meal preceding exercise. 3. Nighttime hypoglycemia Reduce evening meal bolus insulin by 50%.

Appendix 2. Treatment Guidelines for Mild and Severe Hypoglycemia[28,29]

Mild Hypoglycemia (Athlete is conscious and able to follow directions and swallow.)	Severe Hypoglycemia (Athlete is unconscious or unable to follow directions or swallow.)
1. Administer 10 g to 15 g of fast-acting carbohydrate: eg, 4 to 8 glucose tablets, 2 T honey. 2. Measure blood glucose level. 3. Wait approximately 15 min and remeasure blood glucose. 4. If blood glucose level remains low, administer another 10 g to 15 g of fast-acting carbohydrate. 5. Recheck blood glucose level in approximately 15 min. 6. If blood glucose level does not return to the normal range after second dosage of carbohydrate, activate emergency medical system. 7. Once blood glucose level is in the normal range, athlete may wish to consume a snack (eg, sandwich, bagel)	1. Activate emergency medical system. 2. Prepare glucagon for injection following directions in glucagon kit. The glucagon kit has either (1) a fluid-filled syringe and a vial of glucagon powder, or (2) a syringe, 1 vial of glucagon powder, and 1 vial of fluid. • Inject the fluid into the vial of glucagon. Note: If the vial of fluid is separate, draw the fluid into the syringe and inject it into the vial of glucagon powder. • Gently shake the vial until the glucagon powder dissolves and the solution is clear. • Draw fluid back into the syringe and then inject glucagon into the arm, thigh, or buttock.* • Glucagon administration may cause nausea and/or vomiting when the athlete awakens. Place the athlete on his or her side to prevent aspiration. • The athlete should become conscious within 15 min of administration. 3. Once the athlete is conscious and able to swallow, provide food.

*Athletic trainers should be trained in the mixing and administration of glucagon. The athlete or athlete's family can provide training. In addition, a video demonstrating the preparation and administration of glucagon is available at http://www.diabetes.org/type-2-diabetes/hypoglycemia.jsp.[29]

Appendix 3. American Diabetes Association Guidelines Concerning Hyperglycemia and Exercise[16]

Blood Glucose Level	Comment
Fasting* blood glucose level is ≥250 mg/dL (13.9 mmol/L).	Test urine and/or blood for ketones. If ketones present, exercise is contraindicated. If ketones not present, exercise is not contraindicated.
Blood glucose value is ≥300 mg/dL (16.7 mmol/L) and without ketones.	Exercise with caution, and continue to monitor blood glucose levels.

*Fasting is defined as 4 h or more after eating a meal.

Appendix 4. Pharmacokinetics of Commonly Used Insulin Preparations[60–64]

Product	Action Type	Basal or Bolus Use	Onset	Peak Effect	Duration
Humalog (lispro; Eli Lilly and Co, Indianapolis, IN)	Rapid acting	Bolus in MDI*	5–15 min	45–75 min	3–5 h
Novolog (aspart; Novo Nordisk Inc, Princeton, NJ)		Basal and bolus in insulin pump			
Apidra (glulisine; Sanofi-Aventis, Bridgewater, NJ)					
Humulin (regular; Eli Lilly and Co)	Fast acting	Bolus in MDI	30 min	2–4 h	5–8 h
Novolin (regular; Novo Nordisk Inc)		Basal and bolus in insulin pump			
Humulin N (NPH; Eli Lilly and Co)†	Intermediate acting	Basal insulin in MDI	1–2 h	4–10 h	14+ h
Novolin N (NPH; Novo Nordisk Inc)†					
Lantus (glargine; Sanofi-Aventis)†	Long acting	Basal in MDI	1.5–2 h	Flat	18–24 h
Detemir (levimir; Novo Nordisk Inc) †					

*Indicates multiple daily injections.
†Indicates not used in insulin pump therapy.

Appendix 5. Variables That Affect Insulin Absorption Rate[31,32,60,61,66,67]

Variable	Notes
Exercise of the injected area	Exercise of injected area within 1 h of injection may increase the rate of absorption.
Massage of the injection site	Do not rub or vigorously massage injection sites within 1 h of injection.
Thermal modalities	Heat increases absorption, whereas cold decreases absorption. Avoid using thermal modalities for 1 to 3 h postinjection.
Insulin dose	Larger doses are associated with slower absorption rates.
Lipohypertrophy (accumulation of subcutaneous fatty lumps caused by repeated injections of insulin into the same spot)	Injection into lipohypertrophic sites delays absorption.