Diabetes in the Competitive Athlete

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Abstract
Diabetes mellitus is the most common group of metabolic diseases and is characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both. Most patients with diabetes are type 2 (90%); the remaining patients have type 1 disease. Athletes with diabetes range from the athlete participating in various youth sports to the competitive Olympic athlete and present a significant challenge to themselves and the medical staff who care for them on a daily basis. Each sport and the type of exercise have their own effects on diabetes management with numerous factors that significantly affect glucose levels, including stress, level of hydration, the rate of glycogenolysis and gluconeogenesis, and the secretion of counter-regulatory hormones. This article provides a general overview of diabetes mellitus, the effects of exercise on glucose levels, and a detailed review of the potential complications encountered in the management of diabetes in the athlete.

Introduction

Athletes with diabetes range from the athlete participating in various youth sports to the competitive Olympic athlete. Each athlete presents a significant challenge to themselves and the medical staff caring for them. They are at risk for acute hypoglycemia or ketoacidosis and chronic complications involving microvascular and macrovascular disease.

As a physician caring for athletes with diabetes, it is important to inquire about the athlete's thoughts on their performance at different levels of blood glucose, attitudes about judging blood glucose by how it feels versus testing with a blood glucose meter, and their fears about hypoglycemia (7). The athlete's daily management deals with the physiological demands induced by intense exercise and training, their nutritional needs and varied meal timing, their training regimens and competition as well as the stress of competition (22).

Unfortunately for the physician evaluating and managing these athletes, there are limited published well-controlled studies that supplement our knowledge for the formulation of effective treatment plans. There are only a number of anecdotal descriptions of management strategies and published case reports. In addition to the usual management challenges encountered in a medical practice for diabetic patients, the demands of training and competition for diabetic athletes can affect glucose homeostasis in a different manner. This can lead to concerns about the athlete's safety during athletic participation, including adequate monitoring of blood glucose, and adjustments to diet and insulin to allow for safe and effective athletic performance (14).

Another consideration for the athlete is awareness of the chosen sport and includes 1) how much aerobic and anaerobic exercise is involved, 2) how intensively the athlete practices and competes, 3) duration of the exercise, and 4) the risk of injury or morbidity to self or others if the athlete becomes hypoglycemic (7). The athlete with diabetes needs to understand the effect this disease has on their entire body and take individual responsibility for the daily management of his glucose levels. This component of the athlete's care is one of the greatest challenges physicians face in dealing with the young athletes with diabetes.

Lastly, an area often overlooked is identifying the attitudes, abilities, methods, and willingness of the athlete's teammates and coaches to assist them in their diabetes management in order for them to have a successful plan for participation (7).

The Types of Diabetes and the Athlete

Diabetes mellitus is the most common metabolic disease characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both. Most patients with diabetes are type 2 (90%), while the remaining patients have type 1 disease (12).

Type 1 diabetes mellitus (T1DM) can occur at any age but is most often diagnosed in children, adolescents, or young adults and is caused by loss of insulin secretion due to progressive loss of insulin production (2). Type 1A is an autoimmune disease characterized by cellular antibodies that may form against islet cells (ICA), insulin (IAA), and glutamic acid decarboxylase (GAD_{65}). Type 1B is an idiopathic, nonautoimmune disease state with loss of beta cell function (16). Type 1 patients demonstrate hyperglycemia and weight loss and are prone to ketoacidosis. Death may occur if exogenous

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insulin is not administered and the acidosis is reversed. Typical onset is before the age of 30 years with peak incidence during adolescence. Therefore, many athletic encounters involve individuals with T1DM.

Type 2 diabetes mellitus (T2DM) is characterized by defects in both insulin secretion and resistance to insulin action, resulting in impaired insulin secretion, increased hepatic glucose production, and decreased muscle glucose uptake. T2DM is usually a disease of adults and is due to both genetic (family history or familial hyperlipidemia) and environmental (sedentary lifestyle or inappropriate diet with increased caloric intake) factors. Insulin resistance is associated with obesity, hypertension, hyperlipidemia, and type 2 diabetes and may precede the onset of diagnosed diabetes by 10 to 20 years (35). There are many variations of the mentioned clinical scenario, but most patients are older than 40 years when diabetes develops (38). T2DM is not as common in the competitive, well-fit athlete but occurs in those athletes with an increased body mass for their particular sport (football lineman or rugby players) or those who do not remain fit (baseball players).

For both the type 1 and type 2 athletes, the general benefits of physical activity include enhancement of physical fitness, reduction in cardiovascular disease risk, and improved social and emotional well-being (20). The primary risks of physical activity in type 1 patients are exercise-induced hypoglycemia and aggravation of hyperglycemia and ketosis. Some of the challenges managing athletes with diabetes are related to their individual goals.

The reasons why athletes with diabetes participate in sports include the pleasure of competition, improved physical fitness, personal achievement, team atmosphere, improvement of performance, and potential for financial rewards (college scholarships, professional sports contracts, and endorsements). These goals are perceived by the athlete as being far more important than blood glucose control or avoidance of complications and can compromise their blood glucose control and general health. As a physician, our goals are to prevent not only short-term complications (hypoglycemia) but also long-term complications (renal failure, blindness, peripheral vascular disease, and peripheral neuropathy).

The athlete may practice unsafe dietary patterns, use nutritional supplements with no benefit or even detrimental effects, and use illegal drugs. The physician needs to be aware of nutritional problems in the female athlete (amenorrhea, osteoporosis, and eating disorder), rapid weight loss to "make weight," and excessive consumption of a single macronutrient (carbohydrate, protein, or fat). In sports with weight categories (wrestling, boxing, and weightlifting), a common practice is omission of insulin. By withholding insulin, the athlete can lose weight prior to their weigh-in, leading to poor glucose control and the risk of ketoacidosis (14).

Unfortunately, most competitive athletes learn to manage their diabetes during training and competition by trial and error while sharing personal experiences with other athletes (33). Studies suggest that some athletes with type 1 diabetes are not achieving good blood glucose control prior to their competitive event intentionally (31) and have increased lipid utilization (8). This approach often may prevent exercise-induced hypoglycemia.

The metabolic demands of the recommended aerobic activity for healthy adults and for the management of patients with T2DM are a percentage of the $\dot{V}O_{2max}$ and are intended to minimize contributions of the anaerobic energy systems (14,25,29) (Figure). The physical activity recommendations for healthy adults and for patients with T2DM are similar. The American College of Sports Medicine and American Diabetes Association recommend aerobic exercise at an intensity of 40% to 70% of $\dot{V}O_{2max}$ and anaerobic exercise

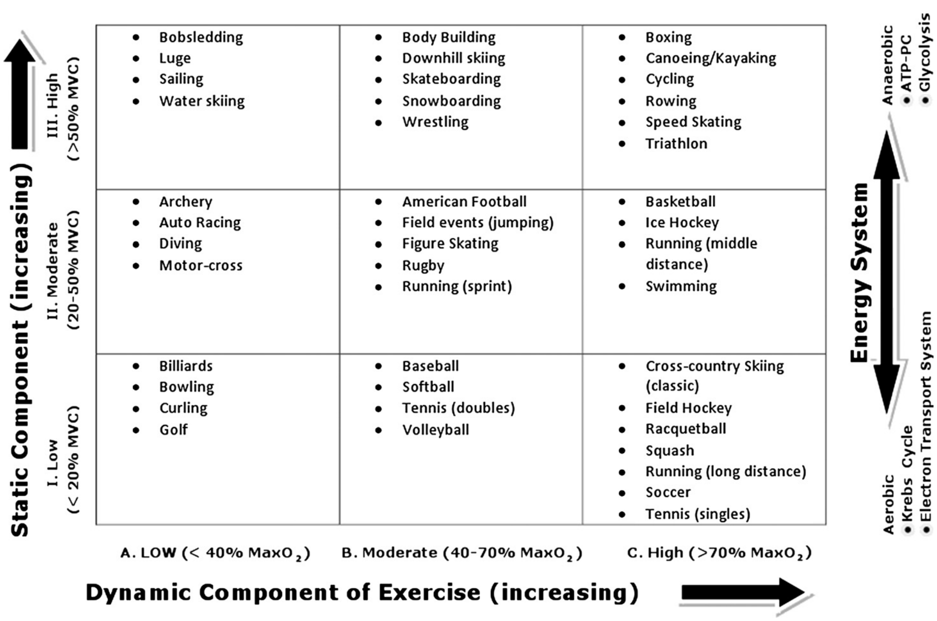

Figure: Classification of sports by energy expenditure [Adapted from Mitchell JH, Haskell W, Snell P, et al. Task force 8: classification of sports. J. Am. Coll. Cardiol. 2005; 45:1364–7. Used with permission.]

for a minimum of one set of 10 to 15 repetitions using 8 to 10 resistance exercises for most patients with T2DM with modifications depending on the patient's co-morbidities (1).

Managing the Athlete With Diabetes

Sport Physiology and Diabetes

Each sport and the type of exercise have their own effects on diabetes management. It is known that moderate aerobic exercise is associated with hypoglycemia while bursts of anaerobic exercise may raise blood glucose (5). The table of exercise exchanges and carbohydrate use from Riddell and Bar-or (30) (minutes of exercise requiring 15 g of carbohydrate based on size and type of exercise) provides a beneficial resource in managing the athlete.

The initiation of exercise elicits hormonal responses and the release of body fuels, glucose from liver glycogen, glucose stored as glycogen in muscle, the generation of lactic acid that is cycled through the liver to make new glucose, and mobilization of fatty acids and gluconeogenesis from amino acids (7). Exercise augments the effect of insulin, facilitating glucose transport across the cell membrane and increasing muscle glucose uptake 20-fold. The main facilitator, glucose transporter 4 (GLUT-4), is impaired in obesity and diabetes. Its activity is enhanced by insulin-like growth factors, thyroid hormone, bradykinins, nitric oxide, biguanides, thiazolidinediones, and exercise (32). A single exercise session (45 min) may increase insulin sensitivity by 40% and continue for the subsequent 48 h. This glucose-lowering effect via exercise helps normal persons and type 1 and type 2 patients with diabetes; type 2 patients seem to benefit the most (32,38). This metabolic response for the nondiabetic individual is a near instantaneous insulin modulation to keep blood glucose levels within normal range during exercise. However, the athlete with diabetes taking exogenous insulin has insulin absorption from subcutaneous depots with various release patterns along with the increased exposure of insulin to receptors on muscle cells as blood flow increases. This increases the risk of hyperglycemia during the initial exercise and hypoglycemia later as the level of injected insulin is unable to respond to a falling level of glucose (7).

Glucose Monitoring During Exercise

The athlete, athletic trainer, and team physician should have agreed-upon predetermined blood glucose levels that determine when the athlete participates and when the athlete is not permitted to participate. For example, if the preexercise level is less than 100 $mg{\cdot}dL^{-1}$, carbohydrate supplementation should take place, and if glucose levels are over 180 $mg{\cdot}dL^{-1}$, the athlete should consume a non-carbohydrate-containing fluid to prevent dehydration and monitor glucose levels to avoid excessive hyperglycemia and ketosis.

Athletes should be educated and questioned about frequent blood glucose monitoring, which should be done two to three times at 30-min intervals before exercise to trend direction of blood glucose levels. During exercise, glucose levels should be checked every 30 min; additional monitoring occurring every 2 h for up to 4 h postexertion to monitor for delayed hypoglycemia (17) should be performed.

If preexercise blood glucose is 100 to 250 $mg{\cdot}dL^{-1}$, it is generally safe to begin exercising (9). Most athletes with T1DM maintain blood glucose levels between 120 and 180 $mg{\cdot}dL^{-1}$ and regulate their glycemic response to exercise and avoid exercise if their fasting glucose is greater than 250 $mg{\cdot}dL^{-1}$ and ketosis is present. They use caution if the glucose is greater than 300 $mg{\cdot}dL^{-1}$ with no ketosis and ingest added carbohydrates (CHO) if glucose levels are less than 100 $mg{\cdot}dL^{-1}$.

Preventing and Managing Hypoglycemia

A number of physiological regulatory and counter-regulatory mechanisms are in place to allow both fasting and nonfasting serum glucose levels to be maintained within a relatively narrow range, despite the impact of eating and physical activity. With exercise, there are numerous factors that significantly affect glucose levels, including stress, level of hydration, the rate of glycogenolysis and gluconeogenesis, and the secretion of counter-regulatory hormones (19).

Hypoglycemia in the diabetic athlete can be either immediate or delayed. Immediate hypoglycemia occurs during or shortly after exercise and is most common in the type 1 patient due to inadequate caloric intake to meet metabolic demands. Other causes include excessive exogenous insulin administration or injection of insulin into the site of exercising muscle or overlying subcutaneous tissue resulting in increased absorption rate (38).

Symptoms and signs of hypoglycemia are principally due to either adrenergic causes (from the release of sympathomimetic mediators) and neuroglycopenic causes (from an inadequate amount of glucose being available to support brain activity) (6). Both main causes have considerable overlap with symptoms caused by strenuous or prolonged physical activity, which may make recognition of low blood glucose difficult during athletic activity. Adrenergic signs and symptoms consist of hunger, anxiety, sweating, tremor, tachycardia, palpitations, and/or a feeling of impending doom. Neuroglycopenic symptoms and signs likely are to include weakness or fatigue, slow or slurred speech, impaired performance of tasks, lack of coordination, blurred vision, odd behavior, confusion, vertigo, paresthesias, and/or stupor (6). The severe signs of neuroglycopenia are seizures and loss of consciousness, although these are less common in adults than in children (4).

To prevent immediate hypoglycemia, one should avoid injection of insulin into an area of exercising muscles (*e.g.*, use of anterior thigh in a runner) (10) and instead inject into the abdominal area. This effect is seen much less with analog insulin preparations (27). Calories should be replaced continually during a period of prolonged activity. Careful glucose monitoring during activities allows the athlete to determine individual caloric requirements and make adjustments. To avoid weight gain, the runner may emphasize insulin adjustment rather than supplemental calories.

Exercising at a lower exercise intensity but for a longer period of time or in cold weather may require more calories, while in a hot environment, athletes with diabetes may experience hypoglycemia due to poor appetite and decreased caloric intake (36).

The best approach in the management of hypoglycemia during exercise is preventing its occurrence. When dealing with athletes with various levels of maturity, commitment to the sport, and personal accountability, one must be prepared for the recognition and management of hypoglycemia. When an athlete self-recognizes symptoms of hypoglycemia or a teammate or coach suspects a low glucose level, the athlete should be removed from play and encouraged to measure the fingerstick glucose. Hypoglycemia should be treated with 15 to 20 g of fast-acting carbohydrate, preferably glucose tablets designed to treat hypoglycemia or a sugar-sweetened beverage or juice. This treatment can be repeated if there is no improvement in symptoms or glucose level after 15 min. If conditions are present that suggest hypoglycemia might recur once the athlete resumes play, additional complex carbohydrates should be consumed before returning to the activity. Hypoglycemia provokes a counter-regulatory hormonal response, so excessive carbohydrate intake should be avoided to prevent a significant hyperglycemic rebound (19).

Severe hypoglycemia with the loss of consciousness or seizures is a life-threatening condition requiring prompt treatment. Once an athlete with hypoglycemia has become unresponsive, emergency response personnel should be summoned urgently. No attempt to force oral consumption of carbohydrates should be made. Instead, glucagon should be injected parenterally (subcutaneously, intramuscularly, or intravenously) or glucose by intravenous administration of one to three ampules of 50% dextrose (one ampule contains 25 g of glucose in 50 mL of water) in water (D50 W) in the field while evaluating and resuscitating the athlete (19).

Delayed Hypoglycemia

Delayed hypoglycemia (also known as nocturnal hypoglycemia) usually occurs 6 to 12 h *after* exercise and has been reported up to 28 h postexercise (21). It often occurs at nighttime when the athlete is to perceive or recognize least likely this condition and is associated with seizures, cardiac arrhythmias, unconsciousness, and death (11). The pathophysiology involves vigorous exercise severely depleting body glycogen stores, followed by inadequate replacement of glycogen stores in the postexercise interval ("golden replenishment period"). The athlete either underestimates caloric requirements or ingests limited calories and defers eating until later (38). Over the ensuing hours, liver and muscle tissues extract circulating blood glucose to replenish depleted glycogen stores and glycogen synthetase is activated (24). In addition, the peripheral muscle tissues are more sensitive to any available insulin postexercise (15). The subsequent severe and persistent delayed hypoglycemia often requires the assistance of another person, parenteral glucagon, and continuous caloric intake over several hours to correct and replenish depleted glycogen stores.

Glycemic Control and Management

Ideally athletes with diabetes perform best at glucose levels between 70 and 150 mg·dL^{-1}. Practically most athletes with T1DM maintain blood glucose levels between 120 and 180 mg·dL^{-1}. Based on the training program, the athlete "learns" the personal glucose response to exercise duration and intensity.

Hypoglycemia in athletes with T1DM occurs due to 1) lack of physiological decline in insulin secretion with energy utilization due to exogenous insulin administration, 2) loss of physiologic autonomic regulation of glucose levels due to dysregulation (loss of counter-regulatory autonomic function), and 3) possible increased absorption of exogenous insulin with exercise (13). Comparison of blood glucose levels in normal, nonketotic diabetic, and ketotic diabetic athletes by Wahren *et al.* (34) found that stimulation of the counter-regulatory hormones in the insulinopenic, ketotic state worsens this condition. A similar effect was found by Berger (3), who studied athletes with diabetes subjected to 3 h of exercise when compared with normal controls.

T1DM

Anaerobic, short-distance, sprint activity events rarely cause metabolic control problems for the type 1 athlete. Proper hydration and maintenance of glucose levels as noted previously often maximizes performance. Hyperglycemia may occur in some athletes due to acute catecholamine release, but delayed hypoglycemia is rare (26). Adjustment of insulin dosing for these events is usually unnecessary.

Some endurance athletes choose to set the basal rate of insulin infusion via continuous subcutaneous insulin infusion (CSII) or insulin pump at a lower rate or select a decreased dosage amount of a long-acting basal insulin dosage and then ingest carbohydrates over a period to match the athlete's energy utilization with exercise (37). This method is utilized by some distance cyclists and runners. By developing a steady-state balance between the exercise requirement, the basal insulin infusion, and ingestion of energy (carbohydrates), the glucose level is held constant (*e.g.*, 130 to 150 mg·dL^{-1}) over several hours. If the cyclist or runner with T1DM encounters a demanding, incline section of the course, either the basal rate can be adjusted downward or extra energy (calories) ingested to maintain optimal glycemic levels.

Many endurance sports commence in the morning. This schedule results in less frequent hypoglycemia due to physiologically elevated diurnal cortisol and growth hormone levels. When events occur later in the day, adjustments must be made accordingly. Practically, training at a time of the day similar to the scheduled competitive event allows the athlete to develop personal adjustments of food and insulin. Athletes with T1DM learn their personal requirements from training and apply these results.

To counteract hypoglycemia, runners and cyclists who are prone to hypoglycemia often perform a series of anaerobic sprints or resistance exercise prior to the aerobic endurance event. Bussau *et al.* (5) have found this anaerobic practice lowers the incidence of subsequent hypoglycemia during the later endurance event. A recent article confirmed a similar effect *following* aerobic exercise (39). Thus, short bursts of anaerobic exercise before *or* after aerobic exercise may help prevent subsequent hypoglycemia.

If the type 1 diabetic athlete is insulin deficient and blood glucose is elevated, endurance running may exacerbate this diabetic state. Osmotic diuresis with relative dehydration also affects performance. As blood glucose rises, the risk of causing even higher blood glucose levels increases (3,26). Further exercise may exacerbate or precipitate ketoacidosis.

Athletes with T1DM will always require some insulin. When the athlete is utilizing human insulin isophane suspension (NPH) or analog long-acting insulin (insulin glargine or insulin detemir) combined with either human short-acting (regular) or analog rapid-acting insulin (insulin lispro, insulin aspart, insulin glulisine), the human intermediate insulin or analog long-acting insulin is often decreased by 50% and the analog rapid-acting or human short-acting insulin is decreased by 25% to 75%, depending on the distance, the time of exercise, and the individual's training response to similar exercise (3). Analog rapid-acting insulins are very predictable in their absorption kinetic profiles (27). In an endurance event, *e.g.*, marathon, total daily insulin dose may need to be reduced more than 80%. One study of half-marathon runners with type 1 diabetes found that athletes must consume adequate carbohydrates and will often reduce insulin dosages far less than traditionally recommended (28). In longer duration events, energy sources are critical; carbohydrate-containing fluids and other solid fuel sources are necessary.

Finally, adequate replenishment of glycogen stores (1.5 g of carbohydrate per kilogram of body weight) at the finish line is critical in the "golden recovery period" (13). If glycogen stores are not replaced, the risk of delayed hypoglycemia is high (21).

T2DM

The management of athletes with T2DM depends on the sport and duration of the diagnosed diabetes state. Early in the disease, the athlete maintains some endogenous insulin production or secretion and requires little, if any, exogenous insulin. These athletes maintain the ability to decrease or increase physiologically endogenous insulin secretion and are able to have optimal glucose levels maintained in the desired range.

As the disease state progresses and endogenous insulin secretion diminishes, exogenous insulin administration becomes necessary. In these athletes with T2DM, the exogenous insulin will require adjustment to prevent hypoglycemia. With active training, it is not uncommon in these athletes for the exogenous insulin requirement to decrease by 50% or greater, and with competition, the requirement may decrease further based on training requirements.

Also important in the athletes with T2DM is that other agents (*e.g.*, insulin secretagogues, insulin sensitizers) are often decreased due to 1) regular training exercise, 2) increased insulin sensitivity, 3) decrease in body fat, and 4) increase in lean body mass. With the given changes, some fit athletes with T2DM note a plateau in medicine requirements for treating their diabetes due to the ability to perform at competitive levels while utilizing less supplemental energy.

Special Situations

Travel Preparations

Travel preparations should be a coordinated effort between the athlete, the team physician, and the athletic trainer. A labeled travel kit should contain unused syringes, blood glucose meters, lancets, test strips, alcohol swabs, insulin, insulin pump with supplies (if needed), glucagon emergency kit, and ketone testing supplies. The athlete should ensure the kit has at least twice as much medication and testing equipment as anticipated for travel. Supplies should be carried with the athlete at all times and not with checked luggage. Additionally, extra prescriptions for these supplies should be carried with the athlete as a precaution along with prepackaged meals or snacks. A letter from the athlete's physician stating the medical condition, necessity of supplies including a red sharps container, athlete's health insurance card, and emergency contact numbers should be included. The athlete should carry an identification card or medical bracelet stating the medical condition (17).

Athletes Competing in Specific Sports

Altitude Sports

Glycemic control decreases in athletes with T1DM and may affect some patients with T2DM at high altitudes. This hyperglycemia is due to 1) increased sympathetic tone with subsequent increased hepatic glucose production, 2) increased insulin resistance, and 3) loss of appetite at high altitude. Other problems encountered by these athletes include variation of glucose monitor reliability and adequate protection of insulin from temperature extremes. As the insulin temperature approaches freezing, it is no longer active (36). Mountain climbers and winter athletes should maintain insulin close to their body to maintain optimal temperature of the insulin.

Water Sports, Swimming, or Scuba

Participation in water sports limits the use of insulin pumps and continuous glucose monitors depending on the specific device and company model. While insulin pumps are water resistant and one model is water proof to 12 ft for 24 h, other models do not withstand pressure. Insulin pumps usually are removed prior to showering or bathing while continuous skin sensors may remain in place. The separate external glucose monitor device is not waterproof.

Scuba diving is discouraged for those with T1DM, although many accomplished divers dive with partners who are aware of their condition. Since recreational dives usually last 30 to 45 min, glucose monitoring can be done on an interval basis at the surface level.

Ice Hockey, Wrestling, or Football

Use of external devices is discouraged in these sports. Wrestling and football competition could be detrimental to insulin pumps or external glucose monitors. While these devices are not prohibited by USA Hockey, participants cannot "wear any equipment that would be harmful to another player." In addition, a letter from a health care provider is required for any special medical equipment. In these sports, the athlete often resorts to intermittent insulin injection and glucose monitoring outside the competition area.

Baseball or Softball

These sports are ideal for persons with diabetes and require bursts of anaerobic energy without prolonged exercise periods. In the dugout, each inning, the athletes may test their glucose levels, ingest carbohydrates, and maintain hydration. Some position players have worn insulin pumps successfully while playing these sports.

Distance Running or Endurance Sports

Distance running and other endurance sports require careful management of fuel sources and insulin management for the type 1 athlete (23). When their metabolic derangements are controlled, type 1 patients demonstrate a normal exercise capacity (29). Endurance runners often strive for optimal prerun blood glucose of 120 to 180 mg·dL^{-1}, take minimal insulin, and estimate a glucose decrease of 10 to

15 mg·dL^{-1} per mile (38). When running for periods of 30 to 60 min, self-monitoring of blood glucose or continuous glucose monitoring (CGM) during the training period will delineate the individual's predicted response. If a type 1 endurance runner experiences difficulty in maintaining satisfactory blood glucose levels, rapid-acting insulin and long-acting insulin will require adjustment and may require changing to more frequent insulin injections or CSII (insulin pump) to improve control.

With longer distances, external fuel sources become more important. The risk of hypoglycemia is increased since insulin levels do not wane in the type 1 diabetic runner as in the runner with normal hormonal control. Carbohydrate-containing fluids and exogenous fuel sources will be required as exercise progresses. Adequate replacement of depleted glycogen stores is crucial in recovery. The use of CGM has improved the ability of athletes with T1DM to compete in many endurance sports.

Type 2 diabetic runners may participate in endurance running events since some may have achieved weight loss and improved their cardiovascular fitness. The risk of either immediate or delayed hypoglycemia is far less in these individuals. The period of increased insulin sensitivity should persist for 12 to 48 h without clinical hypoglycemia (18). Those athletes treated with agents predisposing them to hypoglycemia may require a reduction in dosage as they train, reduce body fat, improve physical fitness, and decrease insulin resistance.

Triathlons

Triathletes who have diabetes and take insulin have competed successfully. Most participants have T1DM and, via training, learn to manage the insulin and glucose satisfactorily and make insulin adjustments for the days of competition based on training experiences.

During the swimming element, either a waterproof pump is worn or the insulin pump and glucose monitor are removed. After exiting the water, many athletes attach the external glucose monitor and the insulin pump. This process requires 10 s or less. Then, the athlete may suspend, continue, or increase the same infusion based on the glucose monitor reading without ceasing activity. With special permission from race officials, "team members" along the course route may pass off glucose supplements to the athlete, if necessary.

Conclusion

With improved insulin analog formulations and specific oral and parenteral medications, the athlete with T1DM or T2DM is able to compete in most sports with specific medicine adjustments and proper training. The athlete with diabetes is able to participate at all levels of competition with successful outcomes while minimizing hypoglycemia and hyperglycemia.

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