Diabetes Mellitus: An Overview

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As an overview, diabetes mellitus is a group of diseases marked by elevated blood glucose levels resulting from defects in insulin production, insulin action, or both. Overall, diabetes can lead to serious complications and premature death, yet those with Diabetes can take action to control their disease and lower their risk of complications. In the United States, the prevalence of diabetes is about 20.8 million people. The significance and burden of diabetes towards the health care system is reflected in the following:

- Diabetes is one of the most common chronic diseases affecting people in the United States. More than 1.5 million new cases are diagnosed annually.
- Diabetes has a major impact on the health of the U.S. population. It is the leading cause of new blindness, end-stage renal disease, and nontraumatic amputations in adults.
- Direct medical costs and indirect costs of diabetes total $132 billion annually (based on 2002 estimates).
- Sixth leading cause of death in U.S. (fifth leading cause of death for women)
- Overall, the risk of death among people with diabetes is about twice that of people without diabetes of similar age.
- Cardiovascular disease
- About 73 percent of adults with diabetes have a blood pressure greater than or equal to 130/80 mm Hg
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• Leading cause of:
  ★ Non-traumatic amputations (82,000/year or 224/day) — More than 60 percent of nontraumatic lower-limb amputations occur in people with diabetes.
  ★ Blindness (~20,000/year or 60/day)
  ★ End stage renal disease (38,000/year or 104/day)
  ★ Neural Defects: About 60-70 percent of people with diabetes have mild to severe forms of nervous system damage. Almost 30 percent of people with diabetes aged 40 years or older have impaired sensation in the feet (i.e., at least one area that lacks feeling).

Based on these disease-related consequences of diabetes, it is imperative for health fitness practitioners to understand exercise risks, benefits, and precautions for those with diabetes. Although there are three main types of Diabetes Mellitus, we focus only on T1DM and T2DM in this issue. Gestational Diabetes Mellitus (GDM) is not addressed; however, many GDM strategies align closely with those for T2DM.

Briefly, T1DM develops when the body’s immune system destroys insulin-producing cells that regulate blood glucose. To survive, people with T1DM must have insulin delivered by injection or a pump, while some do use inhaled insulin. This form of diabetes usuallystrikes children and young adults, although disease onset can occur at any age. T1DM accounts for 5-10 percent of all diagnosed cases of diabetes. Risk factors for T1DM may be autoimmune, genetic, or environmental. Presently, there is no known way to prevent T1DM, even though there are known biologic markers increasing risk for T1DM.

T2DM is the most common form of diabetes and accounts for about 90-95 percent of all diagnosed cases. It usually begins as insulin resistance, a disorder in which insulin receptor sites on the target cell are impaired. As the need for insulin rises, the pancreas gradually loses its ability to produce it. T2DM is associated with older age, obesity, family history of diabetes, history of GDM, impaired glucose metabolism, physical inactivity, and race/ethnicity. Moreover, T2DM in children and adolescents is more commonly diagnosed, particularly in American Indians, African Americans, and Hispanic/Latino Americans.

Treating diabetes requires timely medication(s) use, proper nutrition, and regular physical activity/exercise to aid in regulating blood glucose. Diabetes self-management education (DMSE) is an integral component of medical care, especially routine glucose monitoring, which aids in glucose control and benefits both T1DM and T2DM. To avoid acute risks of exercise, e.g., high or low blood glucose, it is strongly recommended that blood glucose monitoring be performed before/after each exercise/physical activity session.

Health fitness practitioners need to know the role of exercise in diabetes — risks, benefits, and precautions. Overall, if a client with diabetes does not have disease-related complications, e.g., heart and vessel, eye, kidney, or nerve, then the recommendations put forth in this themed issue are prudent for the health fitness practitioner. If there are known complications, physician-directed exercise and/or physical activity planning and development is warranted.

References
Overview of Type 2 Diabetes

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Type 2 Diabetes Mellitus (T2DM) is a significant health burden in the United States due to increased morbidity and mortality associated with macrovascular and microvascular diabetes complications. The rate of growth in T2DM both nationally and globally is projected to double by 2050 and 2025, respectively. One in three people born in the United States in 2000 are projected to develop diabetes in their lifetime. While the prevalence of T2DM is common among all elderly and obese, selected minority and ethnic groups are disproportionately affected. Moreover, persons with diabetes suffer disproportionately from physical and cognitive disability.

Usually, T2DM affects adults over 30 years and is directly related to co-existing conditions, such as obesity, hypertension, dyslipidemia, and insulin resistance. Alarmingly, the incidence of T2DM in children and adolescents has significantly increased over the past 20 years, presumably related to increased levels of obesity secondary to excess caloric intake and too little caloric expenditure. About 85 percent of children diagnosed with T2DM are overweight or obese at diagnosis.

The inextricable relationship between T2DM and obesity in adults and youth has prompted the development of the term Diabesity which is trademarked by Shape Up America. Diabesity refers to the link between obesity and T2DM — the most prevalent form of diabetes in America.

Although T2DM displays varying degrees of insulin production (e.g., normal or elevated), the disease is characterized by insulin resistance. Insulin resistance is considered a “peripheral defect” because of a decrease in insulin-mediated uptake and storage of glucose in the liver and skeletal muscle. Reduced insulin receptor binding at target tissues and impaired post-binding activities related to intracellular insulin action result in insulin resistance. Interestingly, these abnormalities are reversible with weight loss, diet, and physical activity. Elevated blood glucose, or hyperglycemia in T2DM suggests that insulin release is inadequate to compensate for the insulin resistance. At diagnosis, T2DM have significantly elevated levels of insulin, which contributes to insulin resistance. Over time, the pancreas loses its ability to produce insulin, and the need for exogenous insulin to control blood glucose increases. Thus, T2DM is a progressive disease occurring in a gradual succession of stages of increasing glucose intolerance and insulin resistance.

Onset of T2DM is associated with genetic, environmental, and cultural factors. The risk of disease rises with family history, age, obesity, and inactivity. About 80 percent of adults with T2DM are obese and physically inactive, both of which are related to increased insulin resistance. Lifestyle interventions focusing on weight loss and physical activity are essential strategies to not only manage glucose levels and lessen the onset of disease-related complications, but also to prevent the onset of T2DM.

Blood glucose control for T2DM is crucial in managing the disease and lessening the onset of cardiovascular disease and diabetes-related complications (DRCs). Because diabetics are two to four times more likely than nondiabetics to suffer a fatal heart attack or stroke, the health fitness practitioner should ensure that their client with T2DM monitors his/her blood glucose and manages CVD risk factors. Overall glycemic control is routinely assessed using glycosylated hemoglobin (A1c). A1c measures a person’s blood glucose over the preceding two to three months and the goal for diabetes from the American Diabetes Association (ADA) to have a A1c value < 7.0 percent; however, the American Association of Clinical Endocrinologist (AACE) has recommended an A1c value <6.5 percent.

Table 1: Indications For Stress Testing with Diabetes

- Known or suspected cardiovascular disease (e.g., CAD, PAD)
- Age > 35 years
- Age > 25 years if duration of diabetes > 10 years for type 2 or > 15 years for type 1
- Presence of any additional risk factors for cardiovascular disease
- Microvascular disease
- Proliferative retinopathy
- Nephropathy, including microalbuminuria
- Peripheral Vascular Disease
- Autonomic neuropathy

CAD = coronary artery disease; PAD = peripheral arterial disease

Pre-Activity Screening

A thorough pre-activity screening of the patient’s clinical status is recommended to ensure safe and effective participation. Before commencing exercise, prudent screening for vascular and neurological complications, including silent ischemia, are warranted, along with identification of the presence of cardiovascular disease risk factors. Coexisting morbidities in the diabetes health profile are important for the health fitness.
practitioner to determine whether the client status is acceptable for safely engaging in exercise and to determine the need for monitoring of each session. Use of the PAR-Q and PAR-MedX questionnaires are helpful screening tools for the health fitness practitioner to ensure medical oversight in evaluating the client’s health profile. Persons with diabetes are stratified in the high-risk category, according to recommended guidelines[3], and a stress test is strongly advised before initiating moderate to vigorous exercise irrespective of the patient’s cardiac risk profile[6,11]. Specific indications for a stress test to be administered include the presence of one or more of the criteria shown in Table 1.[4]

Exercise: Benefits for Type 2 Diabetes

The benefits of regular exercise for T2DM are significant and over the past 20 years the powerful role of exercise and physical activity has become more fully appreciated in treating and preventing T2DM[1,2,12,13,14]. The molecular understanding of exercise in relation to T2DM is evolving, as is knowledge regarding the optimal mode, frequency, and duration of exercise to treat and prevent this disorder[4,6,11]. In addition, there is a growing appreciation for the role of aerobic exercise, as well as resistance training, in T2DM[6,15]. Although DRCs have been the premise to discourage exercise participation, there are a variety of activities that allow for safe exercise in a supervised setting to oversee diabetes and DRCs. Individualized exercise training needs to be an integral part of the treatment plan for the management of T2DM. It is important for the health fitness practitioner to ensure the development of a safe and effective program for the client with T2DM through physician interaction.

Exercise Program for Type 2 Diabetes:

Current exercise recommendations for T2DM attempt to enhance the volume of weekly aerobic physical activity, along with increasing the quantity and quality of resistance training sessions.[6,15] These recommendations address important outcomes aimed at improved glucose management, reduced heart disease risk, and favorable psychoemotional changes that lessen/delay progression of the disease. Proper precaution of exercise participation is prudent with T2DM clientele, especially, monitoring blood glucose before/after exercise. Finally, the recommendations put forth in this article are limited to persons with T2DM who do not have DRCs. If DRCs are part of a client’s health profile, it is important for the health fitness practitioner to have medical oversight in developing a safe and effective exercise program for those with T2DM, and maybe recommend clinical supervision for safe participation.

The aerobic exercise recommendations presented in ACSM’s Guidelines for Exercise Testing and Prescription, Seventh Edition. (GETP7) for “all diabetes” needs to be modified to meet specific needs of the client with T2DM[3]. As presented in Table 2, the FITT recommendations in GETP7 are compared with current recommendations for T2DM[1,3,15]. The more current aerobic activity is recommended not only to improve glucose metabolism and glucose control, but also to aid in weight management and cardiovascular risk prevention[1,3,6]. Coupled with obesity, health fitness professionals should strive to have their client with T2DM achieve at least 150 minutes of moderate intensity physical activity each week, and may need to increase the amount of time in physical activity/resistance training to aid in weight management.[1]

In addition to aerobic exercise, resistance training is strongly recommended for T2DM. In recent years, many studies have examined the benefits, effectiveness, and safety of resistance training in T2DM. The current guidelines (see Table 2) recommend that resistance training be performed up to three times per week with T2DM[1,3,15]. Moreover, eight or more exercises should be included in this training with eight to ten repetitions (e.g., 8-10 RM) of each exercise performed per set, while the number of sets should progress from one to three. Most importantly, health fitness practitioners must supervise and assess their clients with T2DM to ensure the proper safety, progression, and effectiveness of the training program. Irrespective of aerobic or resistance training, the health fitness practitioner should design an exercise program to accommodate the clinical status of the patient/client and specify the type and intensity of activity as well as duration and frequency.

In summary, the health fitness practitioner can safely and effectively accomplish exercise program development for T2DM. It is important to consider current health and DRC status before physical activity participation. Participation in physical activity affords critical benefits for those with T2DM, while health fitness practitioners need to keep close scrutiny over the intensity of the exercise program to yield both safe and effective outcomes for this clientele.

Table 2: Comparing Aerobic and Resistance Training Recommendations for Type 2 Diabetes

<table>
<thead>
<tr>
<th>Type or Mode</th>
<th>Aerobic Training Recommendations</th>
<th>Resistance Training Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>GETP7 - Diabetes</td>
<td>Current Type 2 Diabetes Recommendations</td>
<td>ACSM Position Stand (2000)</td>
</tr>
<tr>
<td>Frequency</td>
<td>Intensity</td>
<td>Time</td>
</tr>
<tr>
<td>3-4 days/week</td>
<td>50-70% HRR</td>
<td>≥ 40 minutes/week*</td>
</tr>
</tbody>
</table>

*Moderate intensity; **Vigorous intensity

References

Type 1 Diabetes and Exercise

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Introduction

Between Type 1 Diabetes Mellitus (T1DM) and Type 2 Diabetes Mellitus (T2DM), T1DM is significantly less prevalent. T1DM, formerly known as juvenile onset or insulin dependent, afflicts more than one million people in the United States. Though the clinical symptoms for both types are the same (polyuria (excessive urination), polydipsia (excessive drinking/thirst), polyphagia (excessive eating/hunger), blurred vision and/or excessive in the United States. Though the clinical symptoms for both types are the same (polyuria (excessive urination), polydipsia (excessive drinking/thirst), polyphagia (excessive eating/hunger), blurred vision and/or polyuric). T1DM, the primary defect is inadequate insulin secretion secondary to progressive destruction of pancreatic β-cells via an autoimmune process.

Pathological Physiology of Diabetes

The symptoms and complications associated with T1DM can be attributed to a lack of circulating insulin: (a) decreased utilization of glucose by the body cells, resulting in high blood glucose, (b) increased mobilization and use of fats, resulting in ketoacidosis, and (c) depletion of amino acids. For T1DM, the primary defect is inadequate insulin secretion secondary to progressive destruction of pancreatic β-cells via an autoimmune process. There is clinical evidence suggesting that individuals who develop with T1DM are genetically predisposed to this β-cell destruction. This evidence is several fold. At the time of diagnosis, the presence of anti-insulin and anti-islet cell antibodies is seen in the blood, along with the presence of inflammatory cells around the islets. T-lymphocytes are also activated. Genes located on chromosome 6, the HLA (Human Leukocyte Antigens) genes, help the immune system to distinguish between one’s own cells and foreign cells. There are many different alleles (copies) of the HLA genes. The genetic risk of inheriting T1DM is explained in over 50 percent of the cases by the presence of the genes HLA-DR, HLA-DQ, and HLA-DP. Specifically, in the general population, only 50 percent of the population inherits a copy of the DR genes DR3 and DR4, and less than three percent have two alleles. But, in T1DM, at least one allele of DR3 or DR4 is found in 95 percent of Caucasians, with the prevalence of developing T1DM even higher if the individual has both DR3 and DR4.

Symptoms of T1DM will occur when 80 to 90 percent of the β-cell mass is destroyed. The lack of insulin results in several intracellular abnormalities in both muscle and liver such as excessive hepatic glucose production, decreased muscle glucose uptake, and glucose intolerance. When insulin is secreted from the pancreas, it is dumped into the venous effluent, where it directly passes through the liver. Normally, 50 percent of the insulin is removed from the circulation on this first pass. If there is no insulin being secreted, there is no “cap” on the insulin counter-regulatory hormones: glucagon, catecholamines, growth hormone, and glucocorticoids. This results in an increase in hepatic glucose output and a decreased extraction of glucose from the blood by the periphery. If the liver is dumping glucose, and the skeletal muscle is not able to take that glucose inside the cell, high blood glucose levels develop and continue to increase. This is uncontrolled diabetes, and, in its worse form, results in dehydration, loss of acid-base balance, circulatory shock and death.

Without the help of insulin, glucose does not diffuse easily across cell membranes. High concentrations of glucose cause a fluid shift as the body tries to equalize the osmotic pressure between the intracellular and extracellular fluid. Both intracellular and extracellular fluids are lost in uncontrolled diabetes. Increased osmotic pressure in the extracellular fluid (where there is a high concentration of glucose) results in a shift of water from the intracellular fluid to the extracellular fluid. When blood glucose levels are greater than ~ 180 mg/dl, glucose spills into the urine. Extracellular fluid is lost by water following the glucose in the urine (osmotic diuresis). This is due to the osmotic effect of glucose in the renal tubules which greatly decreases tubular reabsorption of water by the kidneys, causing cellular dehydration.

At this point in time, the body is sensing starvation, and shifts its fuel source from glucose to fat and protein. Increased fat metabolism results in increased keto acid levels (acetoacetic and β-hydroxybutyric) in the blood, creating diabetic ketoacidosis. When fats are supplying the primary fuel source, concentrations of ketone bodies (ketoacidosis) in the blood may increase tenfold or higher. To compound the problem, ketone bodies have a low threshold for excretion by the kidneys, and because they are strong acids, they are partially neutralized by sodium ions from the
extra cellular fluid. These sodium ions are replaced with hydrogen ions, which make the blood even more acidic. If the mechanisms mentioned above continue for weeks to months, death can occur. First priority for the person with T1DM when admitted to the hospital in diabetic ketoacidosis (diabetic coma), is to normalize his/her electrolytes and bicarbonate stores which will restore the blood pH. This is more important than normalization of the blood glucose.

We can see how this explains the previously mentioned symptoms!

- Polyuria: blood glucose higher than kidney “threshold” (usually ~180 mg/dl), glucose will spill into the urine.
- Polydipsia: tissue dehydration triggers the excessive thirst.
- Weight loss: body is wasting away (melting fat), fat metabolism is increased, fat breakdown to supply the necessary intermediates to oxidize fat.
- Polyphagia: constant hunger, as the cells sense lack of fuel.

**Exercise and Type 1 Diabetes**

Given the scenario depicted above, what are the benefits of maintaining a regular exercise program for persons with T1DM? Regular exercise allows the person with diabetes the same advantages seen in persons without diabetes (e.g., cardiovascular risk focus, metabolic improvements, body weight/fat management), plus a few more. The increase in sensitivity to insulin (need less insulin to get the same effect), decrease in cardiovascular risk (lowering blood pressure, total cholesterol, increased HDL cholesterol) are common to both populations. The effect of increased insulin sensitivity results in a decrease in the individual's insulin requirements. If the insulin intake is not decreased or additional carbohydrates (glucose) are not ingested, hypoglycemia may result either during the activity or in the hours following.

**Exercise Recommendations**

Exercise recommendations for T1DM are no different than those without Diabetes. ACSM recommends aerobic exercise (continuous, rhythmic, prolonged activities using the large muscle groups of the arms and/or legs) three to five days per week, for 20 to 60 minutes at 40 to 85 percent of heart rate reserve or 55 to 90 percent of heart rate maximum. Resistance and flexibility training are recommended two to three days per week. If the person with T1DM is over 35 years old, or is over 25 years old and has had diabetes for more than 15 years, has any risk factors for coronary heart disease, autonomic neuropathy, or any microvascular disease (proliferative retinopathy or nephropathy), he/she should undergo a medical evaluation before beginning an exercise program. This will help ensure that he/she will not exacerbate any preexisting complications by participating in an exercise program.

**Precautions**

There are certain precautions which are helpful when advising an individual with T1DM on an exercise program. Always use adequate warm-up and cool-down periods; if neuropathy is present, avoid high impact activities; for weight bearing activities, wear footwear which is properly fitted, supportive and well cushioned; use proper hygiene, keeping feet dry and clean; and, most importantly, perform regular blood glucose monitoring.

To help regulate the glycemic response to exercise several steps can be taken. Remember, everyone is different, and, depending upon how long the individual has had diabetes, how “tight” their glycemic control, and how well they know their body's response to a given exercise bout, to a certain quantity of insulin, to a certain quantity of food, some of these recommendations may or may not be applicable. 1. **Metabolic Control Before Exercise**

- Avoid exercise if fasting glucose is ≥250 mg/dl and ketosis is present
- Use caution if glucose is > 300 mg/dl and no ketosis is present
- Ingest added carbohydrate if glucose is < 100 mg/dl

2. **Blood glucose monitoring before and after exercise**

- Identify when changes in insulin or food intake are necessary
- Learn the glycemic response to different exercise conditions

3. **Food Intake**

- Consume added carbohydrate as needed to avoid hypoglycemia
- Carbohydrate-based foods should be readily available during and after exercise

Use these guidelines to help individuals with T1DM develop a personal history of his/her response. The best way to do this is to monitor blood glucose regularly and keep a written record. Overall, it is the individual's responsibility! The use of an exercise diary is responsibility! The use of an exercise diary is helpful when advising an individual with T1DM on an exercise program. Always use adequate warm-up and cool-down periods; if neuropathy is present, avoid high impact activities; for weight bearing activities, wear footwear which is properly fitted, supportive and well cushioned; use proper hygiene, keeping feet dry and clean; and, most importantly, perform regular blood glucose monitoring.

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**References**

Get out of sales and go fishing!

This is the sixteenth edition of the Coaching News column, sponsored by Wellcoaches Corporation in alliance with ACSM, and it appears regularly in ACSM's Certified News. Our thanks to Robert Rhode, Ph.D., for this title used in his presentation, “Coaching Behavior Change Using Motivational Interviewing,” at IHRSA 2007.

What would happen to your personal training business if you stopped selling training and focused instead on helping your clients clarify their goals, motivations, and the value of becoming fit? Would your business wither or grow?

My money is on growth.

I’m not suggesting that you stop charging for your services or that there is something shameful about selling. I am suggesting that a change in perspective—from selling to fishing—will help your clients clarify why they want to be fit and why they train with you. As a result, your clients are more likely to be intrinsically motivated and, therefore, more successful. They will also happily train with you for longer periods of time.

So what is fishing and how do you do it?

Let me answer this question through the lens of Motivational Interviewing (MI), an evidence-based methodology for helping people change behavior. MI is “a client-centered, directive method for enhancing intrinsic motivation to change by exploring and resolving ambivalence.” Let’s explore this further.

First, MI’s focus is wholly on the client—his/her agenda, motivations, perspective. To preserve this focus, it’s essential to fish for information (“Tell me more…”). Go fishing! This is the perfect time to ask, “Now that I know you don’t enjoy cardio exercise, how do you feel about creating a program that integrates shorter bouts of aerobic training with strength training?” or “I understand your reluctance to strength train because you don’t want to develop bulky muscles. May I share with you some of the science that speaks to that concern?” My clients always say, “yes” when I ask permission and I believe yours will as well.

Secondly, MI proposes that change occurs naturally and fishing gives you an effective way to encourage this natural human propensity. To do this, listen for “change talk.” Statements that begin with “I want to…” or “I can…” or “I started…” or “I will…” or “I need to…” give voice to your clients’ motivations and intention to act. And when you hear change talk, don’t just sit there! Reflect it back to your client, reinforce it by asking for more information (“Tell me more…”). Go fishing and keep the lure dangling where your client can see it!

Reinforcing your clients’ change talk is important because “people are more persuaded by what they hear themselves say than by what someone tells them.” In other words, your clients will always be more motivated by what they say themselves than by what you tell them about your service or the promise of exercise.

Third, MI assumes that ambivalence is a natural part of the change process. Therefore, don’t ignore or diminish your clients’ ambivalence when you hear it. Instead, embrace it—after all, change doesn’t happen without it. Help your clients resolve their ambivalence by amplifying the discrepancy between their present behavior and their goals.

When your client misses a workout, rather than reminding them that they can’t achieve their goals without putting in the time, say instead: “I’m curious. How did it feel to not come to the club when you said you would?” or “What was great about giving yourself an unplanned day off from your workout?” These questions are neutral in tone, respectful, non-judgmental, and appreciate that the client has choice about doing or not doing the healthy behavior.

You can then ask, “What would you do differently next time?” or “What did you learn?” Questions like these help your clients clarify their motivations and reinforce their commitment to their goals. Both outcomes also strengthen the value of the work they do with you.

In summary, if you fish effectively you can sell less. You create for your clients a richer training environment by encouraging them to hear their own change talk, explore their goals and motivations, and articulate for themselves all they receive from your service. In short, fishing gives your clients a powerful framework for success. And the greater your clients’ success, the greater is your reward—personally and professionally. Go fishing!

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References

The Coaching News column is sponsored by Wellcoaches Corporation, the leader in health, fitness, and wellness coaching training and delivery of wellness coaching services, in partnership with ACSM. To learn more about this topic or other topics on coaching health, fitness, and wellness, visit www.wellcoach.com.
Avoiding Possible Interactions Between Exercise and Diabetic Medications

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The presence of Diabetes Mellitus presents specific challenges with regard to effective maintenance of normal or near normal blood glucose levels before, during, and after physical activity. Given the many health benefits bestowed by exercise, though, it has been and continues to be an integral cornerstone of diabetes management. Certain prescribed medications, including some oral hypoglycemic and other diabetic medications, can affect the body’s metabolic response to exercise, however, frequently causing hypoglycemia (a blood glucose level of less than 70 mg/dl). In order to help diabetic individuals engage in regular exercise with a minimal risk of such potentially negative metabolic changes, it is important for health and fitness professionals to gain a better understanding of the actions of such medications and their potential glycemic effects.

**Oral Hypoglycemic and Other Diabetic Medications**

To date, there are Food and Drug Administration (FDA) approved oral Diabetic medications available in six different classes, along with three injectable ones (including insulin). Many oral drugs in the sulfonylurea class (see Table 1) increase the risk of developing hypoglycemia during and after a bout of physical activity. Older-generation sulfonylureas (such as Diabinese and Orinase) cause insulin release from the pancreas and somewhat decrease insulin resistance; due to their longer duration of up to 72 hours, though, gives them a greater potential to cause individuals’ blood glucose levels to go too low during and/or after any physical activity. Second-generation sulfonylureas, such as DiaBeta, Micronase, Glynase, Amaryl, and Glucotrol, generally are cleared from the body more quickly (in 24 hours or less) and thereby present a smaller risk of causing exercise-associated hypoglycemia. Among these, DiaBeta, Micronase, and Glynase convey the greatest risk due to their slightly longer duration (24 hours versus only 12 to 16 hours for the other two). Individuals will need to check their blood glucose levels more often when exercising (and afterwards) if they take any of these longer-lasting oral hypoglycemic medications. When exercise becomes regular, they may also benefit from checking with their health care providers about lowering their doses, particularly if they are experiencing more frequent lows with exercise. For the most effective dosage adjustments, diabetic exercisers should document all bouts of hypoglycemia after verifying them with blood glucose monitoring.

Most of the medications in the remaining classes, however, are far less likely to affect glycemic responses to exercise. For example, insulin sensitizers like Avandia and Actos mainly improve the action of insulin at rest, not during exercise, so their risk of causing exercise-associated hypoglycemia is almost nonexistent. Similarly, Glucophage and Glucophage XR (the extended release form of metformin) are unlikely to cause it because their main action is to lower liver glucose output overnight, which has little effect on exercise responses. Prandin or Starlix use potentially increases risk if taken immediately before prolonged exercise as they increase insulin levels temporarily when taken before meals, and postprandial exercise in individuals with Type 2 Diabetes Mellitus (T2DM) lowers blood glucose levels more than the same bout done pre-breakfast (and before insulin is released). Medications that slow down the absorption of carbohydrates (Precose and Glyset) do not directly affect exercise, but can delay effective treatment of hypoglycemia during activities by slowing the absorption of carbohydrates ingested to treat this condition. Finally, the newest class of oral diabetic drugs, dipeptidyl peptidase-4 inhibitors (DPP-4 inhibitors), extend the action of insulin, but apparently do not increase the risk of exercise-induced hypoglycemia in individuals with T2DM already being treated with metformin.

Most of these oral medications are used by individuals with T2DM, who commonly take a combination of two or more of them in an attempt to more effectively control glycemia. Certain medications themselves are already combination drugs; for example, Glucovance comprises of glyburide and metformin. Some recent research, though, has additionally indicated the use of metformin in insulin-resistant individuals with Type 1 Diabetes Mellitus (T1DM) who are experiencing “double diabetes” with characteristics of both types. Individuals with either type of diabetes can certainly benefit from the insulin-sensitizing effects of an acute bout of exercise and regular physical training, both of which improve insulin action and generally lower blood glucose levels.

There are also two new injectable diabetic medications (listed in Table 1) that can be used by individuals with either T1DM or T2DM: Byetta (exenatide, or extendin-4) and Symlin... Continued on Page 9
Diabetic Medications... Continued from Page 8

(pramlintide), a synthetic form of amylin, which is a hormone normally co-released from pancreatic beta cells with insulin. The main exercise-related concern with the use of these medications is that they both delay the emptying of food from the gut after a meal and could, therefore, slow the release of ingested carbohydrates taken to prevent or treat low blood glucose levels during a bout of exercise. Consequently, to err on the side of safety, if hypoglycemia is likely to occur during physical activity, neither Byetta nor Symlin should be injected within two hours prior to scheduled physical activity.

Precautions for Insulin Use

Although individuals with T1DM must take exogenous insulin, supplemental doses are eventually prescribed for up to 40 percent of individuals with T2DM, making insulin use widespread. Insulin users, particularly ones with T1DM, face a potentially more complicated exercise-medications interaction because they must precisely balance insulin and blood glucose levels to avoid both hypoglycemia and possible elevations in glucose levels during exercise. Longer duration exercise is more likely to have a glucose-lowering effect (unless insulin is deficient and ketone levels are moderate or higher), but shorter bouts of intense exercise, such as sprinting or heating weightlifting, can also cause blood glucose levels to rise from the release of exaggerated amount of counterregulatory hormones like epinephrine and glucagon. In spite of the additional challenges involved, one of the best strategies for optimizing management outcomes is to learn the effects of exercise on insulin action and differing insulin regimens on glycemic control. Today, there are many medical options and they are constantly expanding. The majority of T1DM insulin users and some T2DM users requiring insulin choose to utilize a combination of short- and long-acting insulin (varying by time to peak action and total duration) given two to four (or more) times daily. Others may receive a continuous infusion of short-acting insulin that follows a basal-bolus regimen by using an insulin pump.

The goal during exercise is to mimic the metabolic responses of non-diabetic individuals. When no more than minimal (basal) levels of insulin are circulating in the bloodstream during exercise, normoglycemia will be more effectively maintained. Given that both insulin and muscular contractions evoke separate mechanisms that cause muscles to take up glucose from the bloodstream, they additively increase muscle glucose uptake during exercise. Consequently, the type of insulin taken and the timing of its use can have a large effect on glycemic responses to physical activity. The onset, peak and duration of various insulin are listed in Table 2.

If an individual exercises when exogenous insulin levels are peaking, the risk of hypoglycemia is greatly increased, particularly when failing to compensate with reduced insulin doses or consumption of additional carbohydrates. For instance, intermediate-acting N injected at breakfast will peak around noon and exert its effects throughout the afternoon. If exercise is done after lunch without an increased carbohydrate intake at the prior meal or lower morning dose of N being given, blood glucose levels may decrease more rapidly than at other times of day with lower circulating levels of insulin. Exercise done within two hours of the administration of a rapid-acting insulin analog will also require appropriate compensation. Conversely, if only Lantus or Levemir (both of which provide basal insulin coverage for 24 hours) are circulating during an activity, then hypoglycemia will be much less likely to result. Likewise, insulin pump users can normalize their response to exercise by either disconnecting their pumps or reducing programmed basal rates during physical activity, both of which will lower circulating insulin levels closer to non-diabetic levels. Some pump users also decrease their basal rates before and/or after the activity, depending on how long it lasts and on their individual blood glucose responses.

Medications to Control Other Related Health Problems

Besides taking medications for diabetes control, many individuals may also take others to control elevated blood lipids (especially cholesterol levels), hypertension, and other coexisting health problems. Most medications taken for non-diabetic reasons will not affect exercise glycemia or other responses directly, with a few notable exceptions. Use of a class of drugs to treat high cholesterol levels called “statins” for short (including Lipitor, Mevacor, Pravachol, Crestor, and Zocor) may result in unexplained muscle pain and weakness during physical activity, possibly by compromising the muscles’ ability to generate energy effectively. However, muscle cramps during or after exercise, nocturnal cramping, and general fatigue all resolve after statin use is discontinued. If an individual taking a drug from this class experiences any of these symptoms with exercise, he or she needs to consult with a doctor about possibly switching to another cholesterol-lowering medication. Moreover, any prescribed drugs taken to reduce body water levels (diuretics like Lasix, Microzide, Enduronic, and Lozol) and improve blood pressure can lead to dehydration and

<table>
<thead>
<tr>
<th>Mechanism of Action(s)</th>
<th>Brand Name (Generic Name)</th>
<th>Class of Drug</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucophage, Glucophage XR</td>
<td>Prandin (repaglinide), Starlix (nateglinide)</td>
<td>Meglitinides/ Phenylalanine derivatives</td>
</tr>
<tr>
<td>Helps control glycemic spikes for three hours after meals by delaying gastric emptying</td>
<td>Januvia (sitagliptin phosphate), Galvus (vildagliptin)</td>
<td>DPP-4 Inhibitors</td>
</tr>
<tr>
<td>Stimulate beta cells to increase insulin secretion, but only for a very short duration (unlike sulfonylurreas)</td>
<td>Symlin (pramlintide acetate)</td>
<td>Amylin (injected) Incretins (injected)</td>
</tr>
<tr>
<td>Decrease liver output of glucose while increasing liver and muscle insulin sensitivity, no direct effect on beta cells</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Promote insulin secretion from pancreatic beta cells; some medications may increase insulin sensitivity</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Diabetic Medications... Continued on Page 10
Dizziness from hypotension, but will not likely affect blood glucose levels. Vasodilators such as nitroglycerin increase coronary blood flow during exercise, but can also induce low blood pressure, which increases the risk of fainting during or following an activity. Finally, beta-blockers (e.g., Lopressor, Inderal, Levatol, Corgard, Tenormin, Zebeta, and others) taken to treat heart disease and hypertension lower resting and exercise heart rates. For individuals using such a blocker, their heart rates will not reach age-adjusted values at any intensity of exercise.

On the other hand, if taking either ACE inhibitors (Capoten, Accupril, Vasotec, Lotensin, Zestril, etc.) or angiotensin II receptor blockers (ARBs, such as Cozaar, Benicar, and Avapro), which are commonly prescribed for diabetic individuals to reduce blood pressure and/or protect the kidneys, individuals can expect no negative metabolic effects during exercise. In fact, using certain ACE inhibitors may actually lower the risk of untoward cardiovascular events for anyone with pre-existing heart disease. Other medications taken to treat heart disease and hypertension (calcium-channel blockers like Procardia, Sular, Cardene, Cardizem, and Norvasc), depression (Wellbutrin, Prozac, and others), or chronic pain (Celebrex) also have no impact on exercise responses. Aspirin and other blood thinners (such as Coumadin), however, have the potential to make individuals bruise more easily or excessively in response to athletic injuries.

Conclusion

Clearly, the use of various medications to control diabetes (and related health problems) can affect glycemic and other responses to exercise. In order to engage safely in regular physical activity without fear of unbalancing blood glucose levels, persons with diabetes must be willing to check their blood glucose at more frequent intervals than normal to determine their unique metabolic responses and any potential interactions with their prescribed medications. To help them do so, health and fitness professionals need to be aware of these possible effects and prescribe and monitor exercise appropriately.

References

13. Sherr, R., G. Coleberg, P.D., FACSM, is an associate professor of exercise science at Old Dominion University in Norfolk, Virginia. As well as being a number of articles and four books on diabetes and exercise, including The Diabetes Athlete (2001), The 7 Step Diabetes Fitness Plan (2006), and 50 Secrets of the Longest Living People with Diabetes (November 2007).

Recommended Review Articles and Resources:


About the Author:

Staying up to date with the ACSM Calendar of Events

Whether it’s upcoming dates, home study opportunities, or upcoming conferences, you will find the latest continuing education information in the ACSM Calendar of Events at www.acsm.org/coe. Calendar entries include conferences endorsed by ACSM that offer continuing education credits, as well as general non-ACSM approved programs that have been submitted to our office. If you would like to have your meeting reviewed for endorsement, select “Endorsement Application” to access the Guidelines for Endorsement and Continuing Education Credit application. For questions on ACSM continuing education opportunities, the ACSM endorsement process, or to receive the monthly calendar of events e-mail, please contact the education department at education@acsm.org. For questions on non-ACSM endorsed continuing education that could be accepted for recertification, please contact Traci Rush at certification@acsm.org.
SELF-TEST #1 (1 CEC): The following questions were taken from “Overview of Type 2 Diabetes” published in this issue of ACSM’s Certified News, pages 3-4.

1. For type 2 diabetics, the risk for a fatal heart attack or stroke is increased by over nondiabetics.
   A. 1-2 times
   B. 3-5 times
   C. 2-4 times
   D. 2-3 times

2. Type 2 diabetics only need to monitor their blood glucose before exercising, while recovery and post-exercise is not as important.
   A. True
   B. False

3. Current recommended aerobic exercise at a moderate intensity for type 2 diabetes does NOT include ______:
   A. 3-7 days per week
   B. At least 90 minutes per week
   C. 40-60% HR
   D. At least 150 minutes per week

4. Type 2 diabetes can be effectively treated through exercise is not as important.
   A. True
   B. False

5. An important tool used to determine long-term weight loss, nutrition modifications, and physical activity.
   A. Note when and how much insulin was taken
   B. Note when the last meal was eaten, and the composition of the meal
   C. Hyperglycemia
   D. Improper heart rate response
   E. Inadequate sweat response

SELF-TEST #2 (1 CEC): The following questions were taken from “Type 1 Diabetes and Exercise” published in this issue of ACSM’s Certified News, pages 5-6.

1. Type 1 diabetes is the most prevalent form of diabetes in the United States.
   A. True
   B. False

2. Type 1 diabetes is most commonly seen in
   A. African Americans
   B. Obese individuals
   C. Individuals over the age of 45
   D. Individuals who inherit HLA alleles DR3 or DR4
   E. A, B, and C only

3. A person with diabetes suffering from ketoacidosis has
   A. High blood glucose
   B. High circulating levels of acetocetic and -hydroxybutyric acids
   C. High blood pH
   D. A and B only
   E. All of the above

4. The biggest concern for a person with type 1 diabetes participating in an exercise program is
   A. Hypoglycemia
   B. Diabetic coma
   C. Hyperglycemia
   D. Improper heart rate response
   E. Inadequate sweat response

5. Testing and recording blood glucose levels before and after exercise is good practice for the novice exerciser with type 1 diabetes. He/She should also
   A. Note when and how much insulin was taken
   B. Note when the last meal was eaten, and the composition of the meal
   C. Time of day the exercise was performed
   D. Type, intensity and duration of the exercise
   E. All of the above

SELF-TEST #3 (2 CEC): The following questions were taken from “Avoiding Possible Interactions Between Exercise and Diabetic Medications” published in this issue of ACSM’s Certified News, pages 8-10.

1. Certain prescribed medications, including some oral hypoglycemic and other diabetic medications, can affect the body’s metabolic response to exercise, frequently causing hypoglycemia.
   A. True
   B. False

2. Insulin sensitizers like Avandia and Actos mainly improve the action of insulin at rest, not during exercise, so they’re unlikely to cause exercise-associated hypoglycemia.
   A. True
   B. False

3. Which of the following diabetics medications has the greatest potential to cause hypoglycemia during or after physical activity?
   A. Actos
   B. DPP-4 inhibitors, like Januvia
   C. Glycophage
   D. Glyset
   E. Insulin

4. Type 1 diabetes can be effectively treated through
   A. Lantus
   B. N (NPH)
   C. Basal insulin
   D. Humalog or NovoLog
   E. None of these insulins

5. Which type of insulin administered two hours before the start of exercise is most likely to result in hypoglycemia due to its onset and peak times?
   A. Lantus
   B. N (NPH)
   C. Basal insulin
   D. Humalog or NovoLog
   E. None of these insulins

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  Contact: John Keener, Ph.D., nacsm@d.umn.edu, (218) 726-8531, www.d.umn.edu/~nacsm

- **October 18-19, 2007, Central States Chapter, Springfield, MO**
  
  Contact: Joel Cramer, Ph.D., jcramer@ou.edu, (405) 325-1371, www.centralstatesacsm.org

- **October 25-27, 2007, Midwest Chapter, Columbus, OH**
  
  Contact: Tim Kirby, Ph.D., kirby.1@osu.edu, (614) 292-0664, www.mwacsm.org

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  Contact: W. Craig Stevens, Ph.D., FACSM, cstevens@wcupa.edu, (610) 738-0497, www.marcacsm.org

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  Contact: Jack Young, Ph.D., FACSM, jyoung@ccmail.nevada.edu, (702) 895-4626, www.swacsm.org

- **November 15-16, 2007, New England Chapter, Providence, RI**
  
  Contact: NEACSM Office, neacsm@thocc.org, (860) 224-5888, www.neacsm.org

News You Need... Continued from Page 1

- Completed a Pre-workshop Packet and Study Guide for ACSM Health/Fitness Instructor® 2007 workshops
- Established an Exam Development Team (started at Annual Meeting last year)
- Launched Item Writing Webinars
- Launched the ACSM Certified Personal Trainer® Exam in Spanish – Available in June
- Deployed an ACSM Membership Discount For non-member, ACSM Certified Professionals

Our 70+ subject matter experts that comprise the CCRB are volunteers, and they will be as busy as ever in the coming year. Please help us acknowledge their commitment and hard work with a special “thank you.”

Another important function of our annual updates is to disseminate the activity and performance of all our certification programs. Please find the details in the table below.

### CCRB Examination Activity:

<table>
<thead>
<tr>
<th>Credential</th>
<th>Total Candidates (2006)</th>
<th>Pass Rate</th>
<th>Credentials Awarded</th>
<th>Number of Operational (Scored) Items</th>
<th>Number of Experimental (Non-scored) Items</th>
<th>Total Items</th>
<th>Time Limit</th>
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<tbody>
<tr>
<td>ACSM Certified Personal Trainer</td>
<td>1,889</td>
<td>69%</td>
<td>1,303</td>
<td>125-150</td>
<td>0-25</td>
<td>125-150</td>
<td>2.5 hours</td>
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<tr>
<td>ACSM Health/Fitness Instructor</td>
<td>874</td>
<td>67%</td>
<td>585</td>
<td>125-150</td>
<td>0-25</td>
<td>125-150</td>
<td>3.5 hours</td>
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<tr>
<td>ACSM Exercise Specialist</td>
<td>280</td>
<td>53%</td>
<td>146</td>
<td>100-135</td>
<td>0-25</td>
<td>100-135</td>
<td>3.5 hours</td>
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<tr>
<td>ACSM Registered Clinical Exercise Physiologist</td>
<td>190</td>
<td>88%</td>
<td>163</td>
<td>125-150</td>
<td>0-25</td>
<td>125-150</td>
<td>3 hours</td>
</tr>
</tbody>
</table>

“CCRB Examination Activity: January 1, 2006 – December 31, 2006.”

Also, if you haven’t noticed already, each issue of ACSM’s Certified News is now themed. In other words, each issue is specifically devoted to a single and relevant topic for the health/fitness practitioner. Plus, all CECs available in each issue are now based exclusively on the articles that appear. This makes it easier than ever to accumulate your required CECs to not only maintain your certification status, but continue to develop your knowledge base.

Finally, as a reminder for all of you whose recertification window closes on December 31, 2007: You should submit your accumulat- ed CEC’s (continuing education credits) and accompanying fees as soon as possible, to avoid the last-minute rush as the end of the year approaches. If you have any questions about your recertification status, please contact Traci Rush, ACSM’s Certification Manager, at (317) 637-9200, ext. 126.