CHAPTER 11

Diabetes

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Dr. Verity was appointed to the position stand committee on “Exercise and Type 2 Diabetes” for ACSM. He has had type 1 diabetes for 30 years and is without complications.
Only three decades ago, physical exercise for diabetics was frowned upon. In fact, diabetes was used as an excuse to avoid exercise. Today, questions continue to be asked regarding whether a diabetic can exercise safely. Does exercise actually help diabetics or does it hamper the condition? Can exercise control diabetes? Is it safe for diabetics to exercise any time? Do complications from diabetes affect one’s ability to regularly participate in exercise? To answer these questions, you must know about the disease. This chapter explains what you may do to assess a diabetic’s capabilities and design a safe and effective exercise program.

You may interact with a variety of clients, including those with diabetes. Physical exercise plays an important role in the management of diabetes. It promotes a variety of health-related benefits. Among them, it improves the body’s cardiovascular function and its ability to metabolize glucose.

Physical activity appears to play a pivotal role in preventing type 2 diabetes in men (Helmrich et al., 1991) and women (Manson et al., 1991). Still, you should realize that exercise is not an answer for all metabolic problems related to diabetes. Under certain conditions, exercise can lead to abnormally high levels of blood glucose and ketone bodies in
type 1 diabetes, and can increase the risk of low blood glucose responses in diabetics. Given the benefits and risks of exercise for diabetics, you need to understand this disease; identify practical aspects of physical activity for diabetics; and design and modify exercise programs to improve disease management and health outcomes.

**Definition of Diabetes**

Diabetes is a disorder that disrupts glucose, protein and fat metabolism. Typically, persons with diabetes have an elevated blood glucose level (called hyperglycemia) that results from deficient insulin secretion, insulin action, or both (ECDCDM, 1997). In diabetics, fasting and pre-meal blood glucose levels are usually in the range of 80 - 115 mg/dl. Diagnosis of diabetes requires that blood glucose level meets a minimum value of 126 mg/dl or greater on at least two separate occasions (ECDCDM, 1997). You should understand the acceptable limits of blood glucose for diabetics.

**Classification and Etiology of Diabetes**

Diabetes is a metabolic disorder composed of four classifications; however, this chapter will review the two primary classes of diabetes that account for 95 percent of the diabetic population, including type 1 and type 2 diabetes (ADA, 1996).

Both type 1 and type 2 diabetes have distinct causes and clinical characteristics. Each requires different strategies for disease management. Table 11.1 presents an overview of differences between type 1 and type 2 diabetes.

**Type 1 Diabetes.** Type 1 diabetes requires insulin administration (e.g., via injections or pump) to control elevated blood glucose levels. According to the National Diabetes Information Clearinghouse, this type of diabetes occurs in about 5 percent to 10 percent of the diabetic population, and usually strikes children and young adults, though disease onset can occur at any age. Risk factors for this type of diabetes include genetic, autoimmune and environmental elements (ECDCDM, 1997). Usually, a central defect, or deficient release of insulin (insulin is a hormone produced, stored and released from the pancreatic beta-cells) is the principal cause of hyperglycemia in type 1 diabetes. An autoimmune response selectively destroys the pancreatic beta-cells. That stops insulin production and creates hyperglycemia. Because insulin is an essential hormone that regulates glucose, fat and protein metabolism, the type 1 diabetic must inject insulin daily at regular intervals to maintain as normal a metabolism as possible.

Insulin action in type 1 diabetes is directly related to the degree of glucose control (Reaven, 1988). Usually, good glucose control yields normal insulin action, while poor control reduces insulin’s action. Thus, therapeutic strategies focus on achieving as near-normal blood glucose control as possible to improve insulin’s action and lessen the likelihood for long-term complications associated with this type of diabetes.

**Type 2 Diabetes.** Type 2 diabetes may require dietary intervention, oral drugs and/or insulin injections to control blood glucose levels. Previously called non-insulin-dependent diabetes mellitus (NIDDM) or adult-onset diabetes, this type of diabetes accounts for 90 percent to 95 percent of diagnosed cases of diabetes. You must identify risk factors for type 2 diabetes, including

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<tr>
<th>Table 11.1</th>
<th>Distinguishing Characteristics Between Type 1 and Type 2 Diabetes</th>
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<tr>
<td><strong>Type 1</strong></td>
<td>Insulin requiring (formerly: juvenile onset)</td>
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<tr>
<td><strong>Type 2</strong></td>
<td>Non-insulin requiring (formerly: adult onset)</td>
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<tr>
<td>Synonyms</td>
<td><strong>Type 1</strong></td>
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<tr>
<td></td>
<td>Insulin requiring (formerly: juvenile onset)</td>
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<td></td>
<td><strong>Type 2</strong></td>
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<tr>
<td></td>
<td>Non-insulin requiring (formerly: adult onset)</td>
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<tr>
<td>Former Abbreviation</td>
<td>IDDM</td>
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<tr>
<td>Age of Onset</td>
<td>&lt; 30 years</td>
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<tr>
<td>Cases of Diabetes in US (%)</td>
<td>5-10%</td>
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<tr>
<td>Pathological Factor</td>
<td>Autoimmune deficiency 100%</td>
</tr>
<tr>
<td>Insulin Use</td>
<td>Recent weight loss</td>
</tr>
<tr>
<td>Body Weight History</td>
<td>Uncommon</td>
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<tr>
<td>Obese at Diagnosis</td>
<td>None</td>
</tr>
<tr>
<td>Insulin Production</td>
<td>Common</td>
</tr>
<tr>
<td>Ketoacidotic Episodes</td>
<td>Absent</td>
</tr>
<tr>
<td>Response to Diet Alone</td>
<td>May be present</td>
</tr>
<tr>
<td>Insulin Resistance</td>
<td>Uncommon (80% obese)</td>
</tr>
<tr>
<td></td>
<td>Deficient</td>
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<tr>
<td></td>
<td>Uncommon</td>
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<tr>
<td></td>
<td>In some mild forms</td>
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<td></td>
<td>Common</td>
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obesity, older age, family history of diabetes and physical inactivity (ADA, 1994a). In addition, minority populations have greater susceptibility to type 2 diabetes, as the risk for diabetes is higher in Native Americans, African Americans, Hispanic Americans, and Asian and Pacific Island Americans compared to Non-Hispanic whites (CDC, 1997). Clinically, type 2 diabetics often report recent vision problems and slow-healing wounds (ADA, 1993). Most type 2 diabetics produce insulin, yet suffer from a “peripheral defect” in insulin action (e.g., skeletal muscle) resulting in poor insulin action, or insulin resistance, which is primarily responsible for hyperglycemia.

Although insulin resistance is common in peripheral tissues (e.g., skeletal muscle, liver) and a universal feature of type 2 diabetes, lifestyle changes that focus on diet and physical activity to promote weight loss can favorably modify insulin action (Bourn et al., 1995). Therefore, a primary strategy for managing type 2 diabetes is to improve insulin action through a reduction in body weight/fat and an increase in physical activity, as insulin resistance has been linked not only with hyperinsulinemia and hyperglycemia, but also with an increased prevalence of hypertension and hyperlipidemia (Reaven, 1988). Insulin resistance also contributes to the progression of cardiovascular and peripheral vascular disease in type 2 diabetics and increases both morbidity and mortality. Weight loss improves the quality of life and reduces the morbidity related to insulin resistance.

You must realize that both types of diabetes are associated with serious complications and premature death. Additionally, you must encourage your diabetic clientele to adopt healthy lifestyle habits and perform regular self-blood glucose monitoring (SBGM) to reduce such adverse health outcomes.

**Pathophysiology of Diabetes**

Diabetes leads to a variety of metabolic and physiologic problems. The disease affects both the macrovascular (e.g., cardiovascular disease, peripheral vasculature, cerebral vasculature) and microvascular (e.g., retina, kidney and peripheral nerves) systems. Yet the onset of problems is less likely to occur in physically active type 1 (LaPorte et al., 1986) and type 2 (Schneider, Vitug & Ruderman, 1986) diabetics. Moreover, good metabolic control is associated with a significant reduction in diabetic complications.

Macrovascular, microvascular and nerve disease complications are commonly linked to hyperglycemia and diabetes. You should know whether a client has complications because these reflect the severity and duration of the disease, and may contribute to accelerated morbidity and excessive mortality in diabetics. Diabetes affects 5 percent to 6 percent of the United States population (CDC, 1997) and is a common cause of premature onset of macrovascular diseases (ADA, 1993).

Macrovascular Disease. Large vessel disease, or macrovascular disease, is common in persons with diabetes. One type of macrovascular disease, coronary heart disease, is accelerated in people with glucose intolerance and hyperglycemia, which lead to premature morbidity and mortality. Additionally, diabetes contributes to accelerated atherogenic processes in other large vessels, including those to the lower extremities (peripheral vasculature) and to the brain (cerebral vasculature) (ACSM, 2003). Lower extremity complications usually limit the weight-bearing tolerance of afflicted individuals, and contribute to a greater risk of nontraumatic amputations. Cerebral vascular disease, another serious complication, is worsened by high blood pressure, and increases the risk of stroke in diabetics. Consequently, you must know whether a diabetic client has any macrovascular disease. If this is the case, you must modify the assessment, programming and leadership accordingly.

Multiple risk factors for macrovascular disease in the nondiabetic population are well established, and are commonly present in type 1 and type 2 diabetics (ADA, 1993). For nondiabetic populations, cigarette smoking, elevated lipid levels, high blood pressure and physical inactivity are independently related to the risk of macrovascular disease and are prevalent in persons with diabetes (ADA, 1993). Moreover, obesity is independently linked to an increased risk for macrovascular disease and is characteristic of most type 2 diabetics.

Physiological and metabolic abnormalities of diabetes that are believed to exacerbate the
macrovascular atherogenic process are glucose intolerance, hyperglycemia and insulin resistance (Reaven, 1988). Though there may be different mechanisms responsible for the pathogenesis of atherosclerosis in type 1 and type 2 diabetes, no clinical trials have found that modification of any individual risk factor for either type of diabetes lessens the risk of atherosclerotic vascular disease (ADA, 1993). Given the current knowledge regarding nondiabetic populations and atherosclerotic disease, diabetics should modify existing risk factors to lower their risk for macrovascular disease.

Microvascular and Neural Complications.

Small vessel diseases, or microvascular complications, and nerve diseases are common outcomes of long-standing diabetes. Usually, the onset of microvascular disease progressively contributes to failure of the target tissue involved. The three different types of microvascular complications include retinopathy (eye disease), nephropathy (kidney disease) and neuropathy (nerve disease). Respectively, these complications of diabetes are the leading cause of new blindness and end-stage renal disease in adults, and contribute to nervous system damage in 60 percent to 70 percent of diabetics (ECDCDM, 1997). Moreover, these complications can affect work tolerance, as well as the mode and intensity of work performed.

You must know whether microvascular complications exist to safely and effectively program exercise for diabetics.

Research has shown that near-normalization of blood glucose reduced the risk for onset and/or progression of microvascular disease in type 1 diabetics by more than 50 percent (ADA, 1994b), and additional research suggests similar outcomes for type 2 diabetics (ADA, 1994a). Compelling data links diabetes complications with poor blood glucose control, and affords diabetes healthcare professionals persuasive evidence about the importance of maintaining metabolic control through self-blood glucose monitoring (SBGM) to prevent or delay progression of complications. Thus, you can help in diabetes management by encouraging clients to maximize glucose control and lessen the progression of small vessel complications.

**Therapeutic Interventions for Diabetes**

The core elements of diabetes therapy include insulin, diet and exercise, and focus on blood glucose regulation (e.g., diet and insulin). The primary goal of treating diabetes is not only to normalize glucose metabolism, but also to delay or prevent disease complications common to diabetes. Diabetes treatment has expanded to include behavioral strategies to enhance self-care management of the disease (Figure 11.1). You are now part of the diabetes management team and can motivate clients to participate safely and regularly in physical activity. Also, you must be proactive in communicating with other members of the diabetes treatment team (e.g., personal physician, nurse educator) to ensure the safety and effectiveness of a physical activity program.

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**Table 11.2**

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<thead>
<tr>
<th>Benefits of Regular Physical Activity on Health-Related Parameters in Type 1 and Type 2 Diabetes</th>
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<tr>
<td><strong>Cardiovascular-Related</strong></td>
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<tr>
<td>• aerobic capacity, or fitness level</td>
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<tr>
<td>• resting heart rate</td>
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<tr>
<td>• blood pressure in mild-moderate hypertensives</td>
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<tr>
<td>• work of the heart at submaximal loads</td>
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<tr>
<td>• abnormal thickening of the heart</td>
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<tr>
<td>• Lipid/Lipoprotein Alterations</td>
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<td>• VLDL/Triglycerides</td>
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<td>• Risk Ratio (Total cholesterol/HDL)</td>
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**Change**

**Car**

diovascular-Related

• aerobic capacity, or fitness level
• resting heart rate
• blood pressure in mild-moderate hypertensives
• work of the heart at submaximal loads
• abnormal thickening of the heart

**Lipid/Lipoprotein Alterations**

• HDL
• LDL
• VLDL/Triglycerides
• Total Cholesterol
• Risk Ratio (Total cholesterol/HDL)

**Metabolic Aspects**

• insulin sensitivity
• glucose metabolism
• thermic effect of food
• basal and postprandial insulin needs

**Psychological Aspects**

• self-concept/self-esteem
• depression
• stress response to psychologic stimuli
Exercise Benefits: Its Role in Diabetes Management

Regular physical activity and/or exercise spurs fitness benefits for both type 1 and type 2 diabetics (Table 11.2). Mild to moderate exercise may assist with daily glucose regulation on a short-term basis for both type 1 and type 2 diabetes, which may explain the role of regular exercise to favorably alter metabolic functions related to glucose metabolism. Regular exercise helps lessen cardiovascular risk factors, such as mild to moderate hypertension, insulin resistance and abnormal lipid profiles. Regular exercise affects not only metabolic control, but also factors related to cardiovascular and psychological health in diabetes.

Short-term Benefits of Exercise in type 1 Diabetes

Although circulating insulin is derived from an exogenous injection site, or through a continuous infusion pump, exogenous insulin absorption does not mimic the normal insulin secretory pattern, especially during physical exercise. Consequently, insulin administration poses a potential problem for type 1 diabetics to sustain near-normal glucose levels while exercising. Yet some medical professionals still believe that exercise is not appropriate for type 1 diabetics. They identify the risks for diabetics to participate safely in physical activities.

Insulin therapy for most type 1 diabetics typically consists of multiple-dose exogenous insulin injections. Exogenous insulin absorption is not well regulated and results in varying degrees of insulin excess or deficiency in the peripheral blood. Insulin levels are very important during the increased metabolic demands of physical exercise. In type 1 diabetics, several factors influence the blood glucose response to exercise, including the time of the insulin injection; location of insulin injection (i.e., active versus nonactive muscle sites); pre-exercise glucose; pre-exercise nutrition; intensity and duration of the exercise session; and the novelty of the exercise performed.

Given so many factors to regulate, it is not surprising that physical exercise brings about unpredictable blood glucose responses in type 1 diabetes. Because of the dependency upon exogenous insulin and an inability to regulate the absorption of insulin, type 1 diabetics commonly oscillate between insulin excess and insulin deficiency. Hence, the degree of “insulinization” and the level of blood glucose before the start of exercise determine the blood glucose response during and after exercise for type 1 diabetics. In well-controlled or well-insulinized type 1 diabetics, a single session of moderate exercise brings about normal metabolic responses. Under certain conditions, blood glucose may increase or decrease, depending on insulin levels.

Hypoinsulinemia. Hypoinsulinemia, or insulin deficiency, results in elevated blood glucose and ketone bodies before exercise. Insulin-deficient diabetics rely heavily upon free fatty acids (FFA) as a primary energy source, which leads to elevated ketones in the blood and urine.

What happens when an insulin-deficient diabetic exercises? As work increases, there is an increase in metabolic functions to provide adequate fuel for the body. Unfortunately, a person with inadequate insulin is not able to adequately regulate blood glucose levels, and experiences an increase in blood glucose, along with an increase in FFA use and ketone production. Exercise seems to worsen hyperglycemia in an insulin-deficient state because insulin action does not promote normal metabolic functions. Diabetics should use SBGM before exercise, as this is the safest way to determine whether exercise will help improve insulinization action and lower glucose levels.

Figure 11.1
Diabetes treatment requires a team approach
Hyperinsulinemia. Hyperinsulinemia, or high insulin levels, usually occurs when exogenous insulin absorption is accelerated by increased muscle contraction and blood flow. This can cause exercise-induced hypoglycemia. Insulin injection into nonactive muscle is recommended on exercising days, although the strict use of nonactive muscle as an injection site may not prevent hypoglycemia during exercise in type 1 diabetes.

Elevated insulin levels suppress hepatic glucose production, which causes an imbalance between the rate of peripheral glucose use and production, and results in lowering of blood glucose. Although a decrease in blood glucose is a beneficial short-term effect of exercise, prolonged exercise can bring about hypoglycemia. Consequently, blood glucose lowering is dependent upon such factors as pre-exercise levels of blood glucose and insulin, antecedent nutrition, and exercise duration and intensity. Regular SBGM, as well as modifying food intake and insulin dose on exercise days are useful strategies to prevent hypoglycemia in type 1 diabetics.

Post-exercise Hypoglycemia. Although hypoglycemia can occur during exercise, low blood glucose can develop many hours after an acute exercise bout in type 1 diabetics. Short-lived, post-exercise metabolic adjustments increase the risk for hypoglycemia in the first few hours following an exercise bout. To prevent acute- and late-onset hypoglycemia, strategies should combine aggressive post-exercise SBGM with adjustment of pre- and post-exercise insulin and caloric intake, as changes in insulin dose and caloric intake are not totally effective.

Postprandial (after a meal) Exercise Responses. The majority of type 1 diabetics exercise after a meal, rather than in a postabsorptive or fasted state. Usually, persons with type 1 diabetes have glucose fluctuations with each meal, due to the relative timing of insulin injection and rate of insulin absorption from the injection site. Mild exercise after breakfast blunts glucose elevations throughout the course of a day in type 1 diabetics. It may also prove valuable because of a reduced risk for hypoglycemia during and following exercise. However, postprandial exercise in type 1 diabetes is quite variable, and is dependent upon the pre-exercise glucose level, timing of insulin injection with nutrition before activity, and exercise intensity and duration.

Long-term Benefits of Exercise in Type 1 Diabetes

Our current knowledge about the long-term benefits of regular exercise on various health aspects offers a persuasive rationale for persons with type 1 diabetes to participate in physical activities. Effective exercise programming is based upon an understanding of both short- and long-term benefits, as well as the related risks.

Glucose Metabolism. A single session of exercise acutely lowers blood glucose in type 1 diabetics for a variable amount of time. The syner-

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Table 11.3

| 1) | How well controlled is my client's diabetes? |
| 2) | How often has my client been into your office over the past two years? |
| 3) | Does my client have any other co-existing conditions (e.g., hypertension or high cholesterol) or health challenges that I should pay close attention to? |
| 4) | My client has indicated that s/he is taking medications. Will these medications influence the ability to control his/her diabetes and/or engage in regular physical activity? |
| 5) | Does my client have any evidence of macrovascular complications, especially coronary-, cerebro- and peripheral-vascular diseases? |
| 6) | Does my client have any evidence of small vessel disease, especially retinopathy and nephropathy, or neuropathy? |
| 7) | Are there any precautions or considerations that I should be aware of before beginning my client on a regular physical activity program? |
| 8) | If my client has any events or problems that I am concerned about, is it okay to contact your office for advice or recommendations regarding how to handle this situation? |
The effect of exercise on lowering blood glucose is well established, and a reason that exercise should be part of disease management strategy. In type 1 diabetics, physical training improves aerobic capacity (e.g., VO_{2} max), which is related to glucose uptake and glycemic control (Arslanian et al., 1990). However, regular exercise is not effective for improving blood glucose control of type 1 diabetes and should not be a sole means of controlling blood glucose. You should recommend regular physical exercise for cardiovascular conditioning and modification of cardiovascular risk factors in type 1 diabetes, rather than as a single means for better glucose control.

Although regular exercise improves metabolic control in those with poor control, it does not facilitate a level of metabolic control that is desirable for children, adolescents or type 1 diabetic adults. You should educate clients on daily use of SMBG, insulin adjustment and nutritional needs combined with regular exercise to facilitate near-normalization of glucose control.

Insulin Sensitivity. Physical training enhances the sensitivity of peripheral tissue to insulin action in type 1 diabetes, as reflected by reduced daily insulin dosage (Koivisto, Yki-Jarvinen & DeFronzo, 1986).

While physical activity augments insulin-mediated glucose disposal into skeletal muscle and improves insulin action, physical inactivity facilitates the reversal of important glucose transport activities. Physical activity has a transient effect on glucose transport because insulin sensitivity is lessened for several days after physical activity ceases (Koivisto, Yki-Jarvinen & DeFronzo, 1986). Thus, physical inactivity may be responsible for increased insulin resistance.

Lipids and Lipoproteins. Physical training favorably alters lipids and lipoproteins in type 1 diabetics (Schneider, Vitug & Ruderman, 1986). An improved aerobic fitness is also related to favorable lipid profiles in type 1 diabetics (Austin et al., 1993), which lessens the likelihood for accelerated atherosclerosis. Lipid profiles are most effectively altered when regular exercise is combined with nutritional modifications.

Psychological Health Issues. The psychological benefits of regular exercise in nondiabetics has been rigorously substantiated; however, such benefits for type 1 diabetics have received little attention. The rigors of diabetes management are emotionally stressful, particularly for young children and adolescents, and can adversely influence glycemic control (Lustman, Carney & Amado, 1981). Given that regular exercise lessens physiological reactivity to mental stressors (Kelley & Seraganian, 1984), it may help reduce stress by enhancing psychological well-being, and improving the quality of life for type 1 diabetics (Vasterling, Sementilli & Burish, 1988).

**Short-term Benefits of Exercise in Type 2 Diabetes**

Type 2 diabetics may suffer from abnormal insulin secretion, and hepatic and peripheral insulin resistance. Their obesity, hyperglycemia, hyperinsulinemia and physical inactivity also contribute to insulin resistance.

Glucose Levels. An acute bout of mild-moderate exercise lowers blood glucose levels, but not to hypoglycemic levels for type 2 diabetics. The amount of the decrease is related to the duration of physical activity, and is attributed to an attenuation of hepatic glucose production; meanwhile, muscle glucose uptake increases in a normal manner. Sustained insulin levels during exercise are primarily responsible for reducing hepatic glucose production.

Blood glucose levels of type 2 diabetics who perform higher intensity exercise respond much differently than to low intensity exercise. When obese, type 2 diabetics exercise at a high intensity for short durations, blood glucose levels increase in the presence of hyperinsulinemia, and may persist for up to one hour post-exercise. Thus, mild to moderate exercise is more appropriate to lower glucose in type 2 diabetes.

Insulin Sensitivity. Insulin insensitivity — or insulin resistance — is the universal abnormality of type 2 diabetes with or without fasting hyperglycemia. It significantly reduces insulin-mediated glucose uptake. Since insulin-mediated glucose uptake occurs primarily in skeletal muscle, the rate of insulin-mediated glucose uptake relates directly to the amount of muscle mass, and inversely to fat mass (Yki-Jarvinen & Koivisto, 1983). The short-term effect of exhaustive exercise can increase insulin sensitivity, or its action, for 12 to 16 hours post-exercise in most, but not all, type 2 diabetics.
Long-term Benefits of Exercise in Type 2 Diabetes

The National Institutes of Health (NIH) (1987) formulated a consensus regarding the impact of diet and exercise on metabolic control and quality of life issues for persons with type 2 diabetes. The pathogenesis of hyperinsulinemia, hypertension, hyperlipidemia and hyperglycemia, which are direct precursors for coronary heart disease, have been linked with insulin resistance (Reaven, 1988). Thus, therapy must focus on lessening insulin resistance and its health consequences.

Therapies to control glucose levels and reduce long-term complications in type 2 diabetes, especially of macrovascular origin, should feature behavioral interventions that promote: 1) prudent nutritional regimes for weight reduction; 2) compliance to prescribed oral agents and/or insulin injections, if required; and 3) a physically active lifestyle. The major premise of physical exercise as a part of managing this disease is its potential to improve insulin sensitivity and glucose metabolism. Hence, the role of regular exercise on health in type 2 diabetes is important.

Metabolic Control: Glucose Control and Insulin Sensitivity. Regular exercise improves the aerobic capacity in type 2 diabetes and is linked with modest glucoregulatory changes in \( \text{HbA}_1c \) and/or glucose tolerance, while consistent improvements in insulin sensitivity occur with or without a change in body composition (Koivisto, Yki-Jarvinen & DeFronzo, 1986). Usually, the most favorable change in glucose control accompanies regular exercise and dietary regimentation. Although improved glucose tolerance and insulin sensitivity can be achieved in mild type 2 diabetes with seven days of exercise alone, such changes are relatively short-lived and usually deteriorate within 72 hours of the last exercise bout. Thus, glucose tolerance and insulin sensitivity are a reflection of the last individual exercise bout, rather than training per se. type 2 diabetics may achieve metabolic control through a combination of physical activity and dietary regimes.

Lipids and Lipoproteins. The atherogenic nature of diabetes is largely known, and elevated lipids and lipoproteins contribute to cardiovascular disease risk in type 2 diabetes (Ruderman & Haudenschild, 1984). Increased aerobic capacity in type 2 diabetes is related to a more favorable lipid profile, which lessens the likelihood for accelerated atherosclerosis and its related mortality. The lipid-altering effect of exercise appears to be maximized when combined with a diet program and loss of weight (Wallberg-Henricksson, 1992).

Certainly, the intensity, duration and frequency of exercise training influence lipid and lipoprotein changes. Moreover, dietary advice, counseling and behavioral intervention aid in lowering fat intake and body weight. The effect of exercise on lipid and lipoprotein may depend on body weight.

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Table 11.4

Typical Activity Guidelines

- Make sure that blood glucose is monitored before and after physical activity and take recommended action if blood glucose is too high or too low.
- Know whether macrovascular and/or microvascular complications exist — these require special attention and can modify physical activity.
- Always wear a medical ID bracelet or necklace.
- If insulin injection is required for diabetes management, make injections into a nonactive muscle site on the days of physical activity.
- Report any uncomfortable perceptions or problems you are having.
- If you have co-existing heart disease you should have a stress test and obtain physician approval prior to beginning an exercise program.

For type 2 diabetes:
- Participate in low-impact activity (e.g., walking, cycling, swimming) every other day.

For type 1 diabetes:
- Participate in physical activity according to...
Body Weight Reduction. Obesity is present in four out of five type 2 diabetics (CDC, 1997). It also contributes to insulin resistance (NIH, 1987), while excess abdominal fat increases poor diabetes control, lipids levels and cardiovascular complications (Van Gaal et al., 1988). Weight loss is recommended for obese persons with diabetes, especially those with upper body obesity, as blood pressure, insulin resistance, glucose levels and lipid profiles can be favorably altered. However, most obese clients with diabetes do not lose weight, and those that are moderately successful regain it. Thus, effective therapy must address long-term weight loss and improved glucose control for obese persons with diabetes.

Although various programs promote weight loss, combining behavioral modification with low calorie diets have produced the most encouraging long-term weight loss results in type 2 diabetics (Wing, 1989). A strategy for obese people with diabetes to achieve and maintain weight loss includes a low calorie diet, physical activity and behavioral modification. Any single therapy is less effective in producing long-term weight loss (Zierath & Wallberg-Henricksson, 1992).

The addition of exercise may not significantly add to the rate of weight loss; however, physical activity augments insulin sensitivity, which has marked effects on other metabolic functions and macrovascular risk factors. You may emphasize the long-term maintenance of dietary and exercise behaviors to manage weight and glucose control in type 2 diabetics. Certainly, management strategies using self-reporting of behavior, relapse prevention training and spousal/family support systems may also help sustain weight loss in people prone to regain the lost weight.

Psychological Issues. The impact of diabetes on lifestyle and health and the psychosocial adjustments to complications later in life may have important consequences on perceived stress, glucose control and psychological health. With prolonged duration of diabetes, complications are more prevalent (ADA, 1996) and require greater psychosocial adjustments (Wulsin, Jacobsen & Rand, 1993). Long-term outcomes of diabetes add to perceived stress of disease management (Surwit & Feinglos, 1988) and affective disorders, especially depression (Gavard, Lustman & Clouse, 1993).

Given that diabetes management is emotionally stressful, particularly in elderly type 2 diabetics, and that this stress can adversely influence glycemic control (Lustman, Carney & Amado, 1981), regular physical activity may play an important role in reducing stress, enhancing psychological well-being and augmenting the quality of life for type 2 diabetics (Vasterling, Sementilli & Burish, 1988).

Pre-Exercise Screening and Client Assessment

The diabetes management team must encourage clients to participate in physical activity. While regular exercise carries significant benefits, the risks are also undeniable. It is best to proceed cautiously. You must acquire information about each diabetic client to ensure safe and effective participation in physical activity. Assessment of clients with diabetes includes the following important areas:

- Medical information
- Physician approval
- Lifestyle and habits questionnaire
- Pre-test screening
- Health-related fitness assessment

Medical Information and Physician Approval

Diabetic clients must receive physician approval to begin an exercise program. You should determine whether vascular and/or neural complications exist (Gordon, 1995). You should learn about a client's health and clinical status. How long has the client suffered from diabetes? How long has he or she taken medication? Are other co-existing conditions present (e.g., hypertension, elevated lipids, smoking habits, obesity)?

Because diabetes is a potentially progressive disease, you should develop a continuing-care plan that requires clients to have periodic (i.e., at least one physician visit per year) medical evaluations. These follow-up visits may identify the onset or progression of complications.

Depending on the client's current health status and medical history, a graded exercise test (GXT) may be advisable before the start of an exercise program (ACSM, 2006). GXTs are advisable for diabetics who are classified as being at moderate or high risk for coronary heart disease.
A GXT is needed to assess cardiorespiratory integrity — as heart disease risk is increased with both type 1 and type 2 diabetes (ADA, 1996) — and to identify safe exercise heart rate limits for persons with or without neural complications (e.g., autonomic neuropathy). A GXT can also identify a hypertensive response to exercise. You may then design a safe program.

You must ask your clients about current medication(s) for diabetes and other conditions. All type 1 diabetics and some type 2 diabetics use insulin to aid in lowering blood glucose. Prior to initiating any exercise program, the client pinpoints the daily dose(s) of insulin and location of the insulin injection. You must also keep a ready supply of simple sugar (e.g., candy bar, snacks) to counter the likelihood of low blood glucose, or hypoglycemia. In some clients who require insulin injections, physical activity combined with close monitoring of blood glucose may contribute to a lowering of the daily insulin requirement. However, any adjustment of insulin dosage must be carefully balanced with nutritional needs and close glucose monitoring. It must also be discussed thoroughly with the client’s physician, diabetes educator or nurse practitioner. Under no circumstances should you recommend an unusual lowering of daily insulin dosage.

Oral medications are commonly prescribed for type 2 diabetics. About 40 percent are prescribed insulin (CDC, 1997). The purpose of oral drugs is to lower blood glucose by augmenting insulin release and insulin action, or sensitivity. Once again, you should ask clients to identify the daily dosage of oral medications. Oral agents to lower blood glucose for type 2 diabetics include: Glucotrol XL (glipizide extended release); Prandin (repaglinide); Amaryl (glimepiride); Glucophage (metformin); and Micronase (glyburide).

Medication dosage can be reduced following a period of weight loss and/or physical activity; however, only the client’s physician should make changes in oral medications. You should encourage clients who are taking oral medications to regularly monitor and record their blood glucose, and provide this information to the physician. This may help a physician in determining dosage.

Are there other types of medications that you should anticipate in clients with diabetes? Hypertension (defined as blood pressure ≥140/90 mmHg) is an extremely common comorbid condition in diabetes, affecting approximately 20 to 60 percent of patients with diabetes, depending on obesity, ethnicity and age (ADA, 2003). Hypertensive medications are outlined in the hypertension chapter of this book. Drugs commonly prescribed to treat high blood pressure can adversely elevate blood glucose. These include diuretics, beta blockers and calcium
channel blockers. Furthermore, beta blockers are known to mask the symptoms related to low blood glucose. Other hypertensive medications may actually lower blood glucose, including ACE inhibitors and alpha-adrenergic antagonists (Ganda, 1995). The varying effects of hypertensive medications is further reason to monitor blood glucose.

You should follow standard fitness screening procedures (ACSM, 2006; Van Camp, 1993). Using a questionnaire (e.g., PAR-Q) is appropriate. If the client responds positively to a question, you must ascertain its significance through a follow-up with the client's physician. Also, if any client with diabetes has been diagnosed with coronary heart disease, or has suffered a heart attack, then this is a contraindication to exercise. The advanced personal trainer should refer the client to a clinical setting for supervised exercise.

**Lifestyle and Habits Questionnaire**

You should consider a number of factors before developing an exercise program for diabetics (Figure 11.2). Based on limitations identified by the physician, you can devise a safe and effective individualized exercise program. To motivate the client, you should devise an exercise program that considers personal interests and past and/or present exercise habits. Because more than 70 percent of diabetics do not engage in regular physical activity (Ford & Herman, 1995), you must develop an activity program that motivates clients to participate and develop long-term habits. The program should address a client's personal goals.

Identifying personal goals and needs in a physical activity program to maintain the type 2 diabetic's interest is crucial. Additionally, past exercise habits can provide important information regarding present exercise habits. Previous habits and interests can also provide you with information about the client's awareness and knowledge of his/her disease, and about his or her effort in trying to control blood glucose. Glucose control is a lifelong habit and helps ensure that exercise is safe and effective.

Education about the role of SBGM before and after each exercise session is usually presented in diabetes education classes. If your client has not participated in a series of diabetes education classes, you should encourage your client to do so. This will aid his/her understanding of the disease and the importance of regular glucose monitoring. You may also provide your client with a list of diabetes educators and other resources.

**Pre-test Screening**

You should administer the PAR-Q, review and sign informed consent and possible release forms, and measure the resting heart rate and blood pressures. The diabetic should bring his/her glucose meter on the day of the health-related fitness assessment and on subsequent exercise days for glucose monitoring before and after each exercise session.

Resting heart rate and blood pressure assessment are commonly used as a screening aid for apparently healthy persons to partake in physical activity. About 60 percent to 65 percent of persons with diabetes have high blood pressure or hypertension. Medications used to treat hypertension may actually lower the resting heart rate; however, resting blood pressure may remain elevated. Consequently, diabetics may have a normal resting heart rate but elevated blood pressure.

A resting heart rate of > 120 bpm, or resting blood pressure exceeding 180/105 mmHg, are contraindications to exercise (Gordon, 1995). Other contraindications to exercise follow previously established guidelines (ACSM, 2006).

**Health-related Fitness Assessment**

Fitness assessments are integral to effective exercise programming. You can chart client progression and set goals to motivate clients. Fitness evaluations include body composition, cardiorespiratory fitness and musculoskeletal fitness tests. Although fitness assessments can be administered, you may have to adapt the procedure for some diabetics. If any testing procedures are changed, you should record the modifications of the client's initial test so that you are consistent in your subsequent evaluations.

Body composition. Excessive body weight and/or body fat is common in diabetics. Approximately 80 percent of persons with type 2 diabetes are overweight or obese and type 2 diabetes occurs at an earlier age in overweight people (Pi-Sunyer, 1991; Mokdad et al., 2000). Skinfold and circumference measures are the preferred methods to determine body fat.
However, it is acceptable to use the same generalized equations that have established norms for age and gender of apparently healthy persons for type 1 diabetics. The determination of body fat is not very useful for type 2 diabetics, because most are obese. More importantly, fitness appraisers can measure and record skinfold thicknesses, as well as circumferences, on type 2 diabetics. These have far greater practical outcomes and can be easily compared with previous assessments.

Cardiorespiratory Fitness. Diabetics tend to participate less frequently in regular physical activity (Ford and Herman, 1995). Moreover, scientific research suggests that type 2 diabetics who perform a graded exercise test consume a lower amount of oxygen than nondiabetics throughout low level to high level work (Regenstein et al., 1995). Fitness appraisers are encouraged to use standard submaximal testing protocols to assess cardiorespiratory fitness in persons with diabetes. Also, you should include heart-rate data, as well as ratings of perceived exertion (RPE) information in a cardiorespiratory assessment. However, diabetics can pose difficulties in administering a valid submaximal test.

Many diabetics are hypertensive and take heart-rate altering medications, which make a submaximal test to assess cardiorespiratory fitness an invalid assessment. In some diabetics, you may opt for a bicycle protocol (e.g., YMCA protocol). A neural condition, autonomic neuropathy, slows the heart rate and limits the validity of submaximal protocols that assess heart-rate responses to submaximal work.

Fitness appraisers may find field tests (e.g., 12-minute walk/run test) to be suitable for the diabetic client. Yet performance in this type of test requires motivation to achieve a near-maximal effort and knowledge of pacing oneself. Because many diabetics are not physically active, the use of a field test may only be useful for those who have a recent history of regular exercise.

Many diabetics will have to undergo a stress test. It is always a good idea to obtain a copy of this report for your records through client consent. In case the cardiorespiratory fitness assessment cannot be administered, you may use the information from a stress test to aid in developing an aerobic program for your client.

Musculoskeletal Fitness. Administration of tests to assess muscle endurance, muscle strength and joint flexibility in diabetics is appropriate only in those who do not have diagnosed complications, especially microvascular (ACSM, 2001; Hornsby, 1995; Vitug, Schneider & Ruderman, 1988). Ensure medical health status prior to initiating any portion of the musculoskeletal fitness battery. Fitness appraisers are encouraged to use standard testing protocols that do not use 1-RM to assess musculoskeletal fitness in persons with diabetes (e.g., YMCA).

Guidelines for Exercise Programming

Diabetics are less active than nondiabetics. About 70 percent of persons with diabetes are sedentary (Ford and Herman, 1995). Diabetics are older, perceive their health more poorly, and identify physical or orthopedic limitations four times more frequently than their nondiabetic counterparts (Ford and Herman, 1995). You should keep these distinguishing factors in mind when devising an exercise plan.

Use of the acronym FITT has commonly focused on cardiorespiratory programming aspects, where F=frequency of activity per week; I=intensity of the exercise session; T=time of each exercise session; and T=type of activity or mode. Developing an exercise plan by using the FITT acronym is commonplace. But you should incorporate RPE to identify exercise intensity, as disease progression and complications (e.g., autonomic and peripheral neuropathy) can limit the ability to accurately assess heart rate. Additionally, the FITT program differs for type 1 and type 2 diabetics (Table 11.5).

This chapter introduces the acronym FIRST for a musculoskeletal fitness program, where F=frequency of resistance training per week; I=intensity of each lift; R=repetitions performed for each muscle group; S=number of sets performed; and T=type of exercise performed by muscle group. Just as FITT programming depends on the type of diabetes, so does FIRST programming (Table 11.6).

When developing the FIRST program, you should ensure that clients do not possess complications that might prevent safe and effective
outcomes. You may need to lower the intensity of each lift, require higher repetitions, forego lifting to exhaustion and limit isometric contractions to lessen exercise-induced blood pressure elevations.

**Exercise Programming for Type 1 Diabetes**

For type 1 diabetics, daily aerobic exercise has been recommended to better regulate insulin dosage and diet needs for glucose control (ACSM, 2006). Yet improving glucose control for type 1 diabetes is best achieved through intensive insulin therapy combined with SBGM. Thus, type 1 diabetics are best served by following the FITT principle in Table 11.5 and exercise three to five days per week to improve aerobic capacity and accrue other health-related benefits. You should know that exercise is not recommended for glucose control in type 1 diabetics, and that daily exercise is unrealistic. Moreover, higher intensity activity can increase the risk of elevating blood glucose and suffering musculoskeletal injuries (Gordon, 1995; Hornsby, 1995). Type 1 diabetics who do not have complications should exercise between 50 percent and 70 percent of functional capacity, or an RPE of 3-5 (using the 0-10 RPE scale). Each activity session should be about 20-30 minutes to spur improved aerobic fitness and health-related benefits.

Finally, strength training in type 1 diabetics may increase aerobic capacity along with increased muscle mass and improved glucose control by increasing insulin sensitivity (Soukup & Kovaleski, 1993). Type 1 diabetics who do not have complications can participate in a moderate strength-training program that mimics a program that nondiabetics use (Table 11.6). A type 1 diabetic should seek physician approval and heed strict limits on participation.

**Exercise Programming for Type 2 Diabetes**

Type 2 diabetics can follow an exercise program adopting FITT principles (refer to Table 11.5). The focus of such programming is to burn calories and lose weight (ACSM, 2006). Physical activity of 40 to 60 minutes in duration at a low intensity of 40 percent to 70 percent of functional capacity is appropriate for overweight/obese persons to burn an adequate number of calories. Research has revealed that low intensity walking improved insulin action and glucose control, and lowered body weight in type 2 diabetics (Yamanouchi et al., 1995). It confirmed that moderate physical activity is helpful for type 2 diabetics (USDHHS, 1996). Because obesity is a problem for type 2 diabetics, more moderate exercise reduces the likelihood of foot irritation and/or musculoskeletal injury.

Exercising 5 to 6 days per week maximizes caloric expenditure necessary for weight management. Although walking is the most convenient activity, persons with claudication pain may have to perform low- or non-weight-bearing activity (e.g., swimming, aquacize, stationary cycling), or alternate between different types of weight-bearing versus non-weight-bearing activities. Moreover, peripheral neuropathy, which may lead to foot irritation, may preclude weight-bearing activities, due to the possibility of foot irritation.

Finally, it may also benefit type 2 diabetics to engage in light-to-moderate resistance training (Table 11.6), which increases muscle mass and lowers basal insulin levels. Resistance training is safe and effective to provide cardiovascular and metabolic benefits for persons with diabetes (Hornsby, 1995). However, it is important for type 2 diabetics to participate regularly in a FITT program before the start of a FIRST program. Most of these clients are severely decondi-

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### Table 11.5

<table>
<thead>
<tr>
<th>Variable</th>
<th>Exercise Nondiabetic</th>
<th>Exercise Type 1</th>
<th>Exercise Type 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>3-5 d/wk</td>
<td>3-5 d/wk</td>
<td>5-7 d/wk</td>
</tr>
<tr>
<td>Intensity*</td>
<td>50-85% HR reserve</td>
<td>50-60% HR reserve initially, progressing to 60-70% HR reserve</td>
<td>50-55% HR reserve initially, progressing to 55-70% HR reserve</td>
</tr>
<tr>
<td></td>
<td>3-6 RPE†</td>
<td>3-5 RPE†</td>
<td>2-5 RPE†</td>
</tr>
<tr>
<td>Time</td>
<td>20-30 min/session</td>
<td>20-30 min/session</td>
<td>40-60 min/session</td>
</tr>
<tr>
<td>Type ‡</td>
<td>dynamic movement</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: Specific heart rate may not be appropriate for persons on heart rate altering medication (HRAM) or those with autonomic neuropathy.

†Using the 0-10 RPE scale

‡Persons may require non-weight-bearing activity or alternating with weight-bearing activities, due to peripheral vascular disease (claudication pain).
tioned. Dynamic, whole body activity through the FITT program will enhance their ability to accommodate the strength and endurance requirements of FIRST.

Guidelines for Exercise Leadership

Diabetics should consider numerous factors before starting an exercise program.

Safety before, during and after exercise is of paramount importance (Table 11.7).

You should ensure that clients learn certain practical information before exercising.

Documenting each exercise session helps you when communicating with a client’s physician about cardiovascular adaptations and metabolic changes resulting from regular exercise. A daily log may be a particularly efficient way to record vital information — both quantitative and qualitative.

In fact, a qualitative assessment of the client’s ability and performance is essential. You may evaluate the client’s self-concept, self-esteem, motivation to exercise regularly and other quality-of-life issues. You should report noticeable dysfunctional changes immediately to a physician. They may include:

- an inability to accurately palpate and obtain a heart rate
- a loss of sensation in the feet or toes during weight-bearing activities
- increasing pain in the legs during weight-bearing activities
- deterioration in reading the RPE chart
- unusual forgetfulness or memory problems

- persistent fatigue

You must evaluate the client on a daily basis and report both quantitative and qualitative information regarding the exercise session.

Barring more immediate problems, you should offer written documentation to the client’s physician on an annual basis. This documentation may compare fitness assessments to those from the previous year. They may include the frequency and amount of daily submaximal work and heart rate; medication doses; glucose levels before and after sessions (averaged weekly or monthly); and any qualitative assessments previously described.

Risks of Exercise in Clients with Diabetes

As the diabetic engages in regular physical activity, are there risks associated with participation, or will he/she develop problems? If so, what are the signs and symptoms of these problems?

The most common problem encountered by diabetics subsequent to physical activity is low blood glucose, or hypoglycemia. Hypoglycemia can occur at any time (before, during or after exercise) and is defined as blood glucose < 80 mg/dl. A client may be experiencing hypoglycemia, or an insulin reaction, when they sweat profusely; are clammy and pale-looking; get shaky; have difficulty answering specific questions; seem exhausted; or become light-headed and may pass out.

It is important then for the client to ingest a simple sugar snack (e.g., candy bar) or drink (e.g., orange juice). After five minutes, blood glucose should be checked to determine whether
more carbohydrates are needed. This cycle should be repeated until a client's blood glucose returns close to 100 mg/dl. You should also terminate the exercise session.

Is there any way to prevent the occurrence of an insulin reaction? Hypoglycemia is not totally preventable. Exercise-induced hypoglycemia most commonly occurs in insulin-requiring diabetics. To minimize the occurrence of low blood glucose, you should link each exercise session to: (1) the timing and site of insulin injection; (2) the antecedent and post-exercise nutrition; (3) the time of day; and (4) the pre- and post-exercise blood glucose monitoring.

The insulin injection should occur at least one hour before exercising, and preferably in a non-exercising area. Some insulin-requiring diabetics reduce the dosage of intermediate insulin by 30 percent, or omit the short-acting insulin by 50 percent to limit hypoglycemia. For persons on insulin pumps, a reduction in insulin dosage is recommended before, during and after mild to moderate exercise to minimize the risk of acute and late-onset hypoglycemia (Sonnenberg, Kemmer & Berger, 1990).

Consumption of carbohydrates is critical for type 1 diabetics to avoid low blood glucose levels. Between 15 and 30 grams of carbohydrates should be consumed for every 30 minutes of moderate exercise (ADA, 1994b). A complex carbohydrate snack helps lessen post-exercise reductions in blood glucose and late-onset hypoglycemia.

When the diabetic exercises is also key in avoiding hypoglycemia. Depending on insulin administration and nutrient intake, the best time for type 1 diabetics to exercise is one to two hours after breakfast, or at least in the morning hours. Postprandial exercise aids in mitigating glucose excursions throughout the day and is not as susceptible to dramatic decrements in blood glucose, as is the case at other times.

Yet it is also important to individualize an exercise regimen. A program must fit into a diabetic's schedule.

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### Table 11.7

**Practical Recommendations When Participating in Physical Activity for Persons with Type 1 and Type 2 Diabetes**

<table>
<thead>
<tr>
<th>Check with your Physician:</th>
<th>Exercise with Partner:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• You may need to limit the intensity of physical activity, especially if any disease complications are present;</td>
<td>Affords a “support system” for the physical activity habit. Initially, diabetics should exercise with a partner until glucose response is known. Ideally, a partner who accompanies the physically active diabetic is a source of social support, and encourages continued participation in this healthy lifestyle.</td>
</tr>
<tr>
<td>• You may want to join a supervised program for guidance and assistance, especially if you have not been physically active for a long period of time.</td>
<td></td>
</tr>
<tr>
<td>• If using insulin, diabetics may be instructed by their physicians to reduce rapid or short-acting insulin dosage by 50 percent to limit hypoglycemia.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Self-blood Glucose Monitoring (SBGM):</th>
<th>Wear a Diabetes I.D.:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perform before and after each physical activity session. Excellent cognitive training for diabetics to understand individual glucose response to physical activity. It is important to ensure that your blood glucose is in relatively good control before beginning higher intensity physical activity. If your blood glucose is:</td>
<td>Never leave home without it. Hypoglycemia or other problems can arise that require an understanding of the condition.</td>
</tr>
<tr>
<td>• &gt; 250 mg/dl, then higher intensity physical activity should be postponed;</td>
<td></td>
</tr>
<tr>
<td>• &lt; 100 mg/dl, then eat a snack consisting of easily absorbed carbohydrates (10-20 g);</td>
<td></td>
</tr>
<tr>
<td>• between 100-250 mg/dl, then physical activity can be performed.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Keep a Daily Log:</th>
<th>Wear Good Shoes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Record value and time of day the SBGM is performed and amount/timing of any pharmacologic agent (e.g., oral drugs or insulin). Also, include approximate time (mins), intensity (heart rate) and distance (miles or meters) of each activity session. This will aid the diabetic in understanding the type of response to possibly expect from specific physical activity bouts.</td>
<td>Proper-fitting and comfortable footwear can minimize foot irritations and sores, and reduce the occurrence of orthopedic injuries to the foot and lower leg.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plan for an Exercise Session:</th>
<th>Practice Good Hygiene:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• how much (e.g., time and intensity) activity is anticipated?</td>
<td>Always take extra care to inspect feet for any irritation spots to prevent possible infection. Tend to all sores immediately. Report hard-to-heal sores to your physician. Prevent irritations when physically active by using Vaseline on feet and wearing socks inside-out.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Modify Caloric Intake Accordingly:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Through frequent SBGM, caloric intake can be regulated more carefully on days of and following physical activity. For insulin-requiring diabetics, blood glucose can drop after physical activity and latent post-exercise hypoglycemia can be prevented. Also, in consultation with your physician, a decrease in insulin dosage may be necessary.</td>
<td></td>
</tr>
</tbody>
</table>
Self-blood glucose monitoring is essential for type 1 diabetics and is strongly recommended for type 2 diabetics. Glucose monitoring is appropriate before and after exercising. Given the understanding of glucose levels, diabetics can take more appropriate routes of action to lessen the frequency of severe glucose shifts.

What about high blood glucose levels? Elevated blood glucose occurs in diabetics who are not well insulinized because of excessive caloric intake and/or not enough insulin. Exercise will only worsen the hyperglycemia and ketone levels when pre-exercise glucose levels are elevated. Pre-exercise glucose levels exceeding 250 mg/dl indicate poor control and necessitate postponement of exercise. A log enables a management team to evaluate glycemic excursions and prevent a recurrence. When the blood glucose is high, an appropriate dosage of insulin is necessary for the diabetic. Exercise is not recommended until the blood glucose is < 250 mg/dl.

High intensity exercise has been found to elevate blood glucose from a normal to hyperglycemic level. It is believed that the role of counter-regulatory hormones on glucose production plays a major part in this type of glycemic excursion. Moderate intensity exercise is recommended to facilitate more normal glucose levels and lessen the likelihood of musculoskeletal injury.

**Progression of Program**

The progression of the FITT and FIRST program is determined by several factors, including age, functional capacity, medical and disease complications, and personal preferences and goals (ACSM, 2001; ACSM, 2006; Gordon, 1995). Initial changes in FITT programming for diabetics should focus on the duration of the exercise session rather than the intensity. Such an approach can prevent blood glucose increases; provide a safe and effective exercise that is not unduly taxing; and increase the likelihood that someone sticks with a program.

For clients without complications, initial levels of abilities are quite different between types of diabetes. For example, type 1 diabetics follow a similar FITT program to that of apparently healthy persons. They can initially engage in continuous, moderate physical activity for 20 minutes, while type 2 diabetics may only be able to engage in low level physical activity for five to 10 minutes before fatiguing because of their tendency to be overweight or obese. The initial phase of FITT programming for type 2 diabetes may require low-intensity and short-duration (e.g., < 15 minutes) activity at least three times per week, and preferably five times per week (ACSM, 2001; USDHHS, 1996). But the type 1 diabetic may not require significant modifications in the initial phase of FITT programming. You must closely observe client response to a program, modifying it to prevent fatigue and enhance the enjoyment.

Progression of the program after the initial phase should be approached with caution, especially in type 2 diabetes. For both types of diabetics, the duration of an activity should be increased before the intensity. The duration should be gradually increased to accommodate the ability and clinical status of each client. Because diabetics are likely to be obese and older, they may require a longer period of time to adapt to program changes. Once the client is able to last for a desired amount of time, programmatic changes should be small and approached with caution to lessen the risk of undue fatigue, musculoskeletal injuries and/or relapse.

Some well-controlled type 1 diabetics may set a goal to participate in competitive athletics (e.g., 10K, marathons, triathlons, biathlons). A small number of these clients may require higher intensity, longer duration workouts. Successful participation in competitive athletics by a type 1 diabetic is dependent upon rigorous SBGM, appropriate insulinization, proper nutrient intake and regular medical visits. Still, most diabetics will not strive to compete in athletics. They will need to improve functional aspects that relate to quality of life. Because diabetes onset is related to older age, obesity and dysfunction of physiologic and neurologic processes, the most valuable aspect of any program should relate to functional outcomes specific to each client and his/her limitations.

**Medical Concerns and Disease Complications**

Are there other medical concerns that advanced personal trainers should understand? YES!! Although complications are common in diabetes (ADA, 1996),
their existence does not preclude physical activity. Rather, there are physical activity precautions and limitations for diabetics who have one or more types of microvascular and/or neural complications. The options for diabetics with disease complications are discussed below. You should familiarize yourself with diabetic complications.

Diabetics with the following complications should be referred to a clinical setting where close supervision and monitoring can occur.

Retinopathy. Although exercise increases systemic and retinal blood pressure, there is no evidence that physical activity acutely worsens the retinopathy present in diabetes (Vitug, Schneider & Ruderman, 1988). Diabetics with proliferative retinopathy who engage in low intensity exercise can significantly improve cardiovascular function. However, systolic blood pressure should be monitored during each exercise session and limited to 20-30 mmHg above resting. Clients with retinopathy may exercise safely when they are properly supervised.

Clients with retinopathy should not engage in such activities as strength training or those that require them to raise their arms over their heads. These may cause systolic blood pressure to rise dramatically. Under such circumstances, increased blood pressure may increase the likelihood of retinal hemorrhaging when proliferative retinopathy is present (Vitug, Schneider & Ruderman, 1988).

Nephropathy. Increased blood pressure is a common precursor to worsening of this microvascular disease (Graham & Lasko-McCarthey, 1990); however, it remains to be proven if exercise-induced blood pressure changes exacerbate the progression of nephropathy. It is prudent to avoid activities that cause systolic blood pressure to rise to 180-200 mmHg (e.g., performing Valsalva maneuver, high intensity aerobic or strength exercises), as systemic pressure increases could potentially exacerbate the progression of this disease. Persons with progressive nephropathy or end-stage renal disease may benefit from lower intensity physical activities. Most clients with nephropathy should be referred to a clinical setting where their fragile metabolic condition may be carefully monitored. In many cases, clients with this disease participate in physical activity sessions while undergoing renal dialysis.

Neuropathy. Neuropathy is a nerve disorder. The two main nerve diseases related to diabetes are autonomic neuropathy (AN) and peripheral neuropathy (PN). When this disease affects the autonomic nerves to the heart, it is called cardiac autonomic neuropathy (CAN). The heart rate is altered. The maximal heart rate drops, and the resting heart rate increases (e.g., HR rest > 100 bpm). This causes hypertension and hypotension, and increases the risk for exercise-induced hypotension after strenuous activity (Vinik, 1995).

Persons with AN have impaired sweating and thermoregulatory abilities and impaired hypoglycemia awareness. Persons with CAN exhibit a lower fitness level and fatigue at relatively low workloads due to the disruption in nerve innervation to the heart (Vitug, Schneider & Ruderman, 1988). Consequently, physical activity for these persons should focus upon low-level daily activities, where mild changes in heart rate and blood pressure can be accommodated. Any exercise program for persons with AN or CAN should require physician approval and proceed cautiously.

Peripheral nerve disease affects the extremities, especially the lower leg and feet. Repeated weight-bearing activities on insensitive feet can lead to chronic irritation, open sores and musculoskeletal injuries, especially fractures. Persons with PN are susceptible to overstretching due to loss of sensation, as well as infection, particularly when daily hygiene is lacking. Proper footwear for any weight-bearing activity is important to prevent undetectable sores, which may turn into infections. However, people with PN should participate in non-weight-bearing activities (Graham and Lasko-McCarthey, 1990). Such interventions may include aquatics, recumbent cycling, chair exercises and upper extremity exercises. Additionally, activities requiring a full range of joint motion are highly effective in reducing stiffness due to muscle contractures.

Case Studies

Case Study 1. Jim is a type 1 diabetic. He is 35 years old and has had diabetes since the age of 13. He is 5’10” and weighs 165 pounds. He currently injects insulin and monitors his blood glucose twice each day. He visits his doctor each year and reports his health as “good.” He reports no diabetes-related complications. Jim’s goal is to begin an aerobic program so that he can run...
Case Study 1. Jim is 57 years old. He was diagnosed with type 2 diabetes five years ago. He has come to you for professional assistance.

You must obtain more information about Jim's health before developing an exercise program. According to established guidelines (ACSM, 2006), Jim is classified as "diseased" and must obtain physician's approval before exercising. Jim should complete a comprehensive medical health history questionnaire to ascertain any known cardiovascular or diabetes-related complications; assess his exercise history; and obtain information about his usual meal times and insulin injections.

From this screening, you should probably recommend that Jim enroll in a diabetes education class. His two daily insulin injections are probably not adequate to control his blood glucose levels. He should try to do better. The SBGM before and after each exercise session is a requirement for you to work with him. Jim was heavily involved in high school and college sports, but has not been regularly active for about 12 years.

To develop an appropriate exercise regimen, you should conduct a fitness assessment. Results from the submaximal YMCA bicycle protocol found Jim's aerobic fitness to be average for his age and gender. His body composition from skinfold assessment was 17 percent, while his musculoskeletal fitness was good. Results from the fitness and exercise habits assessments suggest that Jim can immediately participate in aerobic activity. A program should be individualized and focus on the lower-end range for each FITT element. His desire to participate in a 10K does not preclude alternative activities (e.g., recumbent cycle ergometer, upright cycle ergometer, stair stepping). You should record each blood glucose reading, and if his pre-exercise blood glucose is > 250 mg/dl, postpone the session. If Jim's pre-exercise blood glucose is < 100 mg/dl, he should consume about 15-20 grams of carbohydrates for every 30 minutes of anticipated exercise.

When initiating the FIRST program, begin at the lower range of recommended frequency, intensity, repetitions and sets. It is essential to learn proper lifting techniques and breathing cues (e.g., exhale on effort) before starting a FIRST program. If Jim does the FIRST program following the FITT regime, he should check his blood glucose after completing his resistance training. If there is a long delay (e.g., several hours) between the aerobic and resistance training programs, then he should do the SBGM before and after each respective regime.

Case Study 2. Jane is 50 years old and was diagnosed with type 2 diabetes five years ago. Jane is 5'2" and weighs 180 lbs. She is currently taking an oral medication (troglitazone) for her diabetes and an anti-hypertensive medication (beta blocker) for her stage 1 high blood pressure, and does not monitor her blood glucose. Jane reports that her health is okay. She does not suffer from complications, but gets easily fatigued doing housework and cleaning. Furthermore, she reports that taking a stroll with her husband at the local mall makes her knees and hips uncomfortable after about 15 to 25 minutes. She has not seen her doctor in over a year; however, her diabetes educator has encouraged her to participate in regular physical activity. She has asked you to assist in the development of an activity regime. Her goals are to improve her endurance and lose about 45 lbs.

Jane requires her recommended annual check-up on the clinical status of her diabetes (e.g., the evaluation of the presence/absence/progression of disease complications). She must receive her physician's approval to begin an exercise program with a personal trainer.

Because Jane is 50 years old and has had type 2 diabetes for more than five years, she should undergo a stress test prior to engaging in an exercise program. Her discomfort while walking requires further evaluation. The lack of regular blood glucose monitoring must be addressed. You must require SBGM before and after each exercise session as a prerequisite to your work together.

Once physician approval, information from the stress test and disease status are obtained, you can develop an exercise regimen. Of greatest importance are a client's personal interests and goals. Because Jane has difficulty with short-term weight-bearing activity, you should choose activities that are less wearing on her joints. You should help her identify enjoyable activities that she would be likely to do regularly. You should encourage her to seek out weight management professionals to advise her about losing weight.

Jane should exercise wherever the social stigma of obesity and overweight issues is minimized. Jane must feel comfortable in her exercise surroundings. This is an important issue because the exercise environment can cripple Jane's motivation to maintain her physical activity program.

What health-related fitness assessments can be administered? Jane's heart rate-altering medication (e.g., beta blocker) eliminates the use of a cardiorespiratory fitness assessment using submaximal protocols that base aerobic capacity on heart-rate determinations. A field test requiring a weight-bearing exercise (e.g., 1.5 mile walk/run test or 12-minute walk/run test) is inappropriate. The stress test conducted by her physi-
cian is an excellent starting point. From the stress test, resting and maximum parameters, including heart rate, blood pressure and RPE, can be identified. Jane’s physician can determine the upper limit of exercise intensity. Based on this information, she should not exercise at more than 70 percent of her maximum heart rate.

You can devise a FITT program for Jane. You should individualize the program and focus it at the lower range for each FITT element. The program must be safe, effective, reasonable and prudent for this type of client. The FITT should look as follows: F = 4-6 days per week; I = 50-60 percent of maximal heart rate, or RPE 2-3 (on a 1-10 scale); T (time) = 15-30 minutes; T (mode) = alternate between weight-bearing (e.g., walking) and non-weight-bearing (e.g., aquaize; recumbent ergometer; chair exercises) activities.

Is it necessary to assess a person who is already known to be obese? What will be gained? Body composition is not essential but you should do some sort of physical assessment. You should initially measure body weight, selected skinfold site thickness and circumferences. They provide a good baseline for serial assessments. Jane’s measurements were as follows: body weight - 184 lbs.; abdominal skinfold - 36 mm; iliac skinfold - 32 mm; thigh skinfold - 40 mm; tricep skinfold - 34 mm; chest skinfold - 28 mm; waist circumference - 42 in; hip circumference - 48 in; upper arm circumference - 18 in; and thigh circumference - 22 in. From these measurements, it is obvious that weight loss will have a favorable impact on her anthropometric measurements. They can also be motivating for Jane as she strives to improve her fitness and lose weight.

Should you assess Jane’s musculoskeletal fitness? No. Jane has enough to do at this point. Incorporating an additional routine into her activity regime is not appropriate at the outset. As previously indicated, start with FITT before proceeding to FIRST.

You should record each blood glucose reading before and after the activity session. Jane cannot exercise if her pre-exercise blood glucose is > 250 mg/dl. If her pre-exercise blood glucose is < 100 mg/dl, then she should consume about 15-20 grams of carbohydrates for every 30 minutes of anticipated exercise. Jane’s beta blocker for hypertension can mask hypoglycemia so you should periodically check her blood glucose, especially at the start of a program.

Jane is willing to come to your fitness facility two or three days each week. You should recommend that she exercise on two additional days. You should instruct her on the correct use of RPE to ensure a safe and effective exercise environment when she is not supervised.

Always encourage clients to drink adequate amounts of water, especially clients prone to dehydration. Discourage them from exercising when the temperature is above 80 degrees.

During the first activity session, you should instruct Jane on a designed program. Jane should be comfortable when exercising. You should not downplay the intensity level. She should expend energy. Also, she must accurately monitor her blood glucose. In order for Jane to last the recommended 30- to 60-minute exercise period, you may have to alternate a circuit of five-minute aerobic activities with 10-minute rest intervals, or initiate a low-level aerobic interval program of similar work and rest intervals. Keep in mind that the type 2 diabetic must be constantly monitored and given prompt feedback about accomplishments and progress. Also, ensure that blood glucose levels are normal when the client leaves your facility to minimize the risk of low glucose or hypoglycemia problems.

References


Austin, A.et al. (1993). The relationship of physical fitness to lipid and lipoprotein(a) levels in adolescents with IDDM. Diabetes Care, 16, 421-25.

Bourn, D.M. et al. (1995) Impaired glucose tolerance and NIDDM: does a lifestyle intervention program have an effect? Diabetes Care, 17, 1311-1319.


Yamanouchi, K. et al. (1995). Daily walking combined with diet therapy is a useful means for obese NIDDM patients not only to reduce body weight but also to improve insulin sensitivity. Diabetes Care, 18, 775-778.


Suggested Reading


