CHAPTER 9

Developing a Safe Exercise Program

A regular exercise program has many benefits for everyone. These include:

- An improved sense of well-being
- Stress reduction
- Lower blood pressure
- Lower cholesterol and increased HDL cholesterol
- Improved muscle tone and reduced risk of falls
- Better sleep
- Weight loss and maintenance
- Maintenance of bone strength
- Less risk of heart disease

If you have diabetes, you will get all these benefits from exercise. In addition, regular exercise will improve your insulin sensitivity, and if you have type 2 diabetes, regular exercise will also improve your glucose control. However, there are a number of challenges to exercising safely if you have diabetes. The challenges

include avoiding both high and low blood glucose levels during exercise, especially when you are on insulin, and how to exercise safely when you have complications of diabetes, especially neuropathy and heart disease.

Exercise has numerous benefits for people with diabetes, but it is not as simple as saying "go and exercise." Before embarking on an exercise plan, visit your physician and diabetes educator and get guidance on how to exercise safely. If you have type 1 diabetes, you may need to adjust your insulin and your carbohydrate intake before, during, and after exercise. You will also need to monitor your glucose levels more frequently.

If you have type 2 diabetes, you may also need to cut back on the insulin or oral medicines that can cause hypoglycemia. Additional modifications of the exercise plan may be necessary if you have complications of diabetes.

Acute Versus Chronic Exercise

You can think of exercise in two ways:

- Acute exercise, which means one bout of exercise
- Chronic exercise, which means regular, frequent exercise, also known as exercise training

Acute and chronic exercise have different effects on the body. One important difference that is relevant to diabetes is the effect on insulin sensitivity. A single bout of exercise will increase your insulin sensitivity, but this effect is rapidly lost within twenty-four hours. On the other hand, chronic exercise (exercise training) leads to an increase in insulin sensitivity that can last up to two weeks after stopping exercise. If you are taking insulin for glucose control and you do not reduce the dose when your body becomes more insulin sensitive, you will have low glucose reactions. If, however, you stop exercising regularly, your improved insulin sensitivity will wear off, and your glucose levels will go up unless you increase your insulin.

The impact of exercise on insulin sensitivity depends on the intensity of your exercise as well as the total amount of exercise you do per week. It appears that the amount of exercise has a bigger effect than the intensity—in other words, more total minutes of moderate exercise a week has a greater effect on insulin sensitivity than more intense exercise for fewer times per week.

Although this chapter is principally about planned exercise activity, the information also applies to unplanned exercise such as running for the bus or climbing stairs. Other heavy physical work such as gardening, cleaning house, and moving furniture can also be considered as acute bouts of exercise.

Types of Exercise

We'll discuss four types of exercise: aerobic, resistance training, flexibility, and anaerobic.

AEROBIC EXERCISE (CARDIORESPIRATORY ENDURANCE)

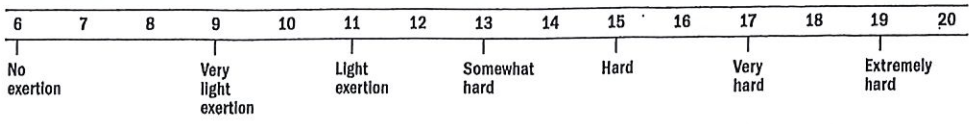
During aerobic exercise, there is sustained physical activity. The heart rate and breathing rate increase to supply additional oxygen and fuel to the muscles. Walking, bicycling, jogging, swimming, and racquet sports are examples of aerobic exercise.

The American College of Sports Medicine defines moderate exercise as 55 to 69 percent of maximal heart rate; hard (or higher intensity) exercise as 70 to 89 percent of maximal heart rate; and very hard exercise as 90 percent of the maximal heart rate and above. You can determine whether your exercise is moderate or intense in several ways:

- **Measure your heart rate using a heart rate monitor.** Your maximal heart rate will vary depending on your age and gender. A simple formula is to subtract your age from 220 for men and from 226 for women. There are also a number of websites that will calculate your heart rate for different levels of exercise and your age and gender. You can also go on a treadmill with a pulse monitor and run an intense program supervised by a fitness coach to determine your maximal heart rate.
- **The talk test.** This is a simple way of determining if your exercise level is too high. If it is just possible to hold a conversation while you are exercising, then your exercise level is moderate. However, if you are having a hard time getting your words out, then the exercise intensity is greater than the recommended range (that is, it is vigorous exercise).
- **Assessing your perception.** Evaluate how hard are you exercising by your breathing rate and level of fatigue. In the Borg perceived exertion scale (see Figure 9-1), you would rank this on a scale of 6 to 20, where 6 is no exertion and 20 is maximal exertion.

So, if you feel that your exercise is at a scale of 9 (very light), you should increase it. But if you feel the exercise is at a scale of 19 (extremely hard), you should back off. Scales of 12 to 14 (somewhat hard) are considered moderate exercise. You can multiply the number for the perceived exertion by 10 to give you an approximate heart rate. For example, if you think you are exercising at a scale of 12, your heart rate is in the range of $12 \times 10 = 120$ beats per minute.

Figure 9-1 Borg Rate of Perceived Exertion



Source: Borg, G. *Borg's Perceived Exertion and Pain Scales.* Stockholm: Human Kinetics, 1998.

This method of assessing intensity of exercise is favored if you have autonomic neuropathy or if you are taking medications such as beta-blockers, when measuring the heart rate to determine exercise intensity is not accurate.

The U.S. surgeon general recommends that most people should have a moderate level of aerobic exercise for thirty minutes or more five times a week. Types of moderate aerobic exercise include a brisk walk, bicycling (at a speed less than 10 mph), and doubles tennis. Vigorous aerobic exercise is jogging, swimming, bicycling (at a speed greater than 10 mph), and competitive sports such as basketball and squash. For weight maintenance, sixty minutes of moderate exercise five days per week may be necessary.

RESISTANCE EXERCISE (STRENGTH TRAINING)

Resistance exercise is using your muscle strength to move a weight—for example, weight lifting and weight machines. It increases muscle strength and, like aerobic exercise, improves insulin sensitivity.

Resistance or strength training using exercise machines involving multiple exercises (three sets three times a week) has been shown to significantly improve glucose control and appears to be safe. Each weight should weigh just enough so that you can't lift it more than eight to ten times a set. Blood glucose monitoring is necessary for this type of exercise.

FLEXIBILITY EXERCISE (STRETCHING)

This type of exercise helps to maintain or increase the range of motion at joints. Yoga and tai chi are examples of such exercises.

There is no good scientific evidence that stretching reduces muscle injury, but most people tend to feel good when they stretch at the beginning and at the end of their exercise session. Although stretching usually does not have a significant effect on glucose control, in some people with type 1 diabetes, just the relaxation that

comes from stretching can cause a fall in glucose levels. It is a good idea to check a few times to make sure that this is not happening to you.

ANAEROBIC EXERCISE

Anaerobic exercise is brief and intense exercise in which oxygen is not necessary for producing the energy needed by the exercising muscles. Sprinting, power lifting, and jumping are examples of anaerobic exercises.

Exercise and Type 1 Diabetes

If you have type 1 diabetes, and you are not in the honeymoon period when the beta cells still have some capacity to make insulin, you can have fluctuating blood glucose levels, and exercise can be particularly tricky. You may encounter the following problems while exercising:

DID YOU KNOW?

Regulating Glucose Levels During Exercise

The delivery and use of different fuels by the body at rest and during exercise depends on the action of the sympathetic nervous system and actions of insulin and glucagon. Having an understanding of these actions will help explain why exercise in diabetes can cause both high and low glucose levels and even lead to diabetic ketoacidosis (DKA):

- At rest, muscles mostly use fatty acids as their energy source. When you exercise, this changes. With short, intense exercise, the muscles switch to using glucose. The sympathetic nervous system facilitates this switch in fuel use. It turns off insulin release and stimulates fat cells to release glycerol and fatty acids. The fall in insulin allows the liver to make and release more glucose.
- The liver has an ability to release a lot of glucose, and when exercise is intense, glucose levels actually go up immediately after exercise. Usually the insulin goes up as well (two- to threefold) to regulate this postexercise glucose rise.
- After exercise, the glucose uptake by the muscle continues—this replenishes the glycogen stores of the muscles and the liver.

- Delivery of insulin into the body by subcutaneous (just-under-the-skin) injection makes it difficult to reduce the insulin levels at the start of exercise—this is particularly true in the case of unexpected exercise. The high insulin levels prevent the liver from making sufficient glucose to maintain normal blood glucose levels, and you can become hypoglycemic during exercise.
- With intense exercise, the increased activity of the sympathetic nervous system can make the glucose go up during and especially after exercise. The rise after exercise can be problematic if the insulin levels remain low.
- If you participate in a competitive sport, the stress of competition and the adrenaline rush can lead to insulin resistance and increased glucose levels before exercise.
- Many hours after exercise, the muscles and the liver continue to take up glucose from the blood in order to replenish their glycogen stores. So, in order to avoid hypoglycemia some hours after exercise, you need to decrease your insulin dose or increase your carbohydrate intake.
- With regular exercise (the training effect), your insulin requirements will generally fall. You will be more insulin sensitive, so you will need to adjust your basal and bolus insulin doses.
- Exercise can accelerate insulin absorption, especially if the site of injection is near the exercising muscle (for example, the thigh).

If your blood insulin levels are low and your glucose level is high before exercise, the combination of high glucose production by the liver and free fatty acid production from the fat stores during exercise can result in high glucose levels and production of ketones, which can lead to DKA. Therefore you have to be cautious about exercising if your glucose is above 250 to 300 mg/dl, especially if you also have urinary ketones.

RECOMMENDATIONS FOR EXERCISE IN TYPE 1 DIABETES

If you have type 1 diabetes, consider taking the following steps.

Keep an Exercise Log

Write down when you are exercising, the relation to the previous meal and insulin bolus, the type of exercise, the duration and intensity, how much carbohydrate (CHO) was consumed before, during, and after exercise, and blood glucose levels (see Figure 9-2). This information is essential for making appropriate changes the next time you exercise.

Figure 9-2 Example of an Exercise Log

Date		Before			During				After			
Activity	Time											
	CHO											
	Bolus											
	Basal											
Comments												

Plan Your Exercise

Plan how long you will exercise, how intense it will be, and how soon after a meal you will exercise. Try to be consistent from day to day.

Monitor Blood Glucose Levels

Take your glucose meter with you when you exercise, and check your blood glucose levels before, during (at least once or twice), and after exercise. If possible check them at least two or three times at half-hour intervals before the exercise to find out the direction of glucose changes. Prick your finger for the blood sample—do not use your forearm, because there may be a five- to twenty-minute lag in the glucose response in the arm.

With intense exercise, be prepared for lower glucose levels several hours after exercise, for example, in the middle of the night. Have a bedtime snack, or wake up and check your blood glucose.

Adjust the Insulin Dose

Before exercise, adjust the bolus or basal insulin, or both, in anticipation of the exercise.

- A bolus of a fast-acting insulin analog lasts for about four hours, and the peak is at about one to one and a half hours. If you exercise within two hours, you will need to cut back on the premeal bolus (to 50 to 75 percent of your usual dose).
- Making an adjustment in basal insulin dosing is easier if you are on an insulin pump. If you are planning for exercise of long duration (longer than ninety minutes), you may want to cut back the amount of your basal insulin for up to two hours before the exercise. If you are participating in

competitive sports, you may find that the "adrenaline rush" means that you may have to increase your basal insulin temporarily for up to two hours before the exercise.

- Adjusting the basal dosage of the long-acting insulins like glargine or detemir is trickier—you can try cutting back to 50 to 80 percent of the dose on the days you exercise. Any high glucose levels earlier in the day can be covered by giving additional bolus insulin.

During exercise your options will depend whether you are on a pump or on injections.

- If you are on the pump, you have a number of options as to what to do regarding the basal insulin delivery. For short-duration exercise lasting an hour or so, you can simply come off the pump. If the pump is taken off for more than an hour (for example, while swimming), a small bolus may be given before coming off. If you will be exercising for several hours, a temporary basal amount (20 to 75 percent of your usual dose) might be necessary. For example, if you go cross-country skiing for several hours, you may change your basal to 20 to 50 percent of your usual dose for the duration of the exercise. A similar change may be required for a marathon.
- If you are on insulin glargine or detemir, you do not have the option of changing the basal rate during exercise: your only option is to consume additional carbohydrates.

After exercise you will adjust the bolus and basal insulins for the acute effects of exercise and also for the effects of chronic exercise.

- If you get predictably high glucose levels after exercise, be prepared to give a little bolus of a fast-acting insulin analog. With intense and/or prolonged exercise, hypoglycemia can occur several hours (up to twelve to sixteen hours) afterward, and you should be prepared to reduce the basal insulin (or eat a snack). You might consider purchasing a continuous glucose monitoring system that can alert you to overnight hypoglycemia.
- After a weekend of increased physical activity such as skiing, a reduction in insulin requirements may persist for an additional twenty-four hours.
- With exercise training, you may become more insulin sensitive, and you may need to change your usual insulin regimen by cutting back on both basal and bolus insulin doses.

Eat Carbohydrates

For athletes with diabetes, it is recommended that 55 to 60 percent of the total daily kilocalories should be carbohydrates. Endurance athletes (such as long-distance runners or cyclists) should consider eating a carbohydrate-rich meal (1 to 2 grams of carbohydrate per kilogram of body weight) about three to four hours before exercising to maximize pre-exercise glycogen stores. If the exercise is unplanned, eat 20 to 30 grams of carbohydrate immediately before you exercise.

The amount of carbohydrate that needs to be consumed will depend on the duration and intensity of the exercise. Generally speaking, about 20 to 30 grams of carbohydrate is needed for each thirty minutes of exercise. Table 9-1 provides a good starting point in determining how many grams of carbohydrate you might need every half hour for different types of exercise.

The type of carbohydrate you consume can vary:

- Before exercise, you could have fruit (apples, dried apricots), bread, yogurt, porridge, pasta, or milk.
- During exercise, you could have a fruit juice/water mixture or sports drink. Sports drinks can give you some sodium and potassium as well as carbohydrate. Read the labels for the carbohydrate, sodium, and potassium

Table 9-1 Approximate Amounts of Carbohydrate for Different Levels of Exercise

Type of Exercise	Approximate Grams Carbohydrate per 30 Minutes of Exercise for a 150-Pound Person
Leisurely walk	10
Tennis (doubles), golf, bicycling (6 mph), painting, raking leaves	15
Vigorous dancing, brisk walking	20
Moderate basketball, bicycling (10 mph), shoveling snow, swimming (slow crawl)	25
Soccer, digging, running (5 mph), waterskiing	30
Cross-country skiing (5 mph), vigorous ice skating, bicycle racing, mountain climbing, swimming (fast crawl)	50

Source: Adapted from Walsh J, Roberts R. *Pumping Insulin*, 3rd ed. San Diego, CA: Torrey Pines Press, 2000.

contents. Sport gels or carbohydrate-rich bars are also good sources of rapidly absorbed carbohydrates and salts—usually, you want to drink some water with them.

- After exercise, you can have bread, potato, rice, cereal such as cornflakes, a granola bar, or cookies.

Drink Fluids

Dehydration will increase your glucose levels, so you need to drink plenty of fluids while exercising. In the two hours before exercise, drink two glasses of water, and during exercise, drink enough to replace fluid loss. For prolonged exercise such as running or cycling, drinking approximately 250 ml (8 ounces) every twenty minutes of exercise would be reasonable. Sport drinks are good for fluid and carbohydrate replacement. Avoid drinking too much fluid, because this can lead to low sodium levels.

Provide Emergency Information

Wear your MedicAlert bracelet or shoe tags, just in case you get a severe episode of hypoglycemia.