CHAPTER 9:

EXERCISE AND THE PUMP

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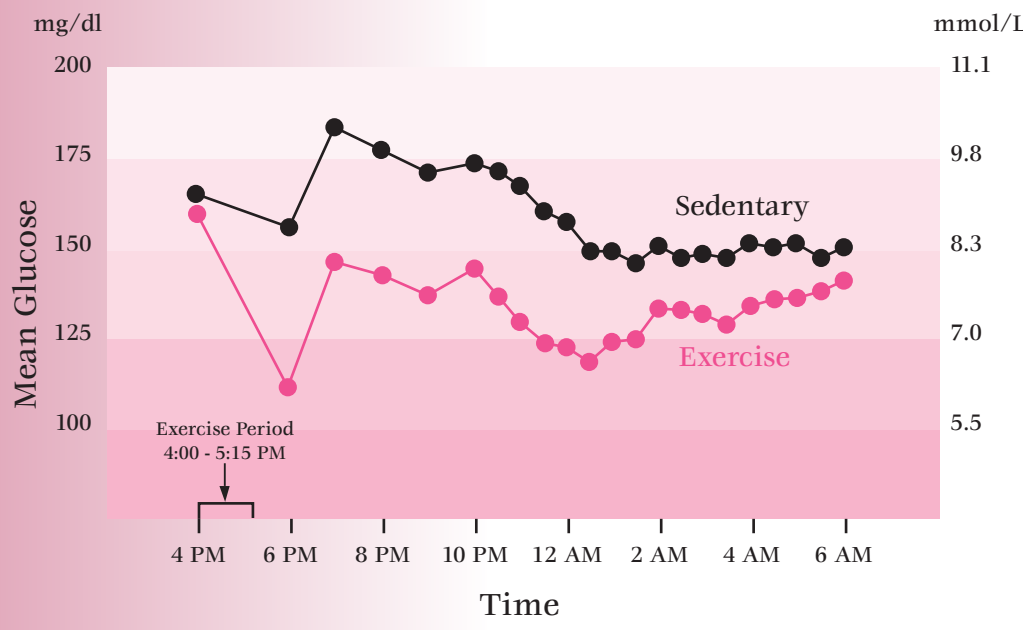
No one questions the importance of exercise whether a person does or does not have diabetes. Weight control is an obvious reason. It is almost impossible (with normal eating) to maintain a desirable weight without exercise. One of the most important reasons for people with diabetes to exercise regularly relates to insulin sensitivity.

Figure 1 shows average blood sugar levels from 50 children on a day when they exercised for one hour in the afternoon (pink dots). The black dots show the average blood sugar levels in the same children on a day without exercise. The blood sugar levels remained lower for 12 hours following the exercise. (11)

FIGURE 1:

THE EFFECT OF EXERCISE ON BLOOD SUGAR LEVELS



This figure presents blood glucose (sugar) levels for the same 50 children on a sedentary day (black dots) and an exercise day (pink dots). The exercise period beginning at 4:00 p.m. resulted in lower glucose levels for the next 14 hours (through the night). Insulin doses and food intake were identical for the two days.

(Data compliments of the DirecNet Study Group: J Pediatr 147,528, 2005)

ADJUSTING BASAL INSULIN DOSAGES FOR EXERCISE

Insulin levels in people without diabetes decrease during exercise. Unfortunately, this effect is hard to replicate in people with diabetes, particularly with sporadic exercise. If a person takes a shot of an intermediate (e.g., NPH) or long-acting basal (e.g., Lantus or Levemir) insulin, there is no way to reverse the insulin activity during exercise. One of the greatest advantages of pump use is the ability to reduce insulin before, during or after exercise. There is no duration or intensity of exercise that cannot be handled when using an insulin pump. Planning (thinking ahead) and experience (trial and error) can determine the optimal insulin dose. Some examples follow:

- For a person who rarely goes low with a given exercise (e.g., a softball game) there may be no need to reduce the basal rate or discontinue the pump insulin.

- For a person who goes low with exercise 25% to 50% of the time, a 75% temporary basal rate (a 25% reduction) may prevent low blood sugar. If the person still goes low, a 50% basal rate can be tried.

- For a person who always goes low during an exercise (e.g., jogging for 45 minutes) it usually works best to disconnect the pump or set a temporary basal rate of "0". This may also be necessary for a contact sport such as football or lacrosse.

TIMING, DURATION AND EXERCISE INTENSITY

The **timing** of the reduction in insulin will vary by the person. Since rapid-acting insulins (Humalog, NovoLog and Apidra) peak in 100 minutes, it may be necessary to begin the reduction in basal insulin 30 to 60 minutes prior to the exercise.

The **duration** of the temporary basal rate or disconnection from the pump varies from person to person. Some people who tend to go low **after** exercise may need to continue the reduced basal rate for 30 to 60 minutes following the exercise. Others may only need to reduce the basal rate before or during the exercise. Experience is the best teacher.

The **intensity of exercise** is important in relation to the insulin reduction. Climbing Pikes Peak is an example of prolonged, strenuous exercise. Basal insulin could not be discontinued completely for the eight hours of hiking because ketones often form after three or four hours without insulin. The answer may be to use a 20% basal (an 80% reduction) plus extra food for the entire eight hours of exercise. To prevent delayed hypoglycemia, an 80% basal rate might be necessary throughout the night. With intense short-term exercise, it is usually best to turn off the pump. Some people may prefer to use a temporary basal rate set at 0% for a set length of time rather than disconnecting or turning the pump off. This can prevent the problem of forgetting to reconnect or restart the pump. It might be necessary to give intermittent boluses of insulin when the blood sugar begins to rise. Frequent blood sugar checking is obviously the key to see what does or does not work.

If the exercise is always the same intensity at the same time of day, it may be easier to use a different basal pattern (e.g., Basal A). Switching to the alternate basal pattern early in the day may help prevent forgetting to make the reductions before, during or after the exercise that have previously been determined to work the best. A possible initial alternate basal pattern is a 0.2 units per hour reduction for the hour before and after the exercise. A 50% to 100% reduction can be considered for the hour of exercise (depending on the intensity). Further changes can be made depending on what works best. If the exercise is cancelled for some reason, the pump user/family can switch back to the usual basal pattern.

TABLE 1:

EXERCISE AND INSULIN ADJUSTMENTS

Duration (in minutes)	Intensity	Blood sugar level mg/dl (mmol/L)	Possible decrease in basal (% decrease)	Possible decrease in bolus* (% decrease)
<30	Mild (e.g., walking)	≥180 (≥10)	0 to 50	50
30-60	Moderate (e.g., tennis)	≅150 (≅8.3)	50-100†	50-75
>60	Intense (e.g., jogging)	≅120 (≅6.7)	80-100†	75-100

*Bolus refers to a food bolus or correction bolus which might be given prior to, during or after exercise.

†A 100% reduction obviously occurs when the pump is removed (essential with a contact sport). If the pump is removed, blood sugars must be done at least every hour. One can then reconnect the pump and give a correction bolus as needed.

ADJUSTING BOLUS INSULIN DOSAGES FOR EXERCISE

As with adjustments in basal insulin, the adjustments in insulin boluses (for food or blood sugar corrections) required by exercise vary from person to person. The intensity and duration of the exercise and the blood sugar level at the time of the exercise also factor into the dose changes. Table 1 suggests reductions in basal and bolus insulin dosages for exercise of various duration and intensity and with different initial blood sugar levels. As illustrated in Table 1, the conditions will vary and one must decide on an initial reduction and see what works best. An initial trial dose must be chosen, depending on the intensity of the planned exercise and the blood sugar level. For example, for an intense exercise (usually a 75% to 100% decrease per Table 1) for 30 minutes (usually a 50% to 75% decrease) with a high sugar level (>180 mg/dl or >10 mmol/L) (usually a 0% to 50% decrease), the person might try a 50% reduction. However, if the blood sugar were ≅120 mg/dl (≅ 6.7 mmol/L), it might be better to try a 75% to 100% reduction. **Remember that to get a 75% reduction in the temporary basal, one must enter 25% (the percent basal actually desired). However, with the Animas pump, one just enters minus (-) 75%.** If high or low blood sugars occur with the first insulin adjustment, increased or decreased basal and bolus rates should be tried the next time. After a few tries, the insulin adjustments get much easier.

FOOD INSULIN BOLUSES AND EXERCISE

The most common change in an insulin bolus for food before, during or after exercise is a 50% reduction. Other factors, such as the duration and intensity of the exercise and the blood sugar level must always be considered as shown in Table 1. Everyone is different and it is necessary to find out what will work best.

CORRECTION INSULIN BOLUSES AND EXERCISE

As with all exercise adjustments, each person will have different insulin requirements. Some people still produce significant adrenaline, which may increase with exercise. Adrenaline (epinephrine) is the excitatory hormone which causes an increase in blood sugar levels. If blood sugar levels climb above 200 mg/dl (11.1 mmol/L), a partial correction (e.g., 50% of the usual) may be needed. It is important to check blood sugar levels often (at least hourly) during the exercise to prevent becoming hypoglycemic.

Some people who disconnect their pump for contact sports may want to give a bolus of insulin prior to the exercise to cover the amount of basal insulin that will be missed during the exercise. While some people may give the full amount of insulin that will be missed, others will give half of the amount prior to exercise, and the other half during or after the exercise, depending on the blood sugar level. Fortunately, it is easy to reconnect the pump, give a bolus, and disconnect again during a rest period. This plan is beneficial for those who tend to have high blood sugars with exercise.

PREVENTING DELAYED HYPOGLYCEMIA

The section above discussed reductions in basal and bolus insulin dosages before, during and after exercise to prevent hypoglycemia. Some pump users also need a temporary basal rate (e.g., an 80% basal [20% reduction] or more) during the night to help prevent **delayed hypoglycemia.** The DirecNet group showed that 48% of youth had low sugar levels during the night following an hour of intense afternoon exercise (during which the insulin dose was not reduced). Low blood sugar during the night was less likely if the pre-bedtime blood sugar value was >130 mg/dl (>7.2 mmol/L). (11) As more people begin using continuous glucose monitoring (CGM), these nocturnal low blood sugars will be recognized and can be prevented. Some people awaken with symptoms of low blood sugar. In other people, the blood sugar will gradually increase after a low. Rarely, a person has a severe hypoglycemic event (e.g., seizure) after prolonged low blood sugar. A temporary basal, often lasting until breakfast, may be the best way to prevent delayed hypoglycemia.

EXTRA FOOD TO COVER EXERCISE AND LOW BLOOD SUGAR

Table 2 suggests different quantities of liquids or solids which may be used to prevent dehydration and low blood sugars. Liquids given alone pass more rapidly into the small intestine where the sugar is absorbed. They are ideal for short periods of exercise. Solids that absorb the liquid (e.g., a sandwich taken with juice) may delay passage of carbs to the small intestine, and therefore may have a more prolonged effect. Once again, all people are different and some need more food than others in order to keep the blood sugar levels up.

The treatment of low blood sugar during exercise may be different than the treatment of low blood sugar at other times. If the exercise is intense, it may be necessary to give 30 grams of carbs (rather than the usual 15 grams). **It is important NOT to resume the exercise until a repeat blood sugar shows that the value is back to normal**. If not back up in 15 minutes, another 30 grams of carbs may be needed. Obviously, **a source of sugar must always be available during exercise.** If a low blood sugar does occur, further alterations will need to be made the next time the similar activity occurs. A general rule of thumb is to err on the safe side to prevent hypoglycemia.

BLOOD SUGAR CHECKING

Frequent blood sugar checking (or a CGM) is the best way to manage exercise effectively and to prevent hypoglycemia. People frequently want to know what the optimal blood sugar level should be at the beginning of the exercise. The

TABLE 2:

EXTRA FOOD TO COVER EXERCISE*†

Expected length of exercise	Blood sugar level mg/dl	mmol/L	Examples of foods
A. Short (15-30 minutes)†	<80	<4.5	8 oz Gatorade or milk** or 4-6 oz juice**
	80-150	4.5-8.3	A fresh fruit (or any 15 grams carb**)
	>150	>8.3	None
B. Longer (30-120 minutes)†	<80	<4.5	8 oz Gatorade or milk** or 4 oz juice plus 1/2 sandwich
	80-150	4.5-8.3	8 oz Gatorade or milk plus fresh fruit
	>150	>8.3	1/2 sandwich**
C. Longest (2-4 hours)*†	<80	<4.5	8 oz Gatorade or 4 oz juice, whole sandwich
	80-150	4.5-8.3	Fruit, whole sandwich
	>150	>8.3	Whole sandwich

** Remember to also drink water, Gatorade or other fluids (one 8 oz glass for* **A**, *two 8 oz glasses for* **B**, *and three 8 oz glasses for* **C**) *before or during the exercise to prevent dehydration. This table is for a moderate degree of exercise (e.g., walking, casual bicycling, shooting a basketball or mowing the lawn). If heavier exercise (e.g., jogging, bicycle race, basketball game or digging in the garden) is to be done for the same amount of time, then more food may need to be added. Amounts vary for different people and the best way to learn is to do blood sugars before and after the exercise and keep a record of the blood sugar values.*

*** Each of these represent 15 grams of carbohydrate which will last for about 30 minutes of moderate exercise. A sandwich with meat or other protein lasts longer.*

† May also need to reduce insulin dosage

DirecNet group found that if the value was >130 mg/dl (7.2 mmol/L), only 9% of youth developed hypoglycemia during the exercise when the insulin pump was discontinued. (12) In contrast, if the blood sugar was below this level initially, 46% of the youth developed hypoglycemia during the exercise.

OTHER CONSIDERATIONS

INFORMING OTHERS

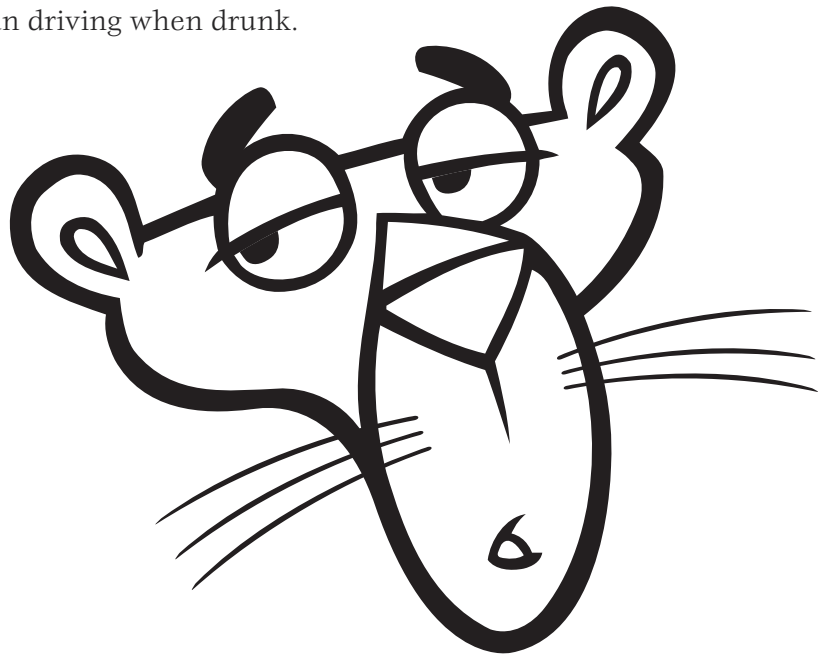
It is important that others know about the diabetes and know how to treat hypoglycemia. A low blood sugar is a possibility for any person with diabetes at any time, and other people must be instructed on how to recognize and treat it. Although many people dislike wearing an ID, it is wise to do so.

KETONES

A person should not exercise if ketones are present. Exercise can increase ketone production.

DRIVING

Youth often exercise in the late afternoon and then drive home. A blood sugar must always be done prior to driving. This is for the safety of the person with diabetes as well as others. Driving when having a low blood sugar has been shown to be more dangerous than driving when drunk.



SUMMARY

Experience is the best way to learn how to handle changes in insulin dosage and blood sugar fluctuations with exercise. An insulin pump can provide definite advantages in insulin management. It is the responsibility of every person/family to think ahead to make exercising an enjoyable and safe experience.

DEFINITIONS

Delayed hypoglycemia: Low blood sugars usually occurring 6 to 12 hours after intense exercise (and often during the night).

REFERENCES

11. DirecNet Study Group, J Pediatr 147; 528, 2005.

12. DirecNet Study Group, Diabetes Care 29; 2200, 2006.