


When in doubt, exercise! Exercise is beneficial to most diabetics who are physically able to participate in an exercise program. Exercise stimulation in insulin-dependent diabetics, normal increase in skeletal muscle capillaries in type I diabetes. Acta Med. Scand. 30:833–856.


1. Introduction

The benefits and risks of regular exercise for people with diabetes have been extensively studied. Regular exercise can improve glycemic control, reduce the risk of cardiovascular disease, and improve overall quality of life. However, exercise can also impact the management of diabetes, particularly in relation to insulin requirements and blood glucose control.

2. Exercise and Insulin Requirements

Exercise can affect insulin requirements in people with diabetes. For people with type 1 diabetes (T1D), exercise can lead to an increase in insulin sensitivity, which may require a decrease in insulin dose. For people with type 2 diabetes (T2D), exercise can improve insulin sensitivity and decrease the reliance on oral antidiabetic medications. Exercise duration and intensity can influence these effects.

3. Exercise and Blood Glucose Control

Exercise can lead to changes in blood glucose levels. For people with T1D, exercise can lead to hypoglycemia if not well managed. For people with T2D, exercise can lead to hyperglycemia if not well managed. Exercise type, duration, and intensity can impact these effects.

4. Exercise and Cardiovascular Health

Regular exercise can improve cardiovascular health in people with diabetes. Exercise can reduce systolic and diastolic blood pressure, improve lipid profiles, and increase HDL cholesterol. Exercise duration, intensity, and frequency can impact these effects.

5. Exercise and Mental Health

Regular exercise can improve mental health in people with diabetes. Exercise can reduce symptoms of depression and anxiety and improve self-esteem and quality of life. Exercise duration, intensity, and frequency can impact these effects.

6. Exercise and Resistance Training

Resistance training can improve muscle strength and endurance in people with diabetes. Resistance training can improve glycemic control, reduce body fat, and increase muscle mass. Resistance training duration, intensity, and frequency can impact these effects.

7. Exercise and Competitive Sport

People with diabetes who participate in competitive sport require careful management of their diabetes. Exercise can lead to changes in blood glucose levels, and athletes with diabetes need to be aware of these changes and adjust their diabetes management accordingly. Exercise type, duration, and intensity can impact these effects.

8. Exercise and Recovery

Exercise can lead to recovery after athletic events. Recovery strategies such as hydration, nutrition, and rest are important for people with diabetes. Recovery duration and intensity can impact these effects.

9. Summary

People with diabetes can benefit from regular exercise. Exercise can improve glycemic control, cardiovascular health, mental health, and overall quality of life. Exercise can also lead to changes in insulin requirements and blood glucose control. Exercise management and diabetes management need to be coordinated to optimize the benefits of exercise.

Table 1: Adaptations to exercise training in people with Type 2 DM

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Glucose-related adaptations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance training</td>
<td>Beta-cell function enhancement</td>
</tr>
<tr>
<td>Endurance training</td>
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</tr>
</tbody>
</table>

Dealing With Complications Of This Disease

Exercise is a crucial component of diabetes management. Exercise can help to prevent and manage complications of diabetes, such as cardiovascular disease, and a higher frequency of foot ulcers.

Hypertension

Exercise can lower blood pressure in people with diabetes. Exercise can help to prevent and manage hypertension. Exercise duration and intensity can impact these effects.

Coronary Artery Disease

Exercise can lower the risk of coronary artery disease in people with diabetes. Exercise can help to prevent and manage coronary artery disease. Exercise duration and intensity can impact these effects.

Foot Ulcers

Exercise can improve circulation in the legs, which can help to prevent and manage foot ulcers in people with diabetes. Exercise duration and intensity can impact these effects.

Drugs for Diabetes

Exercise can help to manage blood glucose levels in people with diabetes. Exercise can help to prevent and manage drug interactions and side effects. Exercise duration and intensity can impact these effects.

Nutritional Requirements

Exercise can help to manage nutritional requirements in people with diabetes. Exercise can help to prevent and manage malnutrition. Exercise duration and intensity can impact these effects.

Psychological Health

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exercise insulin resistance. Thus, the prevailing concern of Type 1 DM is to prevent ketosis (production of ketones from fat and proteins) in the tissues prior to the insulin reserve (the amount that is available for insulin injection) becoming exhausted. Fortunately, in most people with Type 1 DM, the management of diabetes is so well controlled that ketotic crises are rare. However, when such crises do arise, their complications can be severe. The point is that a carbohydrate-rich diet and regular exercise help maintain normal blood glucose concentrations caused by insulin treatment. Moreover, other research suggests that patients who exercise regularly appear to have a reduced risk of cardiovascular disease.

**Exercise and Hyperglycemia**

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The athletic team support staff should know where their athletes live and where they train. They should also contact the athletes’ doctors to determine whether the athlete is on any medicines that interfere with diabetes therapy.

**The Isolated Foot**

Foot ulcers and sensory loss are common complications of diabetes. In feet with sensory loss, ulcers can occur almost without warning. Although ulcers usually heal if treated properly, they are associated with a high risk of amputation. Therefore, prevention is the cornerstone of treatment. Diabetes patients should be educated about foot care and examined by health professionals trained in foot care.

**The Diabetic Athlete**

Adaptations to exercise in people with Type 2 DM are much more variable than in people with Type 1 DM. Some people with Type 2 DM get better at exercising as their blood glucose levels normalize. Exercise is an important modulator of blood glucose levels. Some people gain weight from exercise, and this could lead to an increase in type 2 diabetes and insulin resistance and may also have a positive impact on athletic performance.

**The Lack of Randomized, Controlled Trials**

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Studies in athletes tend to be observational, and they have not been designed to test specific hypotheses. Thus, the results of these studies must be interpreted with caution. Nonetheless, the findings of these studies are consistent with the hypothesis that exercise is beneficial for people with diabetes.

**Conclusion**

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In conclusion, exercise is a beneficial therapy for people with diabetes. However, it is important to remember that exercise is only one component of a comprehensive treatment program. Exercise should be used in conjunction with lifestyle modifications, such as diet and medication, to achieve optimal glycemic control. Exercise can improve insulin sensitivity, reduce body weight, and improve blood pressure and cholesterol levels. Exercise can also improve emotional well-being and quality of life. Therefore, exercise should be encouraged for all people with diabetes, regardless of their age, sex, or level of training.
In people with Type 2 DM, the metabolic demands of, and acute responses to, exercise in people with Type 2 DM is either an increase (⇑) or decrease (⇓) value compared to nondiabetics.
Exercise and Type 2 Diabetes

Type 2 diabetes is characterized by insulin resistance, the body’s inability to respond normally to insulin. If this resistance is mild, blood glucose levels can remain within normal limits. However, if resistance becomes extreme, blood glucose levels rise, and type 2 diabetes develops.

**Insulin Resistance and Type 2 Diabetes**

Insulin resistance refers to a condition where cells, particularly muscle cells, fail to respond to insulin. Insulin is a hormone produced by the pancreas that helps control blood glucose levels. When insulin resistance occurs, the body cannot properly use insulin to control blood glucose.

**The Role of Physical Activity**

Physical activity can help improve insulin sensitivity and reduce the risk of developing type 2 diabetes. Regular exercise can help control blood glucose levels, improve insulin sensitivity, and reduce the risk of complications associated with diabetes.

**Benefits of Physical Activity**

Exercising regularly can help control blood glucose levels, improve insulin sensitivity, and reduce the risk of complications associated with diabetes. It can also help in the management of other conditions like obesity.

**Exercise and Diabetes**

Regular physical activity can be beneficial for people with diabetes. Exercise can help control blood glucose levels, improve insulin sensitivity, and reduce the risk of complications associated with diabetes.

**Summary**

Type 2 diabetes is a chronic condition that affects millions of people worldwide. Regular physical activity plays a crucial role in managing diabetes and reducing the risk of complications associated with this disease.
INTRODUCTION

The benefits of regular exercise in people with diabetes are well documented. Exercise improves insulin sensitivity and glycemic control, muscular strength and cholesterol in type I diabetes.

Exercise is effective in reducing postprandial hyperglycemia and total glucose response. Exercise is the cornerstone of therapy in people with diabetes. It is the most effective intervention available for type 2 diabetes and reduces hepatic glucose production. Exercise may enhance insulin sensitivity by improving muscle blood flow and reducing intramuscular triglyceride content, increasing muscle glycogen and fatty acid oxidation, and increasing mitochondrial biogenesis. Exercise is also beneficial in the prevention of type 2 diabetes. A 5-7% weight loss from exercise can reduce the risk of developing diabetes by 58%. Regular physical activity can reduce body fat and increase muscle mass. It also lowers blood pressure, improves blood lipids, and reduces the risk of premature death.

Exercise has been shown to improve physical and mental well-being, quality of life, and capillary density in people with diabetes. Exercise can improve posture and reduce pain and stiffness, contributing to improvement in blood flow, joint mobility, and overall quality of life.

Exercise also reduces the risk of developing diabetes, stroke, heart disease, and cancer. It can prevent or delay the onset of diabetes, reduce the risk of complications, and improve overall health. Exercise can also improve sleep quality, mood, and self-esteem.

Exercise is safe in people with diabetes, assuming that precautions are taken to avoid hypoglycemia, dehydration, and hyperglycemia. Exercise should not be contraindicated in people with diabetes, but should be individualized based on the person's medical history, current health status, and other factors.

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DIABETES, EXERCISE AND COMPETITIVE SPORTS

type I diabetes.

Type 1 diabetes is characterized by an autoimmune destruction of pancreatic beta cells, which results in an inability to produce insulin. People with type I diabetes require insulin injections to manage their blood glucose levels. Type 1 diabetes is usually diagnosed in childhood or adolescence, but can occur at any age. Type 1 diabetes is often referred to as insulin-dependent diabetes mellitus (IDDM).

Type 2 diabetes, also known as non-insulin-dependent diabetes mellitus (NIDDM), is characterized by a gradual loss of insulin sensitivity and an inadequate ability of the pancreas to produce enough insulin to maintain normal glucose levels. Type 2 diabetes is typically diagnosed in adults over the age of 40, but can occur at any age. Type 2 diabetes is often referred to as adult-onset diabetes mellitus (AODM). Type 2 diabetes is often associated with obesity and other lifestyle factors such as a sedentary lifestyle and poor nutrition.

Type 3 diabetes is a relatively new term that refers to a condition where the body relies on insulin to maintain normal blood glucose levels but begins to produce less insulin as the disease progresses. Type 3 diabetes is often associated with obesity and other lifestyle factors such as a sedentary lifestyle and poor nutrition.

Type 4 diabetes is a term used to describe diabetes that is caused by a drug or medication. It can be caused by diabetes medications, such as sulfonylureas or metformin, or by other medications, such as corticosteroids or immunosuppressants. Type 4 diabetes is often associated with a history of diabetes.

The American Diabetes Association (ADA) and the International Diabetes Federation (IDF) have defined the criteria for these types of diabetes. Any person with diabetes should be evaluated by their healthcare provider to determine the type of diabetes they have and to develop an appropriate treatment plan.

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are influenced by factors such as age, sex, and body mass index (BMI). Exercise is an important component of diabetes care and can improve glycemic control, reduce blood pressure, improve lipid levels, and reduce the risk of developing complications.

Exercise can improve blood glucose control and reduce the risk of hypoglycemia in people with diabetes. Exercise can also improve insulin sensitivity and reduce the need for insulin in people with type 1 diabetes. Exercise can improve physical and mental well-being, quality of life, and capillary density in people with diabetes.

Exercise is an effective intervention in the treatment of diabetes. Exercise can improve glycemic control, reduce blood pressure, improve lipid levels, and reduce the risk of developing complications. Exercise can also improve physical and mental well-being, quality of life, and capillary density in people with diabetes.

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DIABETES AND EXERCISE:
TIPS FOR BETTER PERFORMANCE

With proper experience, planning, conditioning, and strategies for managing diet and insulin, the person with uncomplicated diabetes can engage in any type of exercise at any level of intensity. The goal is to complete the exercise and recovery period with minimal changes in blood glucose. For non-obese people with Type 2 diabetes mellitus (insulin is produced by the pancreas but is ineffective at stimulating glucose uptake from the blood into the cells of the body) who can control their disease simply with diet and regular exercise, no additional precautions are required. The key components of a successful regimen for those with Type 1 diabetes mellitus (no insulin is produced) are to reduce the amount of insulin administered prior to exercise and/or to supplement the diet with carbohydrate. While these are seemingly simple strategies, it is the fine-tuning of these actions that spells success or failure.

Many of the recommendations that follow have been adapted from the publications cited in the list of suggested additional resources at the end of this supplement.

What is the Optimal Time of Day for Exercise?
Disturbances in blood glucose are less likely if exercise is performed in the morning before breakfast and before the morning administration of insulin. This is because circulating insulin is low at this time, and if a regular meal was consumed the night before, both liver and muscle glycogen stores should be filled.

What Should Be Done Before Exercise?
1. Measure blood glucose concentration to determine how well it is under control.
   - If blood glucose is <5 mM (90 mg/dl), extra carbohydrate before exercise will likely be required.
   - If blood glucose is 5–15 mM (90–270 mg/dl), extra carbohydrate may not be required.
   - If blood glucose is >15 mM (270 mg/dl), delay exercise and measure urine ketones.
     a. If urine ketones are negative, exercise can be performed, and extra carbohydrate is not required.
     b. If urine ketones are positive, take insulin and delay exercise until ketones are negative.

2. Determine the appropriate pre-exercise carbohydrate meal.

3. Administer the appropriate pre-exercise insulin dose.
   - Inject insulin (or adjust the output of an insulin pump) about 1 hour before exercise.
   - Decrease the dose of insulin so that the greatest increase in circulating insulin does not occur during the exercise period.
   - Do not use an arm or leg that will be involved in exercise as an injection site and be sure that the insulin is injected into subcutaneous tissue not muscle.

What Should Be Done During Exercise?
1. Monitor blood glucose during long exercise sessions. For running, cycling, swimming and other endurance types of activities, this may require setting a circular course so that glucose meters are periodically available.

2. Always replace fluid losses adequately. The goal should be to replace all or nearly all of the body weight lost as sweat during the exercise period itself. This weight loss can be estimated by recording the difference in body weight before and after exercise on prior occasions.
3. If required, use supplemental carbohydrate feedings (an additional 40–50 g for adults, 20–30 g for children) every 60 min during extended periods of moderate intensity exercise. For example, Gatorade restores blood glucose very rapidly during exercise in people with Type 1 DM who are becoming hypoglycemic. Other sports drinks with a similar composition (~6% carbohydrate plus electrolytes) may also be effective but have not been studied.

What Should Be Done After Exercise?

1. Monitor blood glucose, including overnight monitoring if exercise is not habitual and/or is performed in the late afternoon. Avoid alcohol consumption after exercise because alcohol diminishes the ability to monitor marked or subtle feelings that would otherwise alert the person with diabetes to the fact that blood glucose is either too high or too low.

2. Adjust insulin administration downward to decrease immediate and delayed actions of insulin. If required, increase carbohydrate intake for up to 24 hours after activity, depending on the intensity and duration of exercise (more intense and prolonged exercise requires more carbohydrate) and the risk—based on prior experience—of the occurrence of low blood glucose. Ingestion of ~1.5 g carbohydrate/kg body weigh (0.7 g/lb) soon after exercise will help restore muscle and liver glycogen after very prolonged or exhausting exercise. It should be noted, however, that although low blood glucose can occasionally occur several hours after exercise in diabetics, some insulin is needed late after exercise to fully restore muscle glycogen levels.

3. Ingest the appropriate amount of carbohydrate on a daily basis.

   The type of exercise—endurance, sprint, resistance, intensity of exercise—high, medium, low, and duration of exercise—brief, moderate, prolonged—(or as in most sports some combination of these) must be considered:

   ■ If aerobic exercise of a moderate intensity is to be undertaken on a daily basis and usually lasts less than 1 hour, the diabetic athlete should ingest 5–6 g of carbohydrate/kg body weight (2.3–2.7 g/lb) on a daily basis.

   ■ If the athlete trains more than 1–2 hours per day, 6–8 g of carbohydrate/kg body weight (2.7–3.6 g/lb) may be required daily.

Which is Worse, Low Blood Glucose (Hypoglycemia) or High Blood Glucose (Hyperglycemia)?

The answer is that both hypoglycemia and hyperglycemia should be avoided whenever possible. For athletic competitions, hypoglycemia must be avoided because fatigue, loss of mental focus, and reductions in strength are obviously not compatible with athletic success. Thus, it may seem reasonable that maintaining a state of hyperglycemia is one way to insure athletic success. In the short run this may work, but the consistent state of hyperglycemia must be avoided because even mild but consistent hyperglycemia significantly increases the likelihood of serious medical complications of diabetes. Unfortunately, some diabetic athletes apparently sacrifice glucose control in favor of avoiding hypoglycemia so they can perform at high levels.

Other Practical Considerations

Here are some additional tips for the diabetic exerciser:

■ Frequent glucose monitoring is obviously essential for safe exercise.

■ Carry some form of carbohydrate snack (simple sugars).

■ Carry medical identification.

■ If convenient, exercise with a friend who knows you have diabetes. Carry a cell phone in case of a diabetic emergency.

■ Invest in good footgear if walking, jogging, and/or running are among your chosen activities.

■ Use extra care to avoid large fluctuations in plasma glucose when exercising in the cold or heat.

SUGGESTED ADDITIONAL RESOURCES

