To complete the formal report assignment, I am submitting the attached report. This report is about diabetes and its treatments. The report is designed to provide relevant information about diabetes to people who are curious about the disease and want to learn about a particular aspect. While the report is not intended to serve as a replacement for a doctor or a doctor’s guidance, it can be used as an introduction to many of the most common topics related to diabetes.

The report is divided into four sections. The first main section, entitled Overview, provides definitions for the different types of diabetes and the conditions usually associated with each type. This section also includes details on who is at risk for developing diabetes. The second section is devoted to prevention of the disease and covers basic guidelines for prevention.

The last two sections focus on treatments for people who already have diabetes. The third section covers current treatment methods. The section is subdivided into treatments applicable for all forms of diabetes and treatments for each individual form of diabetes. The final section discusses new, experimental treatments that are not ready to be tested or used safely as a mainstream treatment option.

I would like to thank Mrs. Ruby Varghese for taking time to discuss her experience with diabetes medications with me. Her input provided a valuable basis to begin research on the current and experimental methods of treatment for diabetes.

Attachment: Diabetes and its Treatments Report
Diabetes and its Treatments Research Report

Structure of the insulin hormone
Source: Science in School; Diabetes Mellitus article.

Prepared for: English 301-200

Prepared by: Joshua Varghese
Summary

Project Objectives and Approach

The subject of this report was diabetes and the treatments used to fight diabetes. The objectives of this research project were:

- Collect and present information about the basics of diabetes, such as the different types of diabetes, in an organized and complete manner.
- Research diabetes prevention techniques and present the best techniques in the project report.
- Gather and organize information about the treatments currently used for the three major forms of diabetes.
- Research some of the experimental treatment techniques and present the most promising methods in the project report.

The information was gathered and compiled from online medical databases, articles from major news sources and professional journals, and online education resources. Online resources were heavily used because many sites are dedicated to presenting news and information about diabetes. Another benefit of online resources was the ability to quickly check the information from any source with another source to see if the information was correct and usable.

Research Conclusions

Completion of this report led to the following conclusions:

- Diabetes may affect anyone, regardless of age, race, etc. No cure exists for diabetes.
- Type II diabetes can be prevented by making appropriate lifestyle changes.
- All forms of diabetes are treatable enough to allow the patient to live a normal life.
- New methods of treatment look promising for finding a cure, but they will take many years to arrive.
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Introduction

Diabetes is a group of diseases that affects the body’s ability to produce or use a hormone known as insulin. Diabetes can lead to severe complications and a premature death. This disease affects over 20 million Americans, which amounts to more than 7% of the population. [1] According to the United States National Center for Health Statistics, diabetes was the sixth leading cause of death in 2005. [2] The number of cases of type II diabetes has been increasing at a rate fast enough to be deemed an epidemic by the Centers for Disease Control and Prevention (CDC). [3]

Despite these grim statistics, it is possible to decrease the chances of developing certain types of diabetes. Careful eating and control of body weight can greatly reduce the risk of type II diabetes. It is extremely important to be aware of the risk factors, complications, and treatments for diabetes.

This report has been created to serve as an introduction and overview about these topics. It is not intended to replace the guidance or directions of a doctor or health care provider. This report begins with the basics of diabetes, which includes the different types of diabetes and conditions associated with each type. This is followed by a description of some of the possible complications of diabetes and the risk factors for the disease.

The final three sections of the report are dedicated to treatment of the disease. The first of these sections is about prevention and the steps needed to effectively fight diabetes before it develops. The second section describes some of the current treatment methods for diabetes. The last section gives an introduction to some of the new and experimental work being developed for diabetes treatment.

Overview

What is diabetes?

Diabetes mellitus, often referred to simply as diabetes, is a metabolic disorder characterized by an abnormally high level of glucose, or blood sugar, in the blood. [4, p. 2] The high levels of blood sugar are a result of the body’s inability to create insulin, use it efficiently, or both. [5] Insulin is a hormone produced by the body to transport glucose to the body’s cells, where it can eventually be converted into usable energy. When insulin is not used efficiently by the body, the glucose remains in the bloodstream. Excess glucose in the body can lead to life-threatening complications.

The World Health Organization recognizes three different types of diabetes: Type I diabetes, Type II diabetes, and gestational diabetes. [4] Type I and Type II diabetes are chronic conditions, meaning that they are long-lasting conditions. Gestational diabetes occurs during
pregnancy, but is usually resolved after the child has been delivered. For more information on a specific form of diabetes, please refer to the appropriate section in the report.

Some general symptoms of diabetes occur regardless of the form of the disease. If you experience some of these symptoms, please visit a physician. **Please note that diabetes may still develop even if you do not experience these symptoms.** [5]

- Frequent urination
- Excessive thirst
- Unexplained weight loss
- Extreme hunger
- Sudden vision changes
- Tingling or numbness in hands or feet
- Feeling very tired much of the time
- Very dry skin
- Sores that are slow to heal
- More infections than usual

**Type I diabetes**

Type I diabetes, formerly called insulin-dependent diabetes mellitus or juvenile-onset diabetes, is one of the three major forms of diabetes. [5] Type I diabetes is an autoimmune disease that causes the body to damage or destroy its own beta cells in the pancreas. [6] These beta cells are responsible for the production of insulin. Without the ability to create insulin, the body is unable to convert glucose into energy. This form of diabetes is life-threatening without regular injections to replace the needed insulin within the body.

Type I diabetes, although originally referred to as childhood diabetes, is not exclusive to children. Many cases of type I diabetes are diagnosed during a patient’s childhood years, but adults may also be diagnosed with this form of diabetes. Children who grew up with type I diabetes but were not diagnosed properly may have the disease appear during their adult years. Type I diabetes, along with every other form of diabetes, is not contagious and cannot be spread by contact with someone who has diabetes. [7]

The exact cause of type I diabetes is unknown. It is known that it is an autoimmune disease, meaning that the body’s immune system attacks and damages the body’s own structures.
Research has suggested that the autoimmune response is due to an infection by a virus known as a coxsackie virus. [8] Other research has suggested a genetic vulnerability to developing the disease. [9] Many researchers are working to find the cause of this form of diabetes.

Currently, no cure for type I diabetes exists. However, proper treatment and effective management can allow a person diagnosed with type I diabetes to live a normal life. Insulin replacement therapy is needed for type I patients. Insulin replacement therapy involves the use of insulin replacement, proper eating habits, and daily physical activity. [10] Since the body cannot produce insulin, insulin must be injected into the patient’s body. Injection can be done with a syringe, insulin pens, or insulin pumps. Several types of insulin can be used, each with different effects. [11] For more information, please talk to a physician or refer to the type I treatment section of this report.

**Type II diabetes**

Type II diabetes, once called non-insulin-dependent diabetes mellitus or adult-onset diabetes, is another major form of diabetes. According to the CDC, type II diabetes may account for 90% to 95% of all diagnosed cases of diabetes. [5] Because the number of cases of type II diabetes is increasing rapidly worldwide, the CDC has deemed this form to be an epidemic. [3]

Type II diabetes begins when a condition called insulin resistance develops. Insulin resistance occurs when fat, muscle, and liver cells do not use insulin properly. [12] The pancreas is able to keep up with the need for insulin for a short while, but it will eventually be unable to meet the body’s demand for insulin.

The exact cause of type II diabetes is not known. However, researchers have identified several contributing factors that can lead to the development of type II diabetes. [13] These include, but are not limited to, the following:

- Obesity
- Physical inactivity
- Older age
- Family history of diabetes

For a more detailed listing of risk factors, please see the **Who is at risk** section of this report.

Type II diabetes is a chronic disease that does not have an established cure. Treatment for this form of diabetes is designed to reduce the chances of severe complications or premature death. However, a diagnosis of type II diabetes is not a death sentence. A combination of increased physical activity, proper dietary intake, and weight loss can keep blood glucose levels at a normal level and restore insulin sensitivity. The
loss of even 5-15 pounds can help control the condition. If necessary, insulin injections, similar to those that type I patients receive, may be used to maintain health. More information on treatments can be found in the type II treatment section later in the report.

**Gestational Diabetes**

Gestational diabetes is a form of diabetes that occurs in pregnant women who have not been previously diagnosed with diabetes. [14] This condition occurs in 3 to 8 percent of pregnant women in the United States. [14]

Gestational diabetes develops because of the many changes that occur in a woman’s body during pregnancy. During a pregnancy, the woman’s placenta produces hormones that help transfer nutrients from the mother to the fetus. [15, p.1] These hormones make the mother’s cells more resistant to insulin, and the amount of glucose in the blood eventually rises, similar to type II diabetes. [16, p.3] Gestational diabetes often develops in the second trimester of pregnancy. [16, p.3]

Several risk factors can precede the development of gestational diabetes. Some are preventable, while others are not. A partial list is included below. [16, p.3]

- Age – Women older than 25 are more susceptible to gestational diabetes.
- Family/personal history of diabetes – Women who have relatives diagnosed with diabetes are at a higher risk of developing gestational diabetes.
- Being overweight – Women who are overweight before pregnancy increase their risk of developing this form of diabetes.
- Race – African American, Hispanic, American Indian or Asian women are more likely to develop gestational diabetes than are other women.

If left untreated, gestational diabetes can have severe complications, including the premature death of the baby. [16, p.7] However, following doctor’s orders regarding exercise and diet is usually sufficient for controlling gestational diabetes. Gestational diabetes usually goes away with the delivery of the child, but the woman will be have an increased chance of developing type II diabetes or gestational diabetes during another pregnancy. [15, p.5] For more information, please talk to a physician or a health care provider.

**Pre-diabetes**

Pre-diabetes is a condition where a person’s blood glucose levels are higher than normal but are not high enough for a diagnosis of diabetes. [17] Basically, a person who is pre-diabetic is in danger of developing type II diabetes. Many people with pre-diabetes develop type II diabetes within 10 years. [18] The American Diabetes Association estimates that 54 million people in the United States currently have pre-diabetes. [19]

Because pre-diabetes precedes type II diabetes, many of the risk factors are shared between the two. Of particular note are the risk factors listed below. [18]
- Obesity or being overweight
- Physical inactivity
- Race/ethnicity, specifically being African American, Latino, Native American, or Asian American/Pacific Islander

It is important to regularly be tested for pre-diabetes if you have one or more of the risk factors for pre-diabetes. Simple blood tests can be used to test your blood glucose levels to see if they are at a normal level or if they are at a pre-diabetic level. Please contact a doctor if you need to take one of these tests or want more specific information.

Finally, if you know you have pre-diabetes, you can do something about it. Studies have shown that people with pre-diabetes can delay or even prevent type II diabetes by up to 58% through lifestyle changes. [20] These changes are as simple as eating healthy, losing 5% to 10% of body weight, and exercising regularly. If the signs of pre-diabetes are caught early, it is possible to completely prevent type II diabetes. Therefore, it is vital to make these lifestyle changes as soon as possible.

Conditions and Complications of Diabetes

This section is divided into the conditions associated with diabetes and then into the possible complications of diabetes. Conditions refer to issues that may arise as a direct result of having diabetes. Complications refer to issues that have an increased chance of happening due to the presence of diabetes. Some conditions and complications may occur with both type I and type II diabetes and are listed together.

**Conditions – Both Type I and Type II Diabetes**

- **Hypoglycemia** – This condition means that blood glucose levels within the body are dangerously low. It may occur even if a patient is following a prescribed treatment program. An important part of treatment is continually monitoring blood glucose levels and raising glucose levels when necessary. Glucose levels can be raised through a recommended source of sugar, often a glucose tablet. Some of the symptoms of hypoglycemia are listed below. [21]
  - Shakiness, dizziness, or sweating
  - Hunger or headache
  - Pale skin color
  - Sudden moodiness or behavior changes, such as crying for no apparent reason
  - Clumsy or jerky movements
  - Seizure
  - Difficulty paying attention, or confusion
  - Tingling sensations around the mouth
**Hyperglycemia** – This condition means that blood glucose levels are extremely high. It may also occur during the course of regular treatment. Hyperglycemia may be caused by eating too much, not exercising enough, being ill, or being in stressful situations. Some of the symptoms of hyperglycemia are given below. **Hyperglycemia must be treated quickly, or it can lead to ketoacidosis, a diabetic coma.**  [22]

- High blood glucose
- Frequent urination
- Increased thirst

**Conditions – Type I Diabetes**

**Ketoacidosis** – Ketoacidosis is a serious condition that can lead to a diabetic coma, or even death. It occurs most often in type I diabetics, although very rarely, it may occur in type II patients who are under extremely stressful situations.  [23] Ketoacidosis occurs when there is a buildup of ketones, or byproducts of fat breakdown, within the blood.  [23] This buildup happens when the body uses fat for energy because it is unable to use glucose for energy.

- A high level of ketones can be detected through a urine test. Ask a doctor or health care provider for more details on this procedure. If a high level of ketones is detected, immediately contact your health care provider.

- Some of the symptoms of ketoacidosis are as follows:  [24]
  - Thirst or a very dry mouth
  - Frequent urination
  - High blood glucose (sugar) levels
  - High levels of ketones in the urine
  - A constant feeling of fatigue
  - Dry or flushed skin
  - Nausea, vomiting, or abdominal pain
  - Difficulty breathing
  - Difficulty paying attention, or confusion

- **If you have any of the above symptoms, immediately go to the nearest emergency room.**

**Conditions – Type II Diabetes**

**Hyperosmolar Hyperglycemic Nonketotic Syndrome (HHNS)** – HHNS is a serious condition that occurs in older patients who have been diagnosed with diabetes. It occurs more often in type II diabetics, although it is possible for a type I diabetic to develop this condition. HHNS starts with high blood sugar levels and a need to drink more liquids.
Severe dehydration may soon follow, which can lead to seizures, a coma, and death. [25]

- Some of the symptoms of HHNS are listed below. [26]
  - Increased thirst
  - Increased urination
  - Weakness
  - Drowsiness or headaches
  - Restlessness
  - Altered mental state
  - Inability to speak
  - Paralysis

*Conditions – Gestational Diabetes*

Because the issues associated with gestational diabetes may occur without diabetes, these have been classified as complications for this report. Please refer to the gestational diabetes complications section for details.

*Complications – Type I and II Diabetes*

Many complications can arise from diabetes. These complications are what make diabetes so deadly. Proper management of diabetes can prevent many, if not all, of these complications from occurring. The CDC presented the following facts about some of the possible complications from diabetes. [27]

- **Cardiovascular disease (Heart disease, stroke, etc.)**
  - Heart disease is now the leading cause of diabetes-related deaths, accounting for about 65% of all deaths for diabetics. [27]
  - According to the American Diabetes Association, people with pre-diabetes have a 1.5-fold risk of developing cardiovascular disease compared to people with normal blood glucose. People with type I or type II diabetes have a 2 to 4-fold increased chance of developing cardiovascular disease. [20]
  - The risk of having a stroke is 2 to 4 times higher for people with diabetes. [27]

- **Eye complications**
  - Diabetes is the leading cause of new cases of blindness among adults aged 20-74 years [27].
  - Diabetes causes 12,000 to 24,000 new cases of blindness each year. [27]
  - Diabetics are 40% more likely to develop glaucoma than non-diabetics. Glaucoma is a condition where pressure builds within an eye. The pressure eventually becomes great enough to damage the blood vessels in the eye, thus causing reduced vision. [28]
Kidney disease
- Kidneys are the organs responsible for removing wastes from the blood. Diabetes can cause this natural filtering system to break down, which will eventually lead to kidney failure. In fact, diabetes has become the leading cause of kidney failure, accounting for about 44 percent of all new cases. [29]
- In 2001, over 40,000 new cases of treatment for kidney failure occurred, and over 140,000 patients needed a kidney transplant or dialysis (treatment to provide artificial kidney replacement). [27]

Nerve damage
- Nerves are responsible for sending messages from the brain to the other parts of the body. Nerve damage due to diabetes is called diabetic neuropathy.
- According to the CDC, between 60% to 70% of diabetics have some form of nervous system damage. This kind of damage includes lessened sensation or pain in the feet or hands, carpal tunnel syndrome, and other nerve problems. [27]
- More severe forms of nerve damage may require amputation of an affected limb.

Amputations
- Due to damage to nerve endings and blood vessels, it is possible that minor injuries in affected areas of the body may not heal properly. If a minor injury becomes infected, it may continue to worsen until tissue death (gangrene) occurs and the limb may need to be amputated. [30]
- According to the CDC, in 2000-2001, 82,000 lower-limb amputations were needed for people with diabetes. [27]

Complications – Gestational Diabetes

The presence of gestational diabetes in a potential mother can have a strong effect on the baby. Mayo Clinic provides the following list of complications regarding gestational diabetes. More resources on the complications of gestational diabetes can be found in the references section under Mayo Clinic, reference 31.

- **Excess growth** - The presence of too much glucose within the mother’s body may cause the child to grow too large. Larger babies are more likely to sustain birth injuries or require a Caesarean section birth. [31]

- **Respiratory distress syndrome** - If the baby is delivered early, it is possible that respiratory distress syndrome, a condition that makes breathing difficult, may develop. Babies who have respiratory distress syndrome may need help breathing until their lungs become stronger. [31]

- **Type 2 diabetes later in life** - Children of mothers who have gestational diabetes have a higher risk of becoming obese and developing type 2 diabetes later in life. [31]
Who is at risk

Diabetes is not limited to any one race or age group. Diabetes can affect people of all races and ages. However, certain attributes may increase the likelihood of developing diabetes. These risk factors can be divided into two categories: modifiable risk factors and non-modifiable risk factors.

Modifiable risk factors

Modifiable risk factors refer to personal attributes that can be changed over time. These factors are strongly related to the development of diabetes. However, the presence of such factors can be diminished or even eliminated. Some of the most important factors are listed below.

- **Weight** – Being overweight or obese is one of the primary risk factors for type II diabetes. The more fatty tissue the body has, the more resistant cells become to insulin. [32]

- **Inactivity** – An inactive lifestyle increases the risk for developing type II diabetes (and to a lesser extent, gestational diabetes). Physical activity allows the body to use up glucose as energy, which then allows the body’s cells to become more sensitive to insulin. [32]

- **Diet** – A diet high in fats and foods that lead to high cholesterol can increase the risk of developing diabetes. [33] Additionally, poor dietary habits can lead to obesity and other health problems.
Non-modifiable risk factors

Non-modifiable factors are risk factors that cannot be controlled. These traits are often ones we are born with, like race or a family history of diabetes. The most important non-modifiable factors to be aware of are listed below.

- **Race** – Although the reasons are not clear, people of certain races are more susceptible to the development of diabetes. People of African American, Latino, Native American, Asian American, or Pacific Islander descent are more likely to develop diabetes than people of Caucasian descent. [33]

- **Age** – The risk of type II diabetes increases as you get older, especially after age 45. [32] This is often due to decreased physical activity, lost muscle mass, weight gain, and increased amounts of fatty tissue. These changes affect the body’s ability to react effectively to insulin, which can lead to diabetes. [32]

- **Family history** – Having relatives with diabetes is also a factor in developing the disease. According to the American Academy of Family Physicians (AAFP), having 1 relative with diabetes doubles your chances of development. Having 2 relatives with the disease quadruples your chances of development. [33]

- **Previous case of gestational diabetes** – Women who have already had gestational diabetes have a greatly increased chance of developing type II diabetes. In fact, almost 40% of women who had gestational diabetes during a pregnancy have developed type II diabetes within 15 years. [33]

Prevention

Once it has developed, diabetes cannot be cured by any practical, clinically available treatment. Many of the experimental solutions have a wide range of serious side effects and other problems. Therefore, the best way to deal with diabetes is to stop it before it has a chance to develop. Learning the details about modifiable risk factors and the steps involved in prevention is the first step in the fight.

Modifiable risk factors – what you need to know

The most important of all risk factors is being overweight or obese. More than 85% of all people with type II diabetes are overweight. [34] Losing weight in a controlled manner is the most effective way to prevent diabetes. Studies have shown that a reduction of only 5 to 10 percent of body weight produced a 58% reduction in the chance of developing diabetes. [35] Combined with physical activity and a healthy diet, weight loss is the most important part of diabetes prevention.
To determine if a person is overweight, a commonly used method is the calculation of the person’s body mass index (BMI). This method uses a person’s height and weight to assign them to an index value. If the BMI is greater than 25, the person is considered overweight. If the BMI is greater than 30, the person may be considered obese and at risk for several diseases, including diabetes. It is important to note, however, that a BMI is just an estimate. This method has several limitations. The National Heart, Lung, and Blood Institute notes that the BMI method may overestimate body fat in people with muscular builds and underestimate body fat on people who have lost muscle mass. [36] Despite these shortcomings, a person’s BMI can give them insight to their situation.

Physical activity and dietary habits are the other important modifiable risk factors. Physical activity is closely linked to weight loss, and details can be found in the next section. Dietary habits are also discussed in the next section, which contains some basic guidelines for a proper diet for weight management and diabetes prevention.

**Recommended steps**

**Exercise**

Exercise and physical activity are some of the best ways to achieve weight loss goals. Physical activity is anything that gets you moving. This includes walking, dancing, or working around the home. Being physically active gives you more energy and increases your strength, endurance, and flexibility for daily activities. Physical activity can also reduce your chance of heart disease and stroke, relieve stress, and strengthen your heart, muscles, bones, and joints. [37] It can also allow your insulin to work more effectively, thus diminishing your chances of diabetes.

You do not need to go to a gym or fitness center to gain the benefits of being active. Combining 30 minutes of exercise a day, 5 days a week, with good dietary habits can greatly reduce your chance of developing diabetes. [38] Simple activities like brisk walking, riding a bike, or swimming laps are excellent starting points if you have been inactive for a while. **If you do choose to start an exercise routine, please consult your doctor or health care provider to see if it is safe for you to start exercising.**

If you do not feel that you have enough time to start any kind of routine, you can do many small tasks throughout the day that burn calories and make you healthier. For example, taking the stairs instead of the elevator or parking farther from your destination and walking are two ways that you can burn a few more calories during daily activities. Even a few of these small activities can have a positive impact on your body.

Mayo Clinic offers the following plan regarding starting an exercise routine or increasing your level of daily activity. [39]
• **Assess your current fitness level** - Recording baseline scores for attributes like your waist size, body mass index, and the time needed to walk a mile can allow you to measure your progress.

• **Design your own fitness plan** – Write down your plan to increase your physical activity. Keep in mind your goals, likes and dislikes, and how you can work exercise into your daily routine when creating your plan.

• **Gather necessary equipment** – Gather whatever you think you will need to make your exercise practical and enjoyable.

• **Get started** – Start slowly and build your routine up gradually. It is easy to overwork the body when starting a routine, so a gradual buildup in intensity or length is the best plan of attack.

• **Monitor your progress** – Occasionally checking your progress will let you see if you are meeting your goals. You can also make changes or add goals to your plan.

Please be aware that it is never too late to begin a prevention routine. A major clinical trial known as the Diabetes Prevention Program (DPP) showed that diet and exercise were more effective than an oral diabetes drug for preventing diabetes. [38] In fact, the study showed that lifestyle changes, such as diet and exercise, worked particularly well for participants over 60. This group achieved a 71% reduction in their risk for developing diabetes, which was higher than the 58% risk reduction for all participants. [38] Talk to your doctor and take this important step toward better health.

**Healthy Eating**

While physical activity is necessary for diabetes prevention, it does little good if the diet that goes along with it is poor. A diet high in fats and excessive sugar can cause weight gain, leading to potential complications like diabetes or heart disease. A proper diet combined with physical activity should cause the body to use up more calories than it takes in. Weight loss only occurs if the number of calories used is greater than the number of calories consumed.

Proper dietary habits for diabetes prevention may not require too much change from your regular diet. Cutting back on the amount of food you normally eat is a good first step for managing your weight. Some other steps that can be taken are:

• Limiting servings of meat, fish, and poultry products to about three ounces. [40]
• Replacing fried foods with baked or broiled products, which are usually healthier
• Adding whole grains and more fiber to your diet. Whole grains are a better source of fiber than refined grains (like white bread), and fiber reduces the risk of heart disease. [41]
• Avoiding “fad” diets that stress low carbohydrates or avoiding certain groups of foods. These diets may not provide important nutrients and are not suitable for long-term weight management. [41]

One of the most important things to keep in mind while eating is the portion size of your meals. According to the CDC, a portion size is the amount of a single food item served in a meal or snack. [42] Portion sizes have increased in the past few decades in the United States. Studies from the CDC have shown a strong link between controlled portion sizes and limited calorie intake. [42] Cutting back on portion size or sharing larger portions with others is a good way to have a satisfying meal while still maintaining proper dietary habits. For more information on proper dietary habits or how to change your diet, please talk to your doctor or health care provider.

Current treatments

The goal of all diabetes treatment is to keep blood glucose levels under control and minimize the chances of complications. Blood glucose levels must be carefully monitored for every type of diabetes. The treatment plan is different for each type of diabetes and varies for each individual diagnosed with the disease. The following is intended to serve as an introduction to the treatments typically used for each type of diabetes. A doctor or health care provider must provide a specific plan for each patient that must be followed closely.

The first 3 parts of this section are applicable to all 3 major forms of diabetes. The last 3 parts give a basic outline for treating each of the major types.

Monitoring blood glucose levels

The most important part of all forms of diabetes treatment is the regular monitoring of blood sugar levels. Both low and high blood sugar levels can cause severe reactions and complications within the body. Therefore, it is necessary to check blood sugar levels at important times of the day. Many type I diabetics must test their blood glucose at least 4 times a day. [43] Your doctor should give you an individualized schedule for testing and instructions on how to test.

The most traditional way of testing is by pricking a finger with a small, sharp needle known as a lancet, placing a drop of blood on a testing strip, and placing the strip into a glucose meter. A glucose meter is a device that can display blood sugar levels within a short time. Although it may be painful, this method is accurate and is still the most common method of testing. [44] The glucose reading can be used to decide if an insulin injection or some form of sugar intake is needed. For more information on insulin injections, please refer to the Using Insulin section later in the report.
Normal glucose readings before meals are 90 to 130 milligrams per deciliter (mg/dL) and less than 180 mg/dL after meals. [45] Please note that these values are not the only acceptable ranges. Values will vary based upon physical activity, frequency and type of meals, and when insulin is taken. [45] Your doctor will be able to tell you your range of acceptable values. If you find yourself falling outside of the normal ranges often, contact your doctor immediately so that the appropriate changes can be made to your management plan.

Because the traditional method of testing can be uncomfortable, researchers have been looking for non-invasive methods of testing. These methods are not always as effective as traditional tests. A doctor or health care provider can advise you if you are interested in one of these methods of testing. Three of these alternative types of testing are:

- **Lasers** – These devices use tiny lasers to penetrate the skin on a finger instead of pricking it, thus reducing discomfort. [46]

- **Continuous Glucose Monitoring Systems** – This method of treatment requires the insertion of a small catheter (a small tube) under the skin. Blood sugar levels are measured and recorded over a 72 hour time frame by a recording device worn on the body. [46] [47]

- **GlucoWatch** – The GlucoWatch is a watch-like device that uses small electrical currents to take tiny amounts of fluid from your skin and sends the fluid to a special sensor on the device. [47] The device still requires calibration through blood drawn from the finger, but it is considered to be one of the first steps to completely non-invasive testing. [46]

**Proper diet**

A proper diet is essential for managing every type of diabetes. The foods you eat have a strong influence on blood glucose levels. Maintaining a balanced diet allows you to achieve a healthy weight and lower your risk for heart disease and other complications of diabetes.
No one diet is suitable for all diabetics. You should work with a doctor and a registered dietitian to create a diet suitable for your needs and lifestyle. Healthy diets usually emphasize vegetables, fruits, and whole grains while controlling portion sizes. [48] For most diabetics, a healthy diet might consist of 40% to 60% of daily calories from carbohydrates, 20% from protein and 30% or less from fat. [49]

A good base to start making healthy food decisions from is the food pyramid. This pyramid, shown in Figure 5, divides foods based on their nutritional contents. Food items from the bottom groups should be eaten more often than food from the top groups. [50] Keep in mind that food from the starches, fruits, vegetables, and milk groups have the highest levels of carbohydrates. Carbohydrates have the most significant effect on blood glucose, and these foods should be consumed in moderation.

Your doctor or dietitian may recommend that you take advantage of a tool known as the exchange list. Because many different kinds of foods can satisfy your nutritional requirements, you can substitute or exchange food items to meet your daily needs. [48] Your doctor can give you recommendations for your individual dietary requirements. See Figure 6 for a sample exchange list.

<table>
<thead>
<tr>
<th>Food group</th>
<th>You can have....</th>
<th>Or exchange it for...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit (each serving contains about 15 grams carbohydrates)</td>
<td>1 small or medium piece of fresh fruit</td>
<td>1/2 cup fruit juice, or canned or chopped fruit</td>
</tr>
<tr>
<td>Vegetable (each serving contains about 5 grams carbohydrates)</td>
<td>1 cup raw vegetables</td>
<td>1/2 cup cooked vegetables or vegetable juice</td>
</tr>
<tr>
<td>Starch (each serving contains about 15 grams carbohydrates)</td>
<td>1 slice or ounce bread</td>
<td>1/2 cup pasta, cereal, starch vegetable</td>
</tr>
<tr>
<td>Sugar, honey, molasses</td>
<td>1 teaspoon</td>
<td>4 grams carbohydrates</td>
</tr>
<tr>
<td>Milk (does not include cream, yogurt or cheese)</td>
<td>1 cup milk</td>
<td>12 grams carbohydrates and 8 grams protein</td>
</tr>
<tr>
<td>Meat</td>
<td>1 ounce meat, fish, poultry, cheese or yogurt</td>
<td>1/2 cup dried beans</td>
</tr>
<tr>
<td>Fat (includes nuts, seeds and small amounts of bacon &amp; peanut butter)</td>
<td>1 teaspoon oil, butter or margarine</td>
<td>5 grams fat</td>
</tr>
</tbody>
</table>

Figure 6 – A sample exchange list
Source: American Academy of Family Physicians page for Diabetes and Nutrition.

Always be sure to monitor blood glucose levels around meals or snacks to ensure that your blood sugar levels are acceptable. Making these adjustments to dietary habits can allow a diabetes patient to live longer and more comfortably.
Exercise and physical activity

Physical activity is a vital part of diabetes management. Being physically active can give you a wealth of benefits, including: [50]

- Lowered blood glucose and blood pressure
- Lower “bad” cholesterol levels and higher “good” cholesterol levels
- Improved sensitivity to insulin
- Reduced risk of heart disease and other diabetes complications

Several types of physical activity are beneficial to your body. These vary in intensity and duration, but all can help your body in some way. The types of beneficial activity are: [50]

- **Extra daily activity** – Some examples of this kind of activity are taking the stairs instead of the elevator, cleaning the house or yard, and parking farther away and walking to your destination. These simple tasks can burn extra calories quickly.

- **Aerobic exercise** – Aerobic exercise is more intense than a daily activity and will cause your heart to beat faster. Aerobic exercises such as walking briskly or playing sports for 30 minutes a day will strengthen your body.

- **Strength training** – Strength training involves the use of weights to build up the muscles in the body. Muscle tissue burns more calories than fat does, even when you are not actively exercising.

- **Stretching** – Proper stretching can increase your flexibility and improve muscle recovery from other types of physical activity.

Diabetes patients who begin exercising must be concerned with their blood glucose levels at all times. Diabetics should check their blood sugar before, during, and after exercise. [51] It is especially important to check blood sugar if any prescribed medications may cause low blood sugar. When exercising, it is usually a good practice to carry medical identification information as well as glucose tablets to take if blood sugar levels drop below acceptable levels. [50] Despite the risk of hypoglycemia, exercise is still strongly recommended for any diabetes patient.

For some tips and guidelines for starting an exercise program, please refer to the Exercise section in the Prevention section of this report. **Be sure to talk to a doctor to see if it is safe to start exercising before you begin any routine.**

Type I diabetes treatment

People diagnosed with type I diabetes are unable to produce insulin for use in their bodies. Without insulin, they cannot survive. Even though exercise and diet, as described in the previous sections, are important to type I diabetics, the most important part of treatment is insulin therapy.
Insulin therapy involves the regular injection of insulin into the body. The insulin in this injection serves as a substitute for the insulin that a type I patient’s pancreas cannot produce. Patients usually administer insulin to themselves after they have been instructed on how to do so by their doctor or health care provider. The proper dosage is based on the patient’s lifestyle and the severity of the disease. A doctor will determine this dosage. If insulin is not administered when needed or if a patient does not regularly check his or her blood sugar levels, diabetic ketoacidosis and other serious complications may occur.

A more aggressive form of insulin therapy is known as intensive insulin therapy. This form of treatment requires careful monitoring of glucose levels and frequent injections of insulin. The goal of this treatment is to keep the patient’s blood sugar levels close to the levels of blood sugar in non-diabetics. [52] If a treatment plan is followed carefully, the chances of having eye, nerve, or kidney damage are greatly reduced. [52] Studies have also shown that the chances of developing cardiovascular disease were reduced by 42% in patients who received this kind of therapy. [53] However, if treatment is not followed properly, noticeable weight gain and hypoglycemia may occur. Talk to a doctor for more details if you are interested in following this treatment plan.

Using Insulin

The use of insulin is important for all types of diabetics. Type I patients, however, are the most dependent on insulin injections. This section discusses some of the methods of injections and the different types of insulin.

Several methods for insulin injection are currently used. The most common method is injection with an insulin syringe. The insulin must be injected into the layer of fat just below the skin, typically into the stomach or outer arm. [54] If the insulin is injected elsewhere, it will not work properly. Injection into muscle tissue results in the insulin being absorbed too quickly to be effective. [54] Currently, insulin cannot be taken in pill form because acids in the stomach would destroy the insulin before it could take effect. [55]

Although insulin syringes are the most common method of injection [55], several other devices can also be used to administer insulin. Insulin pens, jet injectors, or insulin pumps are also acceptable methods. [56] Insulin pumps are unique because they do not require individual injections for use. An insulin pump works by delivering insulin throughout the day through a catheter placed under the skin. [57] Although an insulin pump has many advantages, some of the disadvantages can be quite cumbersome. In particular, if the catheter comes out, a patient could develop diabetic ketoacidosis.

Figure 7 – Insulin injection with insulin pen
Multiple kinds of insulin are available for diabetics to use. The type of insulin used can be adjusted for the patient’s situation at the time of injection. Insulin is classified based on three criteria: [58]

- **Onset** - How quickly the insulin starts to work after it has been injected
- **Peak time** – The time when the insulin is most effective in lowering blood sugar levels
- **Duration** - How long the insulin will work in the body

The most common types of insulin are: [58]

- **Rapid-acting** – This type of insulin takes effect within 15 minutes. It peaks after an hour and lasts for four or five hours. It is usually used just before meals.
- **Short-acting** – Short-acting insulin is also used before meals. It takes longer to take effect, but it can continue to work for 6 hours.
- **Intermediate-acting** – This type of insulin is actually insulin mixed with another substance, commonly protamine or zinc. [59] This mixture slows the rate of absorption within the body, causing this type of insulin to start working 2 to 4 hours after injection. However, the insulin will peak after 4 to 12 hours and can last up to 18 hours. [60]
- **Long-acting** – Long-acting insulin is designed to take effect within 6 to 10 hours of injection and work for more than 20 hours. This type of insulin is usually used in the morning or before bed.

**Type II diabetes treatment**

Because most cases of type II diabetes occur in overweight people, the first course of action is often a carefully managed weight loss program. Losing weight lowers blood sugar levels, and consistently low (and healthy) levels of blood sugar reduce the risk of complications. This kind of program begins with an overhaul of a patient’s eating habits and the incorporation of some kind of exercise routine. Please refer to the appropriate sections above for details.

If exercise and diet changes are not enough to control a patient’s blood sugar, doctors may recommend taking oral medications to assist in the process. These medications are not intended to replace exercise and dieting. The oral medications currently available can be divided into 6 categories. [61] [62] [63]

- **Biguanides** – The most important drug in this group is Metformin. Metformin decreases the amount of glucose produced by the liver. It can also decrease the amount of sugar absorbed by the body and make insulin receptors to be more sensitive. Metformin is less likely to lead to dangerously low levels of blood sugar than other drugs.
• **Meglitinides** – These kinds of drugs cause the pancreas to create more insulin for use within the body. The two major drugs in this group, Repaglinide and Nateglinide, are short-acting medications designed to lower blood sugar after meals.

• **Sulfonylureas** – Sulfonylureas are designed to lower blood sugar levels by stimulating the pancreas to create more insulin. Drugs in this group also help the body’s cells to become more sensitive to insulin. This group of medications has worked particularly well on patients under 40. [64] Some of the most common prescriptions are Glimepiride, Glipizide, and Glyburide.

• **Thiazolidinediones** – These medications are designed to increase the body’s sensitivity to insulin. Pioglitazone and Rosiglitazone are the most common prescriptions in this group.

• **Alpha Glucosidase Inhibitors** – These drugs are designed specifically to slow the rate of digestion of carbohydrates. This acts as a control for rising blood sugar after meals. Acarbose is the most commonly used drug from this group.

• **Dipeptidyl Peptidase Inhibitors** – This is a relatively new class of drugs. Sitagliptin, the only drug currently available, is designed to increase insulin production after meals and decrease the amount of glucose produced by the liver.

The most commonly prescribed treatments for type II patients are a combination of the aforementioned drugs. Combinations of Metformin and a drug from the sulfonylureas group are often used because they have been shown to be the most effective at controlling blood sugar levels. [63]

Two other medications that have recently risen in popularity are Exenatide (Byetta) and Pramlintide acetate (Symlin). Although both medications are taken by injection, neither are replacements for insulin. Byetta increases insulin production in response to meals and decreases the amount of glucose produced by the liver. It also reduces the rate of food leaving the stomach, leading to less food being eaten. Byetta is only suitable for type II patients. Symlin, however, performs a similar function and is suitable for both type I and type II patients. [62] A doctor or health care provider can give you more details about these drugs.

A type II patient may progress to the point where the pancreas stops producing any insulin. At this point, doctors will prescribe insulin injections so that the body will have some form of insulin. The types of insulin used are the same as those used for treatment of type I diabetes. Please refer to the Using Insulin section for more detail on insulin use.

**Gestational diabetes treatment**

Treatment of gestational diabetes begins with careful monitoring of the mother’s blood glucose levels. A common practice is to check glucose levels four times daily, including one in
the morning to check for fasting hyperglycemia. A doctor should provide a schedule specific to the mother’s needs.

The next step in managing gestational diabetes is the creation of a diet suitable for the needs of both mother and child. Typically, a modified diet that meets the needs of pregnancy will keep carbohydrate intake to around 35 to 40 percent of daily calories. It is especially important for pregnant women to avoid skipping meals or snacks. An irregular diet can lead to dangerous blood glucose levels.

Many doctors also recommend that pregnant women should exercise at least 3 times a week for at least 20 minutes. Pregnant women should take care to only do exercises that do not stress the lower body. A doctor or health care provider can give a list and description of suitable exercises.

If diet and exercise are not enough to control a mother’s blood glucose levels, the next step is insulin injections. Oral medications like those used for type II diabetes are not used due to the likelihood of affecting the fetus. No specific type of insulin has been deemed superior to others, so the type of insulin used largely depends on the doctor in charge. It is extremely important to closely follow a prescribed insulin treatment plan. Insulin levels need to be carefully monitored and adjusted as the mother’s body weight and hormone levels change during the pregnancy.

Although gestational diabetes usually resolves after the pregnancy, it is common for the glucose levels of both the mother and the child to be monitored after the pregnancy. As the high levels of insulin resistance from pregnancy decrease, the need for insulin will also decrease. Because women who have had gestational diabetes are at a much higher risk for developing type II diabetes, blood glucose tests are often done 6 weeks after the pregnancy and annually thereafter to check for type II diabetes.

New and experimental treatments

According to the American Diabetes Association, diabetes cost the United States over $174 billion in 2007. The rising costs of treatment have led many researchers to explore treatments for diabetes. Because so many different types of research are being done, this section will focus on three of the most notable treatments under development. These treatments are applications of stem cells, pancreas transplants, and islet cell transplants.

Stem Cell Research

Despite the controversy surrounding the use of stem cells for research, researchers around the world have been trying to use stem cells to cure diabetes. Stem cells are cells that can divide themselves indefinitely. Stem cells can also give rise to cells that eventually become specialized for a particular function in the body. Adult stem cells, which are grown from human bone
marrow, are different from embryonic stem cells, which are taken from a human embryo when it is a few days old. Significant progress has been made with both types of stem cells for both type I and type II diabetes.

To treat diabetes, stem cells first need to be changed into insulin-producing cells called islet cells. [68] Once this is done, cultivated stem cells can eventually be given to diabetics so that the body’s cells will start producing insulin within the body. Because the human immune system usually requires many drugs called immunosuppressants to accept transplanted cells, researchers hope that stem cells will eventually be able to take effect without the use of immunosuppressants. [68]

Studies have found that adult stem cells may be useful for treating diabetes. Researchers at Tulane University have been able to increase insulin production in diabetic mice by injecting the mice with these adult stem cells. [69] Researchers in Ontario, Canada, have been able to completely reverse diabetes in mice using adult stem cells. The stem cells apparently sought out damaged tissue in the pancreas and triggered the growth of new cells. [70]

The most notable results from adult stem cells have come from a small study in Argentina. In this study, type II diabetics were treated with stem cells drawn from each individual’s bone marrow. Patients experienced an increase in insulin production and a decrease in blood glucose levels. Amazingly, 84% of patients no longer needed the medications or insulin they were previously receiving. [71]

Studies have also shown that embryonic stem cells also have great potential for diabetes treatment. Researchers were able to control diabetes in mice by injecting them with embryonic stem cells. However, several of the mice eventually developed tumors, indicating that the cells are not ready for use in humans. [72] The researchers are hoping that these stem cells can become islet cells, which produce insulin. Work with embryonic stem cells is still in a very early stage because work with this kind of stem cells only began in 1998.

Although researchers have made progress with stem cells in recent years, stem cells are not yet a viable treatment method. The possible side effects of stem cell treatment have not been fully addressed. It will be some time before research progresses to the point where it is safe to begin testing solutions on humans.

Pancreas transplants

Pancreas transplants may be a potential cure for type I diabetes, but it is not a standard treatment method. This treatment is only recommended for patients with very advanced type I
diabetes, and is only tried if standard treatments are no longer effective. Many complications may occur, and one or two out of every 10 patients who receive pancreas transplants die within a year of the transplant. According to the American Diabetes Association, almost one half of all transplants are not accepted by the recipients’ bodies. [73]

The potential benefits of a whole pancreas transplant are enticing. If the transplant works, the patient can prevent further diabetes complications, eliminate the need for insulin injections, and reduce the restrictions on diet and activity. [74] Additionally, a pancreas transplant that is done with a kidney transplant strongly reduces the risk of developing diabetes related kidney disease. [75]

Although a transplant can be beneficial, the process can be quite difficult. Doctors usually try to match donors to recipients by a blood protein called human leukocyte antigen (HLA) type. [73] However, the number of donors for whole pancreas transplants are few, leading to fewer whole pancreas transplants and more partial pancreas transplants. These partial pancreas transplants also require kidney transplants to work properly. [73]

Additionally, the recipient’s body usually does not react well to the new organ. Immunosuppressants are usually required to force the body to accept the new pancreas, but the pancreas may still fail. Immunosuppressants are drugs designed to reduce the ability of the body’s immune system. These drugs must be taken for the rest of the recipient’s life. One of the major obstacles of use of immunosuppressants is a reduced ability to fight infections. Some of these medications may even increase the risk of developing high blood pressure, high cholesterol, or cancer. [75]

Immunosuppression therapy has improved in recent years, but the use of pancreas transplants as a large-scale treatment option is still many years away. The problem of few donors also complicates the possibility of using pancreas transplants in the future.

**Islet cell transplants**

Islet cells are special hormone producing cells within the pancreas. Diabetes researchers are interested in these cells because beta cells, contained within islet cell clusters known as islets, can produce insulin. [76] Researchers are especially interested by islet cell transplants for two reasons. First, stem cells can become islet cells, which can then be transplanted into a diabetes patient. Second, islet cell transplants can occur without transplanting an entire pancreas.

Islet cell transplants are currently only good for type I diabetics and type II patients who require insulin. These transplants are still in the experimental stage. However, results from several clinical trials indicate that this method may work in the future. The most important trial tested a technique known as the Edmonton protocol. This technique involves injecting islet cells from brain-dead donors or cadavers (corpses) into the recipient’s liver. Early results showed a reduced need for insulin, but over time, only 10% of the patients in the trial remained insulin free. [77] More work needs to be done, but researchers believe they are on the right track with this method.
Islet cell transplants have two obstacles to overcome. The first is the short lifetime of transplanted cells, which was demonstrated through testing of the Edmonton protocol. Researchers are trying to find ways to make the recipient’s immune system learn to accept these new cells. Additional complications arise with the need for immunosuppressants. [77]

The second obstacle is a need for suitable pancreases. In 2001, only 6000 donors were available, and only 2500 of them had suitable organs for transplants. [78] The need for donors is still strong, so researchers are looking into developing islet cells in laboratories. Stem cells appear to have the most potential to solving this problem.

**Conclusion**

Although diabetes is a very serious disease with many potential complications, advances in treatment have kept it from being an immediate death sentence. Many resources have been set up by the government and private organizations to help prevent diabetes in people who have not developed the disease. Anyone who has proper dietary habits and engages in physical activity can greatly reduce their chances of developing diabetes. It is never too late for anyone to begin prevention for diabetes.

For people who have been diagnosed with diabetes, a wide range of treatment options are available. Effective insulin treatments have been created for all forms of diabetes. Doctors have been specially trained to create diets and exercise routines that can help control blood glucose levels. Diabetics who carefully manage the disease can live healthy, normal lives.

Billions of dollars are being used to research more effective treatments and possible cures for diabetes. Advances in stem cells, pancreas transplants, and islet cell transplants have shown that even better treatment options are being developed and may soon be available.
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