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**How the Symptoms and Conditions Associated with Diabetes Can Impact Mobility and
Health of the Individual: A Literature Review**

Kaitlin Grace Fotis

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Introduction

Diabetes, and the overall effects it has on the body, can be debilitating to the level of impaired physical mobility. Individuals may even reach the point where they may not be able to walk again. Research literature has outlined the physiological differences that both Type I diabetes mellitus and Type II diabetes mellitus have on the cells. The effects can snowball from standard blood glucose issues, to circulatory issues, to sores and amputations if not taken care of properly. Diabetes affects roughly 246 million people worldwide attesting this is not a small matter (Said, 2007). The lasting effects affect not only the individual, but can also affect their families and community as this disease can be disabling and costly. Vast amounts of research have already been dedicated to diabetes but more needs to be conducted looking into the progression that leads to amputation and how physical therapists assist those patients with prevention, prehabilitation and post-surgery rehabilitation.

Insulin

Insulin is a naturally occurring hormone in the body that is created in the pancreas. Its role is to signal glucose uptake from the bloodstream resulting in lowering the individual's blood sugar levels. For those with diabetes, the beta cells that create this hormone are either not effective or begin to be less effective as time goes on (Diabetes treatment, 2019). Diabetics must take insulin supplements to balance their blood glucose levels and they can do so through different mechanisms like pumps, pens, and self-administered shots.

Type I Diabetes

Type I diabetes is the result of “a defect auto-immune destruction” that attacks and destroys pancreatic beta cells (Palicka, 2002). Pancreatic beta cells create insulin to decrease blood glucose levels in the body. Type I diabetes leads to the need for injections of insulin post

consumption of food to maintain those blood glucose levels. Overall, usually “the autoimmune process begins many years before clinical detection and presentation” (Palicka, 2002). The volume of cell destruction must be 10-20% in order to be diagnosable. Those affected by Type I diabetes often include infants and small children because their beta cells break down faster. Adults may also have Type I diabetes, but their symptoms set in slower. Overall, only 5-10% of those with diabetes are diagnosed with Type I (Colberg et al, 2016).

Currently, it is unknown if Type I diabetes is caused by only a genetic linkage to chromosome 6, specifically in its HLA system. It is known that islet cell antibodies found in the cytoplasm of the endocrine cells in pancreatic islets may lead to the destruction of cells. There are also environmental factors such as viruses like rubella that can lead to the triggering of Type I diabetes symptoms in the body (Palicka, 2002). According to *Viral Trigger for Type I Diabetes: Pros and Cons*, the main viruses that contribute to the possible development of Type I diabetes are enteroviruses, with CVB4 being the most common. CVB RNA has been detected in the blood of those recently diagnosed with Type I diabetes and also in those who have been living with Type I diabetes (Filippi & von Herrath, 2008). Also, strains of rubella, but only congenital rubella, have been proven sources of development of Type I diabetes later in life (Filippi & von Herrath, 2008).

Type II Diabetes

Type II diabetes affects a larger population with roughly 90% of those diagnosed with diabetes having Type II. Type II diabetes often affects an older population, many times in obese individuals, and it usually develops over time (Palicka, 2002). It is also called “adult-onset” diabetes or “non-insulin dependent” diabetes, meaning the body stops responding and producing insulin. It is linked to environmental, social, and genetic factors. “The links between obesity and

type 2 diabetes are complex: 60-80% of those with type 2 diabetes are obese, diabetes develops in fewer than 15% of obese individuals” (Palicka, 2002).

Many lifestyle changes can be made to increase healthy habits, these can be helpful when it comes to managing Type II. With improvements to health through lifestyle interventions, individuals with Type II diabetes may be able to manage their diabetes before insulin shots become a necessity. Exercise and diet, coupled with sleep and stress, are the main changes that will help make living with Type II diabetes more manageable. Weight loss through diet, exercise, and other forms of physical activity helps their body add muscle mass which makes more opportunity for glucose uptake. Medication wise, insulin supplements, like shots, may be needed as time goes on. These shots are injected into the body after a meal or after an event that will alter the individual’s blood glucose levels. The insulin supplement maintains the patient’s blood glucose levels within the tolerable limits for health.

Overview

Many medical conditions can develop as a result of living with diabetes, particularly if their diabetes is poorly managed. After living with diabetes for years, individuals may develop what is known as diabetic neuropathy. Diabetic neuropathy affects the nerves and feeling, generally in someone's lower extremities. Around 50% of individuals with diabetes will in fact develop diabetic neuropathy (Hicks & Selvin, 2019). Many times, people have symptoms such as a burning sensation on the bottoms of their feet, tingling, and even numbness. Often, diabetic neuropathy sets in later in life and in those who have had diabetes for many, many years.

If the neuropathy continues to progress in the body, further issues may develop. Individuals could develop sores and ulcers on the bottoms of their feet. These injuries are very painful, however, there are times that the patients are not aware they have a sore or ulcer due to

the lack of feeling and numbness in their feet. Due to poor circulation, and lack of sensation, if the sore or injury is not taken care of right away, the risk of infection increases drastically and their chances of needing an amputation increase as well. It can be a slippery slope if the correct protocols are not followed or if the individual is unaware of how serious diabetic neuropathy can be.

In addition to diabetic neuropathy, diabetic amyotrophy could also set in. Amyotrophy is a weakening of motor strength in the body and could lead to a difficulty in daily activities. It can be difficult to diagnose amyotrophy because the symptoms are similar to neuropathy. Many times, those battling amyotrophy will develop a foot drop, loss of balance, and be at a higher fall risk. The difference between diabetic neuropathy and diabetic amyotrophy is amyotrophy only affects the body from anywhere between two months to two years. It normally fades overtime and it is not a lifelong condition. The aftermath of amyotrophy could result in a long-term and significant disability or hindrance, but the pain caused from it will generally fade. Beyond the potential physical pathologies, around 20-40% of individuals with diabetes will develop diabetic nephropathy, a form of kidney disease (Dronavalli, Duka, & Bakris, 2008). Diabetic nephropathy may lead to the development of renal cancer and is the main cause of end-stage renal disease. High blood sugar, high levels of filtration, and poor maintenance of diabetes creates this downward spiral into kidney failure. This can lead to dialysis. Some of the protocols that should be followed, include an exercise plan and a diet or meal plan. Exercise, specifically resistance training and aerobic exercise, have been clinically proven to help maintain blood glucose levels and improve the individual's overall health. Often, people who are diagnosed with Type II diabetes are classified as obese and may have many other health implications that are also

damaging, like high blood pressure. Exercise will help on every level from heart health to liver health and even brain health with the release of endorphins post-workout.

Brain and mental health should not be ignored at any point during an individual's journey with diabetes. Depression and anxiety are symptoms that many develop over time as the person realizes their body is different and their lifestyle must change (Teens with diabetes, 2020). At times, especially in younger diabetics, they rebel and stop taking their medication to “fit in” or because they don't want to feel “different” (Teens with diabetes, 2020). Sometimes this comes from an internal frustration with their ongoing diagnosis and treatment. This action only hurts them in the long run but is a prime example of what psychologically diabetics could be going through. Along with mental health, diabetic individuals, and those at risk of developing diabetes, need more education on the topic This can come in the form of a public health perspective as well as an individual patient education approach.

If a patient with diabetes reaches the point of difficulty with ambulation, issues with neuropathy, or even looking at potential amputation, odds are they would be referred to a physical therapist. Physical therapists would work with them on issues such as their gait, strength, and overall function. . Neuropathy can hinder the feeling in the feet, so that results in the possible loss of everyday activities like walking. At that point they could be at a high risk of falling, so their balance would also need to be an area of focus for the rehabilitation specialists Physical therapists are there to help them improve and sometimes relearn these functions while keeping in mind also improving their overall body health.

Background

The history of diabetes, from its origin to the creation of insulin, has been a long journey with help from physicians, chemists and physiologists. Dating back to the 5th and 6th centuries

AD, Indians made the first connections between diet, lifestyle and genetics to the disease that would later become known as diabetes. Diabetes is a Greek word meaning “to run through” or “siphon” (Ahemd, 2002). This word was coined by Araetus of Cappodoeia after he described people who had diabetes as people who could drink water all day and it would still run right through them. Araetus also described their condition as “a melting down of the flesh and limbs into urine” (Ahmed, 2002). Less accurate than our current understanding and not likely to be used today, it is a good marker to show their past understanding of the disease and how far we have come in our knowledge of this common condition.

As a brief overview, an Arab physician named Avilenna was the first to describe some of the conditions one could develop from having diabetes, i.e., neuropathy. By 1675, Thomas Willis coined the terms diabetes insipidus and diabetes vera, meaning tasteless urine and sweet urine. The sweetness of the urine of those with diabetes was one of the beginning differences of diabetics. It was just unknown as to what caused that difference yet (Ahemd, 2002).

In the 18th century, chemistry was introduced to the topic and helped become a diagnostic tool. Also during this time, endocrinology led to the understanding of glands in organs which would lead perfectly into learning about the secretion of insulin. By 1776, it was discovered that there was sugar in both the urine and blood of those with diabetes, however, the origin of where the excess sugar was coming from was still a mystery (Ahemd, 2002). In 1815, the sugar was found to be in the form of glucose and by 1855 the liver was deemed the origin of secreting this excess sugar. To wrap it all up, the term glycogen was coined in 1857 and it was not until 1947 it was learned how glycogen is converted into sugar with the help of enzymes (Ahemd, 2002).

Role of the Pancreas

Now that the secretion and breaking down of glycogen was known, understanding the role of the pancreas needed to be uncovered. The beginning stages of questioning began in 1673 after Johann Brunner started experimenting on dogs and their pancreases (Ahemd, 2002).

Around 1893, is when pancreatic islets were found to produce internal secretion and were helpful in breaking down carbohydrates. Following that discovery, in 1900 it was found that diabetic individuals had defects in their pancreatic islets. Then, the term “insulin” was coined in 1916 by Edward Sharpy-Shafer (Ahemd, 2002). Claude Bernard, said to be the “founder of experimental medicine by applying physical and chemical methods in artificial induction of diseases”, had issues learning what a person’s blood glucose level was and when he could do it, it required a substantial amount of blood as compared to today (Ahmed, 2002). Bernard also ran into the issue of the enzyme trypsin destroying insulin in the body before it could be examined. In the end, by the 1970s, and after many trials of artificial insulin, highly purified insulin, which is nearly identical to human insulin, was released to the world and is still used today (Ahemd, 2002).

Diagnosing Methods

With the history now known, the steps one would take to learn if they have diabetes could take place a few different ways. Most every test is assessing the individual’s blood glucose levels. Individuals who should consider getting tested are those who are over the age of 45 years old, those with a BMI over 25, and anyone who has already been diagnosed with prediabetes (Diabetes, 2020). Some tests require the individual to fast for 8 hours before the test and if their glucose levels are above 126 mg/dl they are diagnosed with diabetes (Diagnosis, n.d.). This test is named Fasting Plasma Glucose (FPG), it is done in the morning, and is a blood test via venous blood draw or finger stick. Other exams include the Oral Glucose Tolerance test which requires

the patient to drink a sweet drink. Before and after the drink is consumed, the patient's blood sugar is taken to show how their body breaks down sugar. If their blood sugar is equal to or above 200 mg/dl two hours post-drink, they are diagnosed with diabetes (Diagnosis, n.d.). The A1C test, or Glycated hemoglobin test, is debatably the easiest method as the patient has no obligations prior to the test, such as fasting. Their blood sugar is measured and is averaged over the last two months. If the A1C comes back at or higher than 6.5%, the patient is diagnosed with diabetes (Diagnosis, n.d.). The final test is known as a Random Plasma Glucose Test. As the name implies, the patient's blood is checked during a random point in their day and if their blood sugar is above or at 200 mg/dl, they are diagnosed with diabetes (Diagnosis, n.d.). Each of these tests also notify physicians and patients if they are in the pre-diabetes range of blood sugar levels. If they are in the prediabetic range, their levels are around: an A1C of 5.7%-6.4%, a fasting blood sugar of 110-125 mg/dl, or an oral glucose tolerance test results of 140- 199 ml/dl (Diagnosis, n.d.).

Post Diagnosis

Once diagnosed with diabetes, it can be difficult for people to feel normal or feel like themselves. The current prognosis for living with diabetes is a good one. Awareness of blood sugar levels will need to be developed and some devices, like blood sugar meters, may need to be purchased. Life can still go on as it once did, but some adjustment will need to be made. An example of this come back is when two time Olympic swimmer Gary Hall Jr.. Hall was diagnosed with Type I diabetes when he was 21 years old and was about to compete in the 2000 Olympics (Olympic champion, 2020). He was the first Olympian with Type I to compete and subsequently became the first Type I diabetic athlete to medal at an Olympics winning three gold medals, one silver, and two bronze, post-diagnosis at the 2000 and 2004 Olympics (Olympic

champion, 2020). Hall went on to have a successful swimming career and said, “the new technologies and therapies that are emerging are so encouraging. You’ve got great tools at your disposal and if you’re aggressive managing this you can do whatever you want to do” (Olympic champion, 2020).

Technology for Checking Blood Glucose Levels

When it comes to monitoring blood sugar levels, a blood glucose meter, a continuous glucose monitor (CGMs), and/or an insulin pump, are the top mechanisms used. Blood glucose meters are small devices that can fit in a pocket or purse that measure an individual’s blood sugar level with a drop of blood. After pricking their finger, the person dispenses a drop of blood onto a blood glucose meter strip which loads into the meter and reports the current blood glucose level for that person (Devices & Technology, n.d.). The second option to help monitor blood sugar levels is a CGM. A sensor is placed under the skin and reports current levels at set intervals to a recording device. The American Diabetes Association reports this as a good option for someone who has “trouble reaching and maintaining target blood sugar” (Devices & Technology, n.d.). The meter and CGM both report blood sugar levels, however, after doing so the individual would then have to administer either a shot or pill of insulin to maintain their levels. The main difference between the meter and CGM is that CGM’s may not be covered by insurance as it could be considered a non-necessity.

The third option to help manage blood glucose levels is an insulin pump. The pump is attached to the body and generally clipped to a pant loop or hung on a waist strap to be carried by the individual. The pump is different from the other two options because it injects insulin throughout the day or at mealtimes (Devices & Technology, n.d.). The pump completes this task on its own and it reads levels all day long. The main thing to take into consideration when

debating getting a pump is a slight change in lifestyle. Activities such as running, jumping, and swimming are still doable, they may just need to be accounted for. There are special waterproof cases for insulin pumps and they can be disconnected when swimming or showering if the activity is less than an hour long (Diabetes: Living with an insulin pump, 2020). For athletes, to help prevent infection or loss of the adhesive on the catheter, antiperspirants can be sprayed around the site to reduce sweat. When playing sports, the insulin pump can be disconnected, but it is recommended to not be off for more than 1 to 2 hours (Diabetes: Living with an insulin pump, 2020). If they are going to disconnect their pump before exercising, some may first eat a small snack to increase their blood sugar. If they keep their pump connected during exercise, some “need to lower [their] basal rate during the activity” (Diabetes: Living with an insulin pump, 2020). Individuals control their basal rate, or rate of insulin infusion, so less insulin will be pumped into their body during exercise.

There are new technologies on the horizon for blood glucose monitoring, one of which is a hybrid of two other systems: the CGM and the pump. This system will allow the CGM to monitor blood glucose levels and notify the pump if the amount of insulin that would normally be released needs to be higher, lower, or can stay the same. Many people prefer a pump because it limits their daily injections, so these two mechanisms working together ensure no need of daily injections. The pump is a larger commitment, and it does not remove the job of checking one’s blood sugar daily. This new system takes more of the responsibility of monitoring the amount of insulin in the body without needing to be checked constantly (Devices & Technology, n.d.).

If a pump is not ideal, self-administered daily injections or oral medication can be taken. For those with Type I diabetes, insulin is a must have. For Type II diabetics, sometimes exercise and diet is enough to maintain levels with a little help from medication, like oral pills. Oral pills,

or diabetes pills, are not as strong as insulin, but are helpful for those recently diagnosed with Type II and who are also making lifestyle changes simultaneously (Insulin routines, n.d.). As mentioned before, for those with Type I diabetes, insulin is a must. These injections range from two to four a day and are taken in accordance with meals. Most commonly used devices to deliver insulin are syringes, but recently insulin pens have been made. These resemble an Epi-Pen and also insulin pumps can deliver insulin, as discussed earlier. These injections should go into the abdomen because that is where they will work the fastest. Shots in the upper arm or leg take longer to enter the bloodstream. These injection sites should rotate throughout the day to avoid a buildup of fat deposits which could then make it more difficult for the insulin to work (Insulin routines, n.d.).

Summary

Risk factors for diabetes depend upon the type the person has. Type I diabetes is a genetically linked condition that an individual is often born with and lives with their whole life. Their body does not produce insulin and they need to administer it into their bodies daily. Type II diabetes can be developed over time and is linked to a sedentary lifestyle, a lack of exercise, an unhealthy diet and obesity. High blood sugar and a body mass index over 25 are some of the first signs of either pre-diabetes or diabetes, depending on the person's blood glucose levels.

Development of Type II diabetes may be avoided with daily exercise and a healthy diet.

Along with living with diabetes and managing it, diabetes itself has been linked to other medical conditions such as pancreatic cancer and renal cancer. "Subjects diagnosed with diabetes at least 10 years prior to the diagnosis of cancer had a significant (50%) increased risk" as found in *Diabetes mellitus, other medical conditions and familial history of cancer risk factors for*

pancreatic cancer, 1999. Other medical conditions that may develop include diabetic neuropathy, diabetic amyotrophy, diabetic nephropathy, sores, ulcers and amputations.

Medical Issues

Neuropathy

Diabetic neuropathy is caused by high blood sugar leading to the breakdown of nerves in the body (Diabetic neuropathy, 2020). This results in motor signals not being received and degeneration of the muscles, mainly in the foot and leg (Diabetic neuropathy, 2020). Diabetes is the leading cause of neuropathy worldwide and is becoming an increasingly larger issue in populations where obesity is on the rise. Individuals over the age of 50 years old and who have had diabetes for a long stretch of time are also more likely to develop neuropathy, regardless of their weight.

When first diagnosed, patients may complain about pain in their feet. This tingling, and sometimes painful sensation may then travel up to more proximal portions of the lower limbs and at times reach the distal portions of upper extremities; this is known as Length-dependent Diabetic Polyneuropathy (LDDP). As stated in *Diabetic Neuropathy - A Review, 2007*, “more than 80% of patients with clinical diabetic neuropathy have a distal symmetrical form of the disorder” (Said, 2007). The longest nerve fibers are affected first and then, like dominos, the short sensory axons begin to break down and deteriorate. This form of neuropathy is not specific to only people with diabetes; however, it is very common in those with the disease.

Symptoms of LDDP include numbness, burning sensations and pins-and-needles of the feet. It has also been found that these symptoms are more prominent at night (Said, 2007). The sensory neuropathy can be more difficult to feel or diagnose unless examined. Many times, sensory neuropathy results from a painless burn or a plantar ulcer. The loss of sensations, like

temperature, can lead to these painless burns and plantar ulcers which could lead to more serious complications down the road. In such cases, “alterations of the autonomic unmyelinated fibers” must also be occurring (Said, 2007). The most extreme cases result in loss of temperature, pain sensations, and simultaneous tingling and numbness from the toes to the top of the head. When looking at the “loss of large, myelinated fibers and proprioceptive afferent fibers” as an effect of LDDP, the individual may lose their touch and vibration sensations (Said, 2007). There is no cure for LDDP, but improvements in glycemic control can lower the risk of developing a neurological deterioration moving forward.

Diabetic Neuropathy - A Review, 2007, discusses the complications that can come in lieu of LDDP, like painful symmetrical polyneuropathy. This affects diabetics and mainly causes neuropathic pain. Impairments to the individual’s mechanoresponsive nociceptors leads to a loss in sensation of mechanical stimuli and heat (Said, 2007). Also, pain stimulation and the transmission of pain stimuli are linked to the” sodium channels on cell membranes of nociceptive neurons of the dorsal root ganglia” (Said, 2007). If the genetic code for these sodium channels is in any way corrupt, the individual’s pain stimulation will be corrupt. This proves, to an extent, that this loss of stimulation can be genetically linked.

Amyotrophy

In addition to the effects of neuropathy, amyotrophy may result and have effects on the body. Amyotrophy is the weakening of motor strength in the body that can result in a foot drop, body pain, muscle atrophy, and other bodily symptoms. Diabetes is a possible risk factor for the disease of amyotrophy, however, there is no primary link between the two.

Diabetic amyotrophy can be difficult to diagnose as it appears to give off similar symptoms to diabetic neuropathy, nerve root compression, and some infections like HIV (Diaz &

Gupta, 2021). Amyotrophy is different from neuropathy because it affects the body anywhere from a few months to two years while neuropathy can last longer. Its effects can range from mild to severe with some patients experiencing slight chronic pain to others losing their ability to walk or developing a dragging foot, known as a foot drop.

For the common patient with amyotrophy, the disease will get worse before it gets better, it will then plateau, and with the help of both medication and physical therapy, the recovery process will begin. Depression and anxiety are common side effects that make it difficult for patients to get better faster. Due to there being a link to mental health, occasionally selective serotonin reuptake inhibitors (SSRIs) are prescribed (Diaz & Gupta, 2021).

Amyotrophy presents a new chronic pain into the patient's body and that pain needs to be medically or pharmaceutically managed for the individual to continue living a full life. Medication, like immunosuppressants, are prescribed regularly. The treatment for amyotrophy centers around the patient's pain and hopes to find ways to lessen it (Diaz & Gupta, 2021). Treatment also surrounds the concept of preparing the patient for life after the disease if/when motor deficient effects persist. The patient will learn alternative methods to daily activities, like walking up stairs, which may be difficult due to loss of muscle strength. Since many of these patients have been living with diabetes, or were at least recently diagnosed with diabetes, they may also need to learn how to maintain healthy blood glucose levels with controlled exercise and diet. For reference, healthy fasting blood glucose levels are less than 100 mg/dl, prediabetes ranges from 100 mg/dl to 125 mg/dl, and diabetic blood glucose levels are above 126 mg/dl (Diagnosis, n.d.).

Sores, Ulcers and Amputations

Ulcers, sores and amputations can result from having diabetes. “According to the International Consensus on Diabetic Foot, a foot ulcer is defined as a full-thickness wound below the ankle in a diabetic patient” (Atosona & Larbie, 2019). As for the percentage of individuals reporting experiences of a foot ulcer, “11% out of 100 diabetic people” reported having one (Atosona & Larbie, 2019). Foot ulcers are prevalent in diabetic patients and can inhibit their abilities to complete daily activities like walking or standing and can impact balance. “Foot ulcers and their complications are an important cause of morbidity and mortality in patients with diabetes” (Moulik, Gill, & Mtonga, 2003). “About 50% of patients undergoing nontraumatic lower-limb amputations have diabetes” (Moulik, Gill, & Mtonga, 2003).

In connection with neuropathy, a study conducted between 1994 and 1998, out of 185 diabetic individuals with new ulcers, neuropathy was present in 113 people (Moulik, Gill, & Mtonga, 2003). While neuropathy was present in many of their test subjects, amputation rates were lowest in those with neuropathic ulcers and higher in those battling ischemic and neuroischemic ulcers (Moulik, Gill, & Mtonga, 2003). While amputation rates are not incredibly high in diabetics, the risk is still present and should be made clear as a possibility.

Nephropathy

Individuals diagnosed with diabetes have a chance of developing diabetic nephropathy as they get older in age and have had the disease for a longer period of time. Between 20-40% of patients with diabetes will also develop diabetic nephropathy as stated by Dronavalli, Duka, and Bakris, 2008. Those with Type I diabetes have an 80% chance of developing diabetic nephropathy if their Type I diabetes is left untreated. Individuals with Type II diabetes, over the course of 15 years, have a 20-40% chance of developing diabetic nephropathy (Dronavalli,

Duka, & Bakris, 2008). A diabetic individual's chances of developing diabetic nephropathy also increase if someone in their family has or had diabetic nephropathy. There is a genetic link between the two regardless of if the individual has Type I or Type II diabetes.

In fact, "diabetic nephropathy is the leading cause of end-stage renal failure" and has a "20- to 40- fold increased risk for cardiovascular disease" (Remuzzi, Macia, & Ruggenti, 2006). This is believed to result due to a lack of correct treatment that leads to increased blood pressure and results "in increased genesis of renal failure" (Remuzzi, Macia, & Ruggenti, 2006). Also, if proteinuria, an unusual amount of proteins in the urine, is not treated, it can speed up the development of kidney disease. Renal failure leads to dialysis where a patient can experience any number of symptoms: high or low blood pressure, sleep problems, muscle cramps and depression (Hemodialysis, 2019). If proteinuria is treated, it will slow the progression of renal disease by 30% (Remuzzi, Macia, & Ruggenti, 2006).

Treatment and Living with Diabetes

Diet

Living with diabetes can appear to be challenging and scary with all the information above, however, it is doable and only requires a few changes for the better on the patient's end, starting with their diet. Switching up a meal plan and daily snacks is easier said than done, but altering a newly diagnosed Type II diabetic's meal plan is crucial to helping their body. Glycemic index is the assigning of numbers to "carbohydrate-containing foods according to how much each food increases blood sugar" (Glycemic index diet, 2020). This is important for diabetics to be aware of when it comes to their diet as they want a low sugar diet. Their ideal plate should be a generous serving of non-starchy vegetables, equal parts carbohydrates that are

high in fiber and low in sugar, a protein like chicken or fish and a zero-calorie drink, like water (Eating well, n.d.).

Carbohydrates are made up of three main “ingredients”: starches, fiber, and sugar. Sugar in the case of diabetes is what needs to be watched the most. Some carbohydrates, like a bowl of strawberries which have natural sugars, sway a person’s blood sugar levels quicker than others. The more carbohydrates are ingested, the more sugars are broken down in the pancreas and the more excess sugar is in the bloodstream. This is when insulin needs to be injected to bring those levels back down. It is recommended by the American Diabetes Association that a person inject their insulin 30 minutes before they plan to eat, so by the time their body begins to digest their food, the insulin will be the most effective (Eating well, n.d.).

Some non-starchy vegetables include leafy greens, carrots, asparagus and cauliflower. Many of these are already staples in households, so making them fill half of their plate is what is best for their body. These vegetables are high in fiber and low in carbohydrates which help keep blood sugar low. Soluble fiber is a great addition to a diabetic’s diet because it can “slow the absorption of sugar and help improve blood sugar levels” (Mayo Clinic, 2021). As mentioned before, a lean protein should be chosen for one quarter of the plate while keeping in mind that some plant-based proteins like beans are high in carbohydrates (Eating well, n.d.). For the quarter plate of carbohydrates, eating whole grains like brown rice and quinoa will still affect blood sugar levels, but that is why the portion is smaller.

Exercise

Exercise is also a great tool to take advantage of before and during an individual's journey with diabetes. Exercise can help lower blood sugar levels and can make the body more sensitive to insulin. Aerobic exercise and resistance, or strength, exercise can be used in various

ways to help the patient's body become healthier while improving their glycemic control and insulin. The results from these two different types of exercises can be different depending on if the patient has Type I or Type II. No matter the classification, diabetes will lower the individual's strength. A healthy body is the best body when battling diabetes, so a daily workout routine is warranted.

Aerobic exercises like swimming, jogging, and walking should occur daily for at least 10 to 30 minutes for individuals with Type I diabetes. To see a lowering in insulin resistance, no matter type classification, the patient should not miss exercising two days in a row. Aerobic exercise has been linked to substantially lower cardiovascular issues and lower overall mortality risks in individuals with Type I and Type II (Colberg et al, 2016). The effects of aerobic exercise on Type I diabetics include a decrease in insulin resistance, as stated above, improved lipid levels and improved cardiorespiratory fitness. Individuals with Type II will see a reduction in their blood pressure and decreased insulin resistance.

Anaerobic exercises have also been shown to aid in insulin sensitivity and blood glucose management (Fitness, n.d.). Examples of anaerobic exercises are weightlifting, sprints, or any exercise that is done in bursts and cannot be maintained over a long period of time. Like aerobic exercise, there are many pros to working this type of exercise into a workout routine. The individual's blood sugar may increase up to an hour after working out anaerobically. This is due to the stress their body was under (Fitness, n.d.).

Paired with aerobic and anaerobic exercise, resistance training, or strength training, aids diabetics greatly. Resistance training includes exercises with free weights, weight machines, exercises using body weight, and elastic band resistors. Alone, resistance training helps minimize the risk of hypoglycemia in Type I diabetics. In Type II diabetics, it helps with insulin resistance,

glycemic control, maintaining blood pressure, and helping the individual gain lean body mass (Colberg et al, 2016). An interesting fact found by Colberg et al states if a Type I diabetic individual does both resistance and aerobic exercises in the same workout session, and completes the resistance training first, they are less likely to have hypoglycemia occur than if they complete their aerobic exercises first. In general, even if someone does not have diabetes, they should still be completing aerobic and resistance exercises weekly, if not daily, to maintain their health and muscular strength.

Other forms of exercises, such as flexibility training have no research proven signs to improve the health or effects of diabetes on an individual. The most they can do is help loosen up their joints and improve their range of motion. Balance training has been used to improve gait and help prevent fall risks. Specifically, tai chi has proven to minimize fall risks by about 28% (Colberg et al, 2016). Yoga can be used as an alternative exercise to help strengthen an individual. In particular, Type II diabetics can see a lowering in their body composition, an increase in glycemic control, and better maintenance of their lipid levels. Overall, not a lot of research has been conducted on alternative exercise and their effectiveness on Type I and Type II diabetes, but there are pros to them all, and those should not be ignored.

Exercise has positive effects on the body, and for those with diabetes, the effects are helpful with their glucose uptake. After exercise, glucose uptake remains elevated by insulin-independent for roughly 2 hours and remains elevated by insulin-dependent for roughly up to 48 hours (Colberg et al, 2016). Depending on the type and duration of exercise completed, the effects may last longer or shorter. Studies have shown “improvements in insulin action may last for 24 hours following shorter duration activities (~20min) if the intensity level is close to maximal effort” (Colberg et al, 2016). An exercise like running or swimming could achieve this.

If high intensity exercise is not feasible, low intensity aerobic exercise can also help. If low intensity aerobic exercise is completed for at least one hour, it will enhance insulin action in obese, insulin-resistant adults for roughly 24 hours (Colberg et al, 2016). A study completed with older, Type II diabetics, found that 150 minutes a week of aerobic exercise helped improve their glycemic control (Colberg et al, 2016). For the best result, daily exercise that ranges from moderate to high intensity will help insulin action.

Physical activity is helpful to improve anyone's health. Adding in slight resistance training, like two-pound hand weights while going on a walk around the neighborhood, could help those with diabetes enhance their glucose uptake and help everyone improve their muscular strength and cardiovascular system. All exercise helps acutely within hours post-working out where glucose uptake is high and the body is sensitive to insulin (Colberg et al, 2016). Chronic exercise over time helps build muscle strength and lean body mass, decrease body weight or fat, and helps overall heart, mind, and body health.

Muscle Mass

Glucose uptake occurs in skeletal muscles which is why the more muscle one has, the more glucose it can store as glycogen, thus decreasing one's blood glucose levels. The skeletal muscles must be signaled by insulin secretion before this uptake can begin. Increased strength from resistance training "promotes hypertrophy of fast glycolytic muscle fibers" which in turn has metabolic benefits (McPherron, Guo, Bond, & Gavrilova, 2013). Glucose metabolism is increased with an increase in muscle mass which makes the muscles less insulin resistant. Also, exercise increases the amount of oxygen one takes in which "promotes increased nutrient and insulin delivery to muscle fibers" (McPherron, Guo, Bond, & Gavrilova, 2013).

On the other side of that, if someone has an increase in fat mass, their body becomes insulin resistant. Exercise is used to increase cardiovascular health, increase muscle mass, and increase muscle strength. Fatty tissue, like adipose, is prevalent in those with Type II diabetes as obesity is common for those diagnosed with Type II. This lack of muscle strength and muscle mass hurts the individual by not only decreasing their sensitivity to insulin, but also decreasing their cardiovascular health (Virtanen et al, 2005). An obese individual is already at high risk for other health complications like high blood pressure, heart disease, and strokes. The American Diabetes Association suggests if people are either pre-diabetic or have been diagnosed with Type II diabetes, losing 10-15 pounds can help more than they may realize.

Psychological Effects

Besides the physical attributes that can help or hinder blood sugar, psychological emotions can also have an effect on blood glucose levels. Hormones like cortisol and adrenaline are released from the brain, into the body, during times of stress. These hormones create a reactive response; however, they also block insulin activity and increase insulin resistance (Stress and diabetes, n.d.). Along with this increase in stress, mood changes are common in those newly diagnosed with diabetes. These mood changes may alter the way one feels towards others or themselves and may lead to depression or anxiety.

The mental health of diabetics should be watched closely as they may start to either rebel or feel anger towards their condition. Denial is common after being first diagnosed, but at some point, acceptance needs to overtake that emotion. Failure to take medication or to make the lifestyle changes needed to improve health will only hurt the person, not help them. The feeling of sadness can overcome some people and result in depression. Common symptoms of depression include change in sleeping patterns, nervousness, loss of appetite, and many other

issues (Mental health, n.d.). It is important for these people to have a strong support system reminding them this condition will not make them change everything about themselves. Millions of people live with diabetes and are still capable of living a full and happy life.

Education

Before being diagnosed with diabetes, and especially after being diagnosed, education on the topic should be prevalent. The American Diabetes Association offers diabetes education courses for people to take after being recently diagnosed or when they just want to learn more about their condition (Find a diabetes education program, n.d.). They must be referred by their doctors to attend these courses, so this is more of a mixture of public health education and patient education. Some colleges offer courses surrounding public health, which include topics such as diabetes.

The problem with public education and diabetes is that it is not as prevalent as it should be with the number of people who are diagnosed with it. Individuals should be taking precautions before diabetes is mentioned in a doctor's office, but they do not know what they should be doing unless they take it upon themselves to search for the information. If it were more common knowledge, perhaps there would be fewer people at risk or diagnosed overall. As for patient education, or those who have already been diagnosed with a form of diabetes, the CDC recommends taking advantage of the Diabetes Self-Management Education and Support (DSMES) services (Education and support, 2019). These services, such as classes and meetings with health care teams, can also only be accessed via referral from a doctor. These services help newly diagnosed individuals learn how to administer their medication, be aware of their emotions and mental states during this new stage in their lives, learn how to check their blood glucose levels, and many more things (Education and support, 2019).

How Physical Therapists Can Help

The role of a physical therapist changes for each individual. When their patient is diabetic, their main focuses in addition to glucose/insulin management are going to be balance, gait, and strength training. As mentioned before, neuropathy gives off the sensations of tingling and burning of the feet and foot ulcers inhibit walking and balance, so gait training may also be necessary. Physical therapists are first in line providers to help aid musculoskeletal growth, movement disorders, and alleviate symptoms through therapeutic exercises (Cade, 2008). Exercise management is important when someone is at risk or is diagnosed with diabetes. Physical therapists prescribe an exercise plan to these individuals which will result in increased muscle strength, decrease insulin resistance, alleviate pain, and reduce hyperglycemia (Cade, 2008). Also, pre-diabetics going through physical therapy decrease their risk of developing Type II diabetes (Cade, 2008).

While an exercise plan with a care team is helpful, not everyone has access to a gym, so if the symptoms associated with diabetes become more prevalent, being referred to a physical therapist is helpful. Their main goals with diabetics are to increase their muscle mass and if their patient is considered obese, losing fat will also help them on their diabetes journey. Strength training will mainly involve small hand and ankle weights that will increase in amount as the patient's strength increases. Weight machines can be used for simple, but more intense training once the patient maximizes their weight in the hand or ankle weights. Weight machines also add resistance that will aid in increasing muscle mass. Increased muscle mass means more area for glycogen storage and insulin to be sensitive to.

For diabetics living with neuropathy or amyotrophy, they may develop what is known as a foot drop. A foot drop is a dragging or lagging of a foot while one walks and it makes it

difficult for the foot to rise high enough to clear the ground when taking a step. Physical therapists can help them work on the strength of their legs with an exercise called Clam Shells, which involves a TheraBand wrapped around their thighs and has the patient abducting and adducting their legs. They can also help with their gait by having them do Up-and-Overs with raised 3” metal bars placed on the floor. The patients, most likely with a gait belt around their waist, will be guided up and over the “steps” to improve their gait and improve their muscle memory for how high their foot should be rising. These, and many more exercises, are a couple examples of tactics used by physical therapists to help diabetics.

To the extremes, if a diabetic individual must have an amputation, they will be in extensive physical therapy to relearn how to walk and maneuver the world again. Gait training with a lower extremity amputee means primarily working on their balance to prepare them for their prosthetic, if they choose to have one. Once their prosthetic is attached, learning how their new joint bends and affects their gait is the next step in physical therapy (Highsmith et al, 2016). Speed is also affected, and the patient’s body will start to favor leaning on the side with the prosthetic. This results in lateral trunk flexion towards that side and can create “weak hip adductors or decreased balance caused by socket instability and discomfort” (Highsmith et al, 2016). In-patient physical therapists have more time with their patients as opposed to many out-patient clinics. Their one-on-one time with their physical therapists creates a stronger bond and trust that is sometimes crucial to their wellbeing and recovery. Physical therapists do more than just teach patients how to exercise, strengthen their body, and how to recover from a surgery. They are a constant reminder that their lives can still move forward if they work for it. This goes for anyone in physical therapy, including diabetics who are now learning to monitor their blood

sugar, learning how to inject insulin, learning about their new diet, and learning their new workout plan.

Conclusion

Diabetes affects more than 246 million people worldwide. It is not only a condition one can be born with but is also something one can develop over time. Due to either being born without the body producing insulin (Type I) or the pancreatic islets defecting and no longer producing insulin the way they should (Type II), diabetes mellitus can affect anyone or any age. It is important to understand the slippery slope that diabetics, particularly Type II diabetics, are facing.

Diabetic neuropathy, amyotrophy, ulcers, and nephropathy affect the daily living of diabetics. Their ability to walk and to balance are impeded, making them be at a greater risk of falling. Physical therapy can be used at any point in time while battling diabetes as it can help with gait, muscle strength and pain relief. Overall body health is necessary too, so lifestyle changes such as daily exercise and a new diet will be implemented with the help of doctors and diabetic care teams. Education on the topic is crucial when first diagnosed as it can be confusing to learn the steps and protocols for insulin injections. Also, mental health should not be ignored during this journey and should be monitored by clinicians, close friends, and family.

Diabetes can be a life-long disease or a temporary one, but it always should be monitored and taken seriously. Too quickly can the consequences of ignoring or rebelling against this disease take hold. Education, lifestyle changes, and physical therapy can all help to make the transition into or during diabetes a smoother one.

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