Pediatric Type II Diabetes Mellitus: Examining the Upward Trend

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Abstract

In recent years, there has been a significant increase in pediatric onset of type II diabetes. This paper will examine elements contributing to this trend. Type II diabetes will be discussed, including related pathophysiology, manifestations, diagnosis, and complications, with differentiation between adult and pediatric onset. Possible prevention and treatment methods appropriate for pediatric patients will also be discussed, along with possible outcomes in pediatric patients that could result from this disease. Overall, this paper will provide insight on the causes of this growing trend, and ways to improve the risks imposed on pediatric patients.

Pediatric Type II Diabetes: Examining the Upward Trend

Since the mid-1990s, the rate of pediatric type II diabetes has been on the rise. Between the years of 2001 and 2009, the incidence of type II diabetes among pediatric patients increased by over 30% (Laffel & Svoren, 2017a). Currently, according to the American Diabetes Association, the incidence of this disease among children is expected to increase annually by 2.3%, and quadruple within the span of 40 years (American Diabetes Association, 2018). While normally diagnosed in adulthood, this disease is becoming diagnosed more commonly in children and adolescents. In order to gain a full understanding of this phenomenon, the pathophysiology, manifestations, diagnosis, and complications of type II diabetes mellitus will first be discussed, comparing adult and pediatric onset. Secondly, research will be examined to identify any factors that could be causing this upward trend, including risk factors and genetic predispositions. Lastly, current treatments and outcomes among this patient population will be discussed. Lastly, current treatments and outcomes among this patient population will be discussed, providing more insight on the increasing trend of pediatric type II diabetes mellitus and how to decrease its incidence.

Pathophysiology

Diabetes mellitus, commonly referred to as diabetes, is a disease process that interferes with glucose metabolism and regulation. It is often characterized by elevated blood glucose levels, known as hyperglycemia. Glucose is a product of food metabolism, broken down from carbohydrates that are consumed. When it is produced, insulin drives glucose molecules to dissolve into blood plasma, transporting glucose throughout the body to be used for energy production. In a healthy body, pancreatic beta cells naturally produce insulin at a rate to match blood glucose levels. With proper regulation, blood glucose levels are normally between 70 and 120 mg/dL. Insulin also helps to maintain blood glucose levels by encouraging the storage of glucose in the liver as glycogen, and inhibits the production of more glucose, known as gluconeogenesis. However, with diabetes mellitus, beta cell dysfunction or insulin resistance have occurred, which disrupts the normal regulation of glucose metabolism (Lewis, Dirksen, Heitkemper, Bucher, & Harding, 2015).

While multiple forms of diabetes mellitus exist, the primary forms are classified as type I or type II diabetes mellitus. The primary difference between the two types is the cause of the disease and sometimes, its severity. Type I diabetes mellitus is primarily linked to autoimmune effects, in which the body's immune system attacks the beta cells. Ultimately, this results in beta cell dysfunction and a complete lack of insulin production. While this can occur in adults, this type of diabetes is most commonly seen in children. Therefore, it was commonly known as juvenile diabetes (Grossman & Porth, 2014). However, type II diabetes is becoming more common in children. Research by Pulgaron and Delamater (2015) supports this, finding that since the mid-1990s, the percentage of pediatric diabetic cases with type II has increased from 1-2% to 25-45%.

Unlike type I diabetes, type II diabetes does not involve complete beta cell dysfunction with lack of insulin production. Instead, a wide range of insulin production exists for type II diabetics. In fact, some type II diabetics may be able to produce large amounts of insulin. Therefore, one of the biggest problems with type II diabetics is not insulin production, but insulin resistance (Grossman & Porth, 2014, p. 1311). Insulin resistance occurs as tissues throughout the body develop a higher difficulty in absorbing blood glucose. In order to compensate for this, beta cell production increases, providing more insulin in order to foster glucose absorption. However, with time, this increased strain on beta cells can cause dysfunction. This decreases insulin production and glucose levels in the bloodstream begin to rise. As previously mentioned, insulin plays a role in inhibiting gluconeogenesis from the liver. However, with decrease insulin production, the liver continues to break down glycogen, and contributes to further increases in blood glucose levels. Ultimately, these processes contribute to the hyperglycemia that accompanies type II diabetes mellitus (Lewis et al., 2015).

Hyperglycemia can result in a variety of manifestations that often accompany type II diabetes. One of these manifestations is polyuria, or excessive urination. The kidneys play a role in fluid and electrolyte regulation, which is disturbed with hyperglycemia. Normally, the glomeruli of the kidneys filter out different molecules from the blood, such as urea, sodium, and glucose. Then, the renal tubules reabsorb the proper amount of these substances needed for the body’s needs. The rest of the waste is eliminated through the urine. Since glucose levels are in excess with type II diabetes, the kidneys will attempt to eliminate glucose rather than reabsorb it. This results in glycosuria, or the presence of glucose in the urine. Additionally, due to the principles of osmosis, increasing glucose concentration in the urine promotes the movement of fluid of water from inside cells to the urine. As more fluid leaves the cells, dehydration occurs.

This intracellular dehydration contributes to another common symptom of type II diabetes, polydipsia (Grossman & Porth, 2014, p. 1314).

Manifestations

Hyperglycemia can result in a variety of manifestations that often accompany type II diabetes. One of these manifestations is polyuria, or excessive urination. The kidneys play a role in fluid and electrolyte regulation, which is disturbed with hyperglycemia. Normally, the glomeruli of the kidneys filter out different molecules from the blood, such as urea, sodium, and glucose. Then, the renal tubules reabsorb the proper amount of these substances needed for the body's needs. The rest of the waste is eliminated through the urine. Since glucose levels are in excess with type II diabetes, the kidneys will attempt to eliminate glucose rather than reabsorb it. This results in glycosuria, or the presence of glucose in the urine. Additionally, due to the principles of osmosis, increasing glucose concentration in the urine promotes the movement of fluid of water from inside cells to the urine. As more fluid leaves the cells, dehydration occurs. This intracellular dehydration contributes to another common symptom of type II diabetes, polydipsia (Grossman & Porth, 2014, p. 1314).

Manifestations for type II diabetes mellitus usually appear slowly, over time. As previously discussed, some of the manifestations of type II diabetes mellitus include polyuria and polydipsia. However, there is a large variety of symptoms that could be present with type II diabetes. Due to the combination of beta cell dysfunction and insulin resistance, less glucose is being received by tissues throughout the body. This contributes to feelings of and excessive hunger (polyphagia) that can be experienced by patients.

Additionally, patients may experience weight loss, blurred vision, frequent infections, and areas of darkened skin, known as acanthosis nigricans (Mayo Clinic Staff, 2018). Many of these manifestations appear within the pediatric population. Between 57 and 70 percent of cases present with symptomology, including polyuria, polydipsia, and nocturia. Additionally, adolescent girls may present with complaints of a yeast infection, which could be a sign of hyperglycemia (Laffel & Svoren, 2017a).

Some pediatric patients may even present with serious hyperglycemic conditions, such as diabetic ketoacidosis (DKA) and hyperglycemic hyperosmolar state (HHS). DKA is more common in patients with type I diabetes, but can still occur in type II patients. In fact, 5 to 10 percent of pediatric patients may present with DKA (Lassel & Svoren, 2017a). With type II diabetes, it becomes more difficult for the body to use glucose as an energy resource, despite high amounts being available. If tissues are not receiving enough glucose, another source of energy is found through fats and proteins. Cells from adipose tissue release lipase, which releases fatty acids to be used as energy. However, these fatty acids contribute to ketone production by the liver, which contributes to acid production in the blood. As ketones begin to build up in the blood, the kidneys begin to excrete them, causing ketonuria. Additionally, muscles are broken down to form amino acids, which can be used as a source of energy. This results gluconeogenesis in the liver, which worsens the hyperglycemia. Ultimately, the body’s compensation mechanisms for hyperglycemia can often worsen the condition, resulting in acidosis and ketonuria. These factors contribute to a diagnosis of DKA, which can ultimately result in circulatory collapse without treatment (Grossman & Porth, 2014).

While not as common in the pediatric population, it is possible for a patient to present with HHS. Unlike DKA, this condition does not involve ketonuria, but instead involves a more severe shift of fluid and electrolytes. High glucose levels of 600 mg/dL or higher cause a shift of fluid out of the cells, causing severe dehydration. Without proper treatment, this condition is highly fatal for pediatric patients (Laffel & Svoren, 2017a).

Diagnosis

Diagnosis of type II diabetes can be done by recognizing signs and symptoms, monitoring risk factors, and performing diagnostic tests. Noting symptoms such as polyuria and polydipsia are important to recognize the need for further diagnostic testing. However, as previously discussed, many patients may present as asymptomatic. Therefore, it is necessary for healthcare providers to monitor for possible risk factors. Pediatric risk factors may include a family history of type II diabetes, being part of a high-risk ethnic group, maternal history of diabetes during gestation, hypertension, dyslipidemia and polycystic ovary syndrome. Patients with a BMI above 85^{th} percentile, having at least two of these risk factors, should be monitored beginning at the age of 10, and every three years following, according to the American Diabetes Association (Laffel & Svoren, 2017).

These pediatric patients, as well as adults with presenting risk factors, can be diagnosed with the use of three laboratory tests. One of these tests is the hemoglobin A1C test. This test allows healthcare providers to evaluate the patient’s average glucose levels for the past 3 months. If the patient’s A1C score is between 5.7 and 6.4, the patient is considered to have “prediabetes”. This result indicates the patient is at high risk for developing type II diabetes in the future (National Institute of Diabetes and Digestive and Kidney Disease, 2017). Screening tests, such as the hemoglobin A1C, have been shown to effectively diagnose pediatric patients with prediabetes (Laffel & Svoren, 2017a). If the patient’s score is 6.5 or above, the patient can have a definite diagnosis of type II diabetes. Another laboratory test performed is the fasting plasma glucose (FPG) test. The patient must be fasting for at least 8 hours, then their blood glucose level is measured. Type II diabetes can be diagnosed with a blood glucose level of 126 mg/dL or above, while normal levels would be considered below 100 mg/dL. Lastly, the third test used for diagnosis is the oral glucose tolerance test (OGTT). The patient must be fasting for at least 8 hours, then the patient consumes a sugary liquid. If after two hours, the patient’s glucose is over 200 mg/dL, then the patient can be given a diagnosis of type II diabetes (National Institute of Diabetes and Digestive and Kidney Disease, 2017).

Complications

Patients diagnosed with type II diabetes are at risk for a variety of short-term and long-term complications. Short-term complications may be related to fluctuating glucose levels, such as hypoglycemia. Some patients with type II diabetes can receive supplemental insulin, which normalizes glucose levels by driving blood glucose into the cells. However, if the wrong amount of insulin is given, too much of the blood glucose will be removed from the bloodstream, causing low levels of blood glucose, also known as hypoglycemia. Hypoglycemia is characterized by a blood glucose levels below 70 mg/dL (Lewis et al., 2015, p. 1179). Hypoglycemia can cause patients to experience tachycardia and diaphoresis. Without proper administration of glucose, whether through artificial means or food consumption, the patient is at risk for loss of consciousness or even death. Therefore, while type II diabetes is characterized by hyperglycemia, hypoglycemia can be even more dangerous for the patient (Burchum, Rosenthal, Jones, Neumiller, & Lehne, 2016, p. 9).

Despite the possibility of hypoglycemia, hyperglycemia contributes to a majority of type II diabetes complications. The accumulation of blood glucose molecules for prolonged time periods causes damage to blood vessels throughout the body. These complications are organized into two categories: microvascular and macrovascular complications (Amutha & Mohan, 2016).

Microvascular Complications

Microvascular complications affect the smaller blood vessels across the body. Damage most often occurs in areas such as the eyes, microvascular complication of significance is diabetic retinopathy. This condition occurs when high glucose levels affect the blood vessels supplying the retina, which aids in normal vision. Ultimately, with persisting damage from hyperglycemia, diabetic retinopathy can result in blindness. According to Tryggestad and Willi, diabetic retinopathy is “the leading cause of blindness in Americans aged 20-74” (2015, p. 310). However, mixed reports have been found within pediatric cases. A study performed by Dart, Martens, Rigatto, Brownell, Dean, and Sellers compared pediatric type II diabetes, type I diabetes, and non-diabetic patients. The results of this study suggest that pediatric patients with type II diabetes were at a lower risk for retinopathy than their adult and type I diabetic counterparts (2014).

Meanwhile, Mayer-Davis and other researchers of the SEARCH study reported that 42 percent of pediatric patients with type II diabetes were diagnosed with diabetic retinopathy after at least 5 years of duration (Amutha & Mohan, 2016). Either way, risk of blindness should be a consideration for all pediatric type II diabetes patients.

Another microvascular complication includes diabetic nephropathy. As previously mentioned, the glomeruli of the kidney function to filter the blood and excrete waste products through the urine. Persistently high blood glucose levels cause damage to the blood vessels supplying the glomeruli, resulting in increased excretion of albumin (Lewis et al., 2015, p. 1182). Measuring albumin excretion can help to diagnose nephropathy even in pediatric patients. In fact, microalbuminuria, which is an albumin excretion rate of at least 30µg/mg of creatinine, is seen in 10 percent of pediatric patients with type II diabetes. This is especially concerning, since diabetic nephropathy can ultimately result in renal failure and end stage renal disease. Therefore, it is important that both pediatric and adult diabetic patients are monitored annually for their risk of this complication (Amutha & Mohan, 2016).

Diabetic neuropathy is a complication that affects most adult type II diabetes patients. It is a result of nerve damage, and can result in feelings of numbness or tingling, pain, loss of sensitivity, or even incontinence. (Lewis et al., 2015, pp. 1182-1183). While actual pediatric diabetic neuropathy is not common, many adolescents, between 20 and 57 percent, have presented with a detectable decreased nerve threshold (Amutha & Mohan, 2016). Since it is common in the adult population and can develop over the course of time, it is important for child and adolescent patients to be monitoring for symptoms of diabetic neuropathy.

Macrovascular Complications

Macrovascular complications of type II diabetes involves larger blood vessels in the body, causing damage to areas such as the heart and brain. While actual cardiac events such as a myocardial infarction are rare in pediatric patients, type II diabetics present unique cardiac risks. Adolescents with type II diabetes have presented with left ventricular wall thickening, as well as increased signs of arterial stiffening. Arterial stiffening and development of atherosclerotic lesions, which are increased in pediatric diabetes patients, are precipitating factors to cardiovascular and cerebrovascular events later in life. Not much research is present regarding the mortality rates of pediatric patients with macrovascular complications. Therefore, it is recommended that pediatric patients follow current adult treatment recommendations to reduce complications, including controlling hypertension and dyslipidemia (Laffel & Svoren, 2017a).

Causes

The pathophysiology, manifestations, diagnosis, and complications of pediatric type II diabetes have been discussed in detail. Having type II diabetes places child and adolescent patients at increased risk for possibly fatal complications, such as end stage kidney disease and stroke. Therefore, it is essential to study the cause behind the increasing number of pediatric patients that are being diagnosed with this disease.

Obesity

Most research currently links the increase of pediatric type II diabetes to pediatric obesity. Pediatric obesity is diagnosed using a body mass index (BMI) scale, which determines whether or not the child is at a healthy weight for their age and height. Using the patient's height and weight, healthcare professionals calculate the child's percentile, comparing them to other children with the same gender, height, and age. Children who are above the 95^{th} percentile are considered to be obese. In recent years, childhood obesity has become a more common issue in the United States. According to the Centers for Disease Control and Prevention (CDC), the number of obesity cases "has more than tripled since the 1970s" (2017, para. 1). Most recent estimates in 2017 show that 1 in 5 children aged 6-19 years old were classified as obese in the United States. This is a serious issue, because obesity can be linked to a high number of health risks, such as asthma, heart disease, and type II diabetes (Centers for Disease Control and Prevention, 2017).

Pediatric obesity has been linked to insulin resistance. As previously mentioned, a major aspect of type II diabetes is insulin resistance. It decreases the effectiveness of insulin, and tissues throughout the body have more difficulty using blood glucose. This factor often causes the body to produce excess insulin, ultimately leading to beta cell exhaustion. One of the elements thought to contribute to insulin sensitivity is chronic inflammation from the release of adipokines. Adipokines are released from adipose tissue and aid in the metabolism of both glucose and fats (Lewis et al., 2015). In patients with obesity, increased adipose tissue has been linked to increase adipokine activity. This increased activity, as well as the release of free fatty acids, are thought to contribute to increased insulin resistance in pediatric patients. Additionally, increased fat deposits in the abdomen have been linked to decreased insulin sensitivity (Marcovecchio, Mohn, & Chiarelli, 2010). Overall, the increased amounts of fat that accompany pediatric obesity are thought to contribute to reduced insulin sensitivity, a precursor to type II diabetes.

In addition to insulin resistance, obesity can be linked to the development of metabolic syndrome. Metabolic syndrome is a condition in which a patient is diagnosed with at least three of the following five components: hypertension, elevated triglyceride levels, hyperglycemia, lowered high-density-lipoprotein (HDL) levels, and abdominal obesity. Patients with this group of abnormalities is thought to be at high risk for developing type II diabetes (Lewis et al., 2015, p. 1156). This group of conditions is fairly uncommon in pediatric patients. However, up to 50 percent of obese pediatric patients demonstrate metabolic syndrome, which is significantly linked to increased insulin resistance (Marcovecchio, Mohn, & Chiarelli, 2010). Ultimately, this places obese pediatric patients at even further risk of developing type II diabetes.

Poor Nutrition. In order to analyze pediatric obesity more closely, it is essential to acknowledge how obesity can develop. Obesity is usually considered a multifactorial issue. One of the more apparent factors contributing to pediatric obesity is poor diet and nutrition. An important component to a healthy diet is consumption of enough calories to meet metabolic demand. While exact caloric intake on any day may fluctuate, in general, a diet should not contain an abnormally high caloric excess, especially of foods that are not nutrient-dense. Eating caloric amounts excessively over what is needed can ultimately contribute to gaining weight (Seth & Sharma, 2013). Additionally, high calorie diets also tend to include foods that are low in nutrients, high in sugars, and high in dietary fats. Regular consumption of these foods has been correlated with obesity development, especially between the age of 7 and 11, a time of growth for children (Emmett & Jones, 2015).

Another dietary factor contributing to obesity is the popularity of "fast food". Fast-food restaurants are becoming more available across the United States, and its use as a household meal supplement has increased significantly across the past few decades. Fast food conveniently allows food to be presented to its consumers quickly. However, the food served in fast food restaurants "tend to have high glycemic indexes, are often high in fats, and are sold in large portion sizes" (Alviola, Nayga, Thomsen, Danforth & Smartt, 2014, p. 111). This causes consumers to consume more calories than necessary, while consuming excess amounts of sugar. Additionally, fast food restaurants heavily advertise toward children in the media. These factors combined lead to more fast food consumption, ultimately leading to higher rates of childhood obesity (Alviola et al., 2014).

Sedentary Lifestyle. Another factor contributing to the increase in childhood obesity is a sedentary lifestyle. Physical activity is an important aspect of staying healthy and avoiding weight gain. However, increased use of televisions and other electronic devices may be contributing to low levels of physical activity in pediatric patients. In a study of high school students, almost one third of participants were discovered to spend at least three hours daily playing video games. In that same group, nearly half did not engage in the recommended hour of physical activity daily (Pulgaron & Delamater, 2014). Ultimately, these studies show a tendency toward screen time over physical activity. Lacking proper physical activity and increase in sedentary behavior have been positively correlated with insulin resistance and development of childhood obesity (Pulgaron & Delamater, 2014). Moreover, studies have also shown that increased television watching is correlated with increased caloric intake (Seth & Sharma, 2013). Therefore, it is possible that a sedentary lifestyle may contribute to other risk factors of obesity development. Overall, lack of physical activity and increased sedentary lifestyle are additional factors contributing to the increasing obesity epidemic among the pediatric population, and ultimately, type II diabetes.

Home Environment. The odds of a pediatric patient developing obesity can also be affected by the child's home environment. Family is one of the largest influences in a child's life, and can contribute to their overall health. While some exceptions exist, parents play a large role in what their children eat and do on a daily basis. Studies have shown that parental eating and behavioral habits play a role in the child's risk of developing obesity, especially if they are obese themselves. In fact, studies have shown that if a child's parents are obese, those children are more likely "to consume fatty foods, eat few vegetables, and engage in sedentary activities" (Alviola et al., 2014, p. 118). As previously discussed, all of these factors can contribute to the onset of childhood obesity. Not only this, but there has also been positive correlation shown between parental BMIs and their children's BMIs (Pulgaron & Delamater, 2014). Therefore, parental obesity status can play a large role in determining whether or not their children will also become obese.

Schools. In addition to family, school is an important influence in a child's overall health and nutrition. Statistics show that 35 to 47 percent of a child's calories are being consumed while in the school environment (Cluss, Fee, Culyba, Bhat, & Owen, 2014). Schools can directly have an impact on children buying school lunches, especially if unhealthy food options are being provided. Furthermore, studies have linked higher rates of obesity when schools are located closer to fast food restaurants (Alviola et al., 2014). Therefore, where the school is located can also play a role in obesity rates. This is especially true for schools located in areas of low socioeconomic status. One study found that schools of low socioeconomic status were less likely to have funding for physical education teachers (Carlson et al., 2014). Additionally, these schools less likely to provide adequate physical education classes than their high socioeconomic counterparts (Pulgaron & Delamater, 2014). Overall, schools play a large role in determining a child's risk for obesity.

Lower Income Communities. Lastly, one population of children that are particularly affected by obesity are those in lower income communities, especially ethnic minority children. Minority children are more likely to live in lower-income neighborhoods, which often do not provide a safe environment to play outside. Without sidewalks and safe areas to be physically active, these children risk living a more sedentary lifestyle, which increases their risk for obesity and type II diabetes (Pulgaron & Delamater, 2014). Furthermore, children in lower income communities tend to have less access to affordable, healthy foods from supermarkets. Lower income communities, on average, have more access to fast food restaurants, which tends to be cheaper than healthy alternatives. Even with access to supermarkets, healthy food alternatives can still be more expensive. In fact, in a study discussed by Alvioli et al., increases in healthy food prices have been linked to an increased risk for childhood obesity (2014). Therefore, the affordability of food may be another cause to consider in the rise of childhood obesity.

Ultimately, childhood obesity is one of the most common links found to explain the increase of pediatric type II diabetes cases. In fact, Pulgaron and Delamater discuss that “over 85% of children with T2D are either overweight or obese at diagnosis” (2014, p. 508). This is a staggering statistic, showing the positive link between the two. However, there are other factors that could be contributing to this crisis, such as developmental overnutrition.

Developmental Overnutrition

Developmental overnutrition is a theory proposed by many researchers, theorizing that having diabetes during pregnancy increases the risk of the child having diabetes later in life. Different studies have shown fetuses exposed to the hyperglycemia of a diabetic mother are at greater risk for developing metabolic syndrome, obesity, and type II diabetes later in life. The Pima Indian study even compared siblings before and after the mother’s diagnosis of diabetes. The results of the study showed that siblings born after the diagnosis had a three times greater risk of developing type II diabetes. Therefore, there seems to be a definite correlation between maternal diabetes and childhood development of type II diabetes (Dabelea & Harrod, 2014).

Maternal utilization of glucose during pregnancy plays a large role in developmental overnutrition. During a normal pregnancy, insulin sensitivity is naturally decreased as nutrients are pulled from the mother's bloodstream by the placenta. This allows the placenta to provide more nutrients to the baby, and can be related to a number of hormonal factors. By the third trimester, a woman's insulin sensitivity may even decrease by 50 percent (Sonagra, Biradar, K., & Murthy, 2014). However, women with type II diabetes have decreased insulin sensitivity even before the onset of pregnancy. Women with type II diabetes during pregnancy utilize glucose differently than nondiabetic women. The insulin resistance that accompanies type II diabetes causes hyperglycemia, therefore increasing the amount of glucose available in the bloodstream. This excessive amount of glucose is brought to the fetus, causing the developing pancreas to secrete insulin. Exposure of the fetus to excessive amounts of insulin can cause increased growth, which has been linked to increased risk of obesity and type II diabetes later in life. Maternal diabetes and obesity were estimated to play a role in 47.2% of the pediatric type II diabetics in the SEARCH case-control study (Dabelea & Harrod, 2014). Therefore, maternal glucose levels and how they are utilized during pregnancy can impact the fetus's risk of long term complications.

With cases of type II diabetes on the rise, it is important to note that developmental overnutrition could definitely play a role in increasing pediatric cases. Developmental overnutrition views the risks of type II diabetes from the perspective of the fetus's environment. However, a baby's chance of developing type II diabetes can also be affected by their family history.

Family History

One risk factor that seems to increase the risk of pediatric type II diabetes is a family history of the disease. While lifestyle changes are often causative factors, genetics can also determine whether or not a child is predisposed. Almost 75 percent of pediatric patients with type II diabetes have a parent that is affected by the disease (Laffel & Svoren, 2017a). Additionally, twin studies have shown that "in monozygotic twins with one affected twin, the other twin has a 90 percent chance of developing diabetes" (Laffel & Svoren, 2017a, para. 15). This evidence shows that a familial link does appear to exist between relatives with type II diabetes. With type II diabetes also on the rise in adults, this link would most likely contribute to increases in pediatric cases. However, definitive genetic proof for this link has not yet been determined. Over 150 variations of DNA are been discovered that can be associated with the risk of type II diabetes. Some are theorized to play a role in developing the pathophysiology behind the disease, such as beta cell dysfunction. However, some of these genes are present in patients without type II diabetes, and no specific inheritance pattern has been discovered (U.S. National Library of Medicine, 2018). Therefore, having specifics genes may increase a child's risk for developing type II diabetes, but it is unlikely that this factor alone directly causes the disease.

Other Factors

Stress. Another interesting approach to the development of pediatric type II diabetes is the involvement of psychological factors, such as stress. While it is noted that pediatric patients with diabetes tend to have poor diets and decreased physical activity, another factor that tends to be common amongst them is high stress levels (Nadeau et al., 2016). When experiencing stress, the body initiates the *fight or flight* response from the sympathetic nervous system. This causes various responses throughout the body that could aid in an emergency situation. This includes improved cardiac output, increased blood pressure, and increased blood glucose levels. In order to increase blood glucose levels, the hypothalamus within the brain releases corticotropin-releasing hormone (CRH). CRH initiates the release of adrenocorticotropic hormone from the pituitary gland, which stimulates the adrenal cortex to allow for the release of cortisol. For short periods of time, cortisol can be helpful in decreasing inflammation, aiding the work of other hormones, and increasing blood glucose for energy utilization (Lewis et al., 2015, p. 90). However, having prolonged, high levels of blood glucose is not beneficial for the body, as seen with type II diabetes complications.

While the stress response is often related to emergent physical situations, mental stress can also cause it to initiate. In adults, mental stress has been linked to increased glucose levels, especially in type II diabetes patients (American Diabetes Association, 2013). However, adults are not the only ones to experience stress. With the development of higher academic standards and expectations for high school students, adolescents may be at increased risk for mental stress. One exploratory study found that nearly half of high school students in a test group reported having a “great deal of stress on a daily basis” (Leonard et al., 2015, p. 5). Other research has shown that children in situations of high family stress, such as single parent homes, were found to be more overweight than children from low stress households (Pulgaron & Delamater, 2014). Additionally, studies have shown how “chronic exposure to social and environmental stressors negatively impact body weight, metabolism, blood pressure, and the sympathetic nervous system” (Nadeau et al., 2016, p. 1637). These factors could play a large role in the development of prolonged hyperglycemia and metabolic syndrome. As previously mentioned, prolonged hyperglycemia can ultimately lead to beta cell dysfunction, contributing to type II diabetes. Therefore, mental stress in pediatric patients, particularly adolescents, may contribute to the development of type II diabetes.

Sleep. Sleep is another factor that could contribute to type II diabetes. Abnormal sleeping patterns have been considered a risk factor in pediatric patients in decreasing insulin sensitivity with puberty (Nadeau et al., 2016). In a longitudinal study examining children’s sleep quality from infancy to mid-childhood, it was found that over time, insufficient sleeping patterns could contribute to poor diet quality. Ultimately, the results showed that this poor diet quality could be contributing to childhood obesity (Cespedes et al., 2016). Poor diet quality, increased adipose tissue and childhood obesity have all been linked to the development of type II diabetes in pediatric patients, according to research stated throughout this paper. Therefore, while more research may be needed, it is possible that lack of proper sleep could be contributing to the type II diabetes crisis among pediatric patients.

Treatment

As the pediatric population with type II diabetes soars, healthcare professionals need to provide proper treatment. One of the largest problems in regard to type II diabetes is prolonged hyperglycemia. Since most of these patients still have some insulin production, some treatment methods may not involve the use of medications.

Diet Changes

Adults with this disease are usually encouraged to treat the condition with proper diet control. Diabetic diets focus on eating healthy foods that have a low glycemic index. A glycemic index indicates how quickly a food will raise the patient’s blood sugar (Mayo Clinic Staff, 2018). Certain foods, such as many fruits and vegetables, have a low glycemic index, while other foods, such as candy, may have a high glycemic index. By consuming certain foods and monitoring carbohydrate intake, diabetic patients can help themselves to maintain a more normal blood glucose level (Mayo Clinic Staff, 2018). In pediatric patients, diet changes are just as important. Especially since childhood obesity is associated with higher levels of insulin resistance, it is essential for these patients to exercise portion control and eliminate many unhealthy foods from their diets. Eating as a family and avoiding snacking while using electronics can help to eliminate excessive food and drink intake. Instead, healthy snacks and portioned meals, with less saturated fats and sugars, should be eaten throughout the day (Samaan, 2013). Ultimately, this will help pediatric patients to lose weight and manage their blood glucose levels.

Physical Activity

Another intervention commonly used to control type II diabetes is the use of physical exercise. As previously discussed, both diet and lack of physical exercise can play a role in the development of pediatric type II diabetes. Physical activity is a helpful tool in treating type II diabetes since it can improve insulin sensitivity (Laffel & Svoren, 2017b). By improving insulin sensitivity, more glucose can be absorbed and used for energy by the body, instead of accumulating in the bloodstream. Pediatric patients are encourage to participate in "moderate to vigorous physical activity for at least one hour daily" (Laffel & Svoren, 2017b, para. 17). Participating in this physical activity can also help to improve mood and reduce stress levels (Samaan, 2013). As previously discussed, many pediatric patients have increased stress, leading to the release of excess glucose. Therefore, by reducing stress and improving insulin sensitivity, physical activity could improve blood glucose control for some patients.

Weight Control

Ultimately, using diet changes and physical activity can help pediatric patient with weight control. Childhood obesity has already been linked to increased insulin resistance and the development of pediatric type II diabetes. Contrastingly, weight loss in these obese patients has been shown to improve symptoms of type II diabetes. In pediatric patients specifically, reductions in BMI have been shown to produce low hemoglobin A1C results, increased insulin sensitivity, and reduced need for medications. While the specific goals of weight loss or maintenance depend on the individual patient, the general goal for all of these patients is to be below the 85^{th} percentile for BMI. While diet and physical activity may been adequate for some patients, some studies have shown the effects of gastric bypass surgery on obese adolescents. While little research is available, some research shows that it could be correlated with weight loss and remission of type II diabetes in these patients. However, more research must be conducted to conclude whether or not this is an appropriate interventions for other pediatric patients (Laffel & Svoren, 2017b).

Medications

Insulin. While other interventions may be helpful in controlling type II diabetes, some patients often require the use of medications to control their glucose levels. Synthetic insulin is a commonly used medication among both the adult and pediatric type II diabetes population. Due to either insulin resistance or decreased insulin production, type II diabetes patients often require extra insulin to bring blood glucose levels within a normal range (Laffel & Svoren, 2017b). Several types of insulin exist, including short-acting and long-acting varieties. Each type of insulin is differentiated by time of onset, peak, and duration. Longer acting versions, such as insulin glargine, can be used to control blood glucose levels over the course of a day. However, other formulations, such as insulin lispro, are commonly used with meals and can be adjusted based on the specific dietary intake. Ultimately, healthcare providers may use one or a combination of different insulins in order to regulate a patient's glucose levels (Burchum et al., 2016, pp. 676-679).

While using any form of insulin, it is important for patients to monitor their own glucose levels. Due to the nature of diabetes and its treatment, type II diabetics are at risk for both hypoglycemia and hyperglycemia. Blood glucose levels could fluctuate depending on the amount of insulin given, whether it was too much or too little. Therefore, it is important for patients to monitor their blood glucose levels while self-administering treatment at home with the use of glucometers. By using a drop of blood, these machines can enable patients to discover their current blood glucose level. The frequency of taking these levels can range from multiple times a day to once a week depending on individualized treatment. Common times for measurement include before meals and at bedtime with shorter-acting insulins. Generally, blood glucose levels should fall between 70 and 130 mg/d prior to meals and 100 to 140 mg/dL before bedtime. Knowing these exact blood glucose levels can help patients to adjust their insulin dosage according to their healthcare provider’s instructions (Burchum et al., 2016, pp. 673-674).

Metformin. While insulin is an essential part of some medication regiments, the first line medication for pediatric patients with type II diabetes is actually metformin (Samaan, 2013). Metformin is an oral medication that helps to decrease blood glucose levels by inhibiting gluconeogenesis in the liver and increasing insulin sensitivity (Skidmore-Roth, 2016, p. 746). This allows tissues throughout the body to more easily use naturally produced insulin, while disrupting the overcompensation mechanisms from the liver. In pediatric patients, metformin has been shown to provide decreased hemoglobin A1C levels and body weight (Samaan, 2013). In general, this drug is used by many adolescents initially with type II diabetes diagnosis, along with diet control and physical exercise. While it can be used alone, metformin can also be used with other drugs, such as insulin, to maintain adequate glucose levels in type II diabetic patients

(Burchum et al., 2016, p. 684). Ultimately, use of this drug in adolescents should provide an initial blood glucose reduction, and should maintain adequate levels in almost half of patients (Laffel & Svoren, 2017b). Therefore, unless contraindicated, metformin is considered a cornerstone of treatment of pediatric type II diabetes patients.

Other medications. Additional hypoglycemic medications can be added to an adult regimen, including sulfonylureas, thiazolidinediones and incretin mimetics, which all work to lower glucose levels. These treatments have been primarily researched for effectiveness only in adult patients (Samaan, 2013). Some of these drugs, such as glimepride, have been studied in the pediatric population and have been shown to be effective in lowering hemoglobin A1C levels. However, use of drugs other than metformin and insulin have not yet been approved by the U.S. Food and Drug Administration (FDA) for use in the pediatric population (Laffel & Svoren, 2017b). Therefore, while these drugs may provide alternative treatment options to these patients, further research must be conducted in order to ensure their safety with use in children.

Compliance

One of the biggest obstacles facing this epidemic is lack of treatment compliance, both in the pediatric and adult populations. Due to their age, pediatric patients with type II diabetes may be at a specific disadvantage for adhering to treatments. Parents and other family members often still play a large role in lifestyle choices, which has an impact on possible dietary changes, improvement in physical activity, or medication adherence. Therefore, it is important to include the family in education and treatment plans (Reinehr, 2013). However, when diagnosed, adolescents tend to have more autonomy over their actions, and often experience a cognitive disconnect between their disease and long-term outcomes. Lack of compliance can also occur due to inconvenience and fear of peer rejection. Therefore, it is important that in these cases, healthcare workers recognize these extra difficulties in treatment compliance when treating pediatric patients with this disease (Pulgaron & Delamater, 2014).

In addition to involving the family in care, treatment compliance can be improved by individualizing treatment plans. One area that can be individualized in pediatric patients are dietary changes. Every child has a different palette, preferring certain foods over others. Therefore, dietary changes and education should be implemented based on each child's specific dietary habits. This may include reducing fast food intake, replacing foods with healthier alternatives, and decreasing portion sizes of foods already consumed. It should be a priority to set realistic goals with both the pediatric patient and their family. Otherwise, it may be difficult for compliance in the long-term setting (Laffel & Svoren, 2017b).

An additional area to improve treatment compliance is physical activity. As previously discussed, recommendations show that children and adolescents should be getting about 60 minutes of physical activity daily. However, for a patient with a generally sedentary lifestyle, this may be a difficult change. One intervention that may be helpful in improving compliance is flexibility. All 60 minutes of physical exercise do not have to be performed in one sitting. Instead, this activity can be spread throughout the day, including activities such as climbing stairs and taking walks. By providing flexibility and allowing the patient to do activities they prefer, treatment compliance for physical activity may be improved (Samaan, 2013).

Lastly, medication adherence is another important aspect of type II diabetes management. Taking medications properly can help to manage blood glucose levels and prevent some complications. However, routinely monitoring blood glucose and injecting insulin may prove to be inconvenient and embarrassing for pediatric patients (Pulgaron & Delamater, 2014). Therefore, the use of oral medications, such as metformin, are correlated with higher rates of compliance in pediatric patients (Reinehr, 2013). Therefore, use of oral agents, such as metformin, are routinely given over injectable agents such as insulin when possible.

Clinical Outcomes

Ultimately, this increasing epidemic is taking a large toll on the pediatric population. Having type II diabetes can take a toll on pediatric bodies throughout the rest of their life. Being diagnosed in childhood places pediatric patients at a higher risk for developing microvascular and macrovascular complications in adulthood (Amutha & Mohan, 2016). This can include cardiovascular disease and diabetic nephropathy, each serious conditions that could ultimately result in death. In fact, it is estimated that pediatric patients with type II diabetes are expected to live 15 years less than those without type II diabetes (Pulgaron & Delamater, 2014). Furthermore, pediatric patients may be at risk for higher levels of psychological problems. In a study addressed by Pulgaron & Delamater, up to 20 percent of pediatric patients with type II diabetes reported feeling depressed (2014). Overall, having type II diabetes in a younger population is showing reduced physical and psychological outcomes for patients.

Conclusion

In conclusion, the growth of type II diabetes in pediatric patients is still being studied. This area of research is still relatively new as compared to adult research, since as previously discussed, this disease used to primarily have onset in adulthood. Now, both children and adolescents are at a greater risk for acquiring this disease. With an earlier onset, pediatric patients are at great risk for a variety of complications, both physical and psychological. Current research points to obesity as the main cause of this epidemic, but other factors, such as developmental overnutrition and family history, may also play a role. While treatment options exist, more research must be done in regard to finding effective ways to both prevent and manage this disease. Hopefully, by recognizing these possible causes, new measures can be developed to ultimately improve patient’s lives and outcomes.

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