

## **PHYSICAL THERAPY APPROACHES FOR CHILDREN WITH DIABETES: A REVIEW**

**Mohamed E. Mohamed<sup>1\*</sup> ; Asmaa O. Sayed<sup>1</sup> ;  
Amira M. Abd-Elmonem<sup>1</sup>  
and Shimaa Atef<sup>2</sup>**

<sup>1</sup>Department Of Physical Therapy For Pediatrics, Faculty Of Physical Therapy, Cairo University, Giza, Egypt.

<sup>2</sup>Department Of Endocrinology, Faculty of Medicine, Cairo University, Egypt.

\*E-mail- mohamedabsoo93@gmail.com

### **ABSTRACT**

Diabetes is a heterogeneous complicated metabolic health condition characterized by elevated plasma glucose concentrations as a result of insulin resistance, inadequate insulin production, or both. Diabetes mellitus is a complex, persistent condition that necessitates ongoing medical treatment and multifactorial risk reduction techniques in addition to glucose control to prevent acute complications and lower the chance of long-term problems. Diabetes has become a major worldwide health concern due to its rising incidence and accompanying health complications including neuropathy, retinopathy, and nephropathy, all of which impair functional activities and health related quality of life. Diabetes can impact functional performance in several ways: Sensory and visual impairment, muscle weakness, postural instability, low exercise tolerance and decreased functional capacity. Exercises play an important role in controlling blood glucose. It has become one of the ideal means of rehabilitation for patients with diabetes.

**Key Words:** Diabetes mellitus, Balance, Health related quality of life, Rehabilitation.

### **INTRODUCTION**

Diabetes Mellitus is a serious problem that impacts the entire world, particularly Egypt; the Ancient Egyptian physician 'Hesyra' described it around 3000 B.C. In fact, early Egypt was the first society is known to have learned about medicine widely, and the first created reference to Diabetes is identified as the Upper Egyptian Ebers Papyrus circa 1550 B.C., we are able to notice that Diabetes has been impacting lives for lots of years, and based on "The National Medical Journal of India", old Indians recognized diabetes which they identified as "sweet urine disease" by assessing if ants were attracted to a person's urine. Diabetes mellitus is a major problem that affects both the world and Egypt. Diabetes is prevalent in many Egyptian families, accounting for about 10.4% of the Egyptian population (Soliman *et al.*, 2021).

Diabetes, an endocrine system disease characterized by unusually high blood glucose levels, is among the most prevalent and fastest-rising diseases in the world, with 693 million adults predicted to be affected by 2045, a more than 50% increase from 2017. Diabetes is caused by either the pancreas failing to create enough insulin or the body's cells failing to respond correctly to the insulin produced. Insulin is a hormone that aids in the transport of glucose from food into cells for use as energy (Cole *et al.*, 2020).

Diabetes is a varying complicated metabolic condition characterized by excess blood glucose concentrations caused by insulin resistance, inadequate insulin production, or both. Diabetes mellitus is a sophisticated, persistent condition that necessitates ongoing medical treatment and multifactorial risk reduction techniques in addition to managing glucose to avoid serious consequences and lower the chance of long-term problems (El Shafei *et al.*, 2021).

#### **Diagnostic Procedures**

For measuring venous plasma glucose and Glycosylated hemoglobin (HbA1c), only standardized, quality-certified testing procedures may be used. The measurement of glucose in venous plasma is now the preferred method for detecting diabetes. Only if glycolysis is suppressed in the blood sample immediately as it is obtained will this measurement be reliable. This can be accomplished in two ways. The blood tube is either kept on cold and drained within 30 minutes, or glycolysis in the tube is efficiently prevented by proper additions (citrate with fluoride; fluoride alone is insufficient) (Kerner & Brückel, 2014).

- HbA1c  $\geq 6.5\%$  ( $\geq 48$  mmol/mol)
- Random plasma glucose  $\geq 200$  mg/dl ( $\geq 11.1$  mmol/l)
- Fasting plasma glucose  $\geq 126$  mg/dl ( $\geq 7.0$  mmol/dl)
- OGTT 2-hour glucose in venous plasma  $\geq 200$  mg/dl ( $\geq 11.1$  mmol/l)

#### **Signs and Symptoms**

Unintentional weight loss, polyuria (increased urine), polydipsia (increased thirst), and polyphagia (increased appetite) are the hallmark symptoms of uncontrolled diabetes. Type 1 diabetes (T1D) symptoms might appear quickly (weeks or months), whereas type 2 diabetes (T2D) symptoms appear considerably more slowly and may be faint or absent (WHO 2019). Many additional symptoms and signs, though not particular to diabetes, can indicate the disease's development. In addition to the previously mentioned symptoms, they include blurred vision, headache, fatigue, poor wound healing, and skin that feels itchy.

Persistent high blood glucose levels can cause the absorption of glucose in the lens of the eye, causing changes in its shape and, as a result, vision alterations. Diabetic retinopathy can potentially cause long-term vision loss. Diabetic dermadromes refer to a group of skin rashes that can emerge as a result of diabetes (**Rockefeller, 2015**).

#### **Classification of Diabetes**

Diabetes is a chronic metabolic condition marked by high blood glucose levels caused by absolute or relative lack of insulin in the context of  $\beta$ -cell malfunction, insulin resistance, or the two. Even though diabetes is usually classified into an early-onset autoimmune form (T1D) and a late-onset non-autoimmune form (T2D), other clinically distinguishable subtypes exist, including monogenic diabetes (for example, maturity-onset diabetes of the young or neonatal diabetes), gestational diabetes, and possibly a late-onset autoimmune form (latent autoimmune diabetes in the adult). Indeed, the term T2D refers to any type of diabetes that is not autoimmune or monogenic in character, and it has come to be accepted that it may reflect a collection of several pathophysiological states (**Udler *et al.*, 2018**).

**According to cause there are primary types and secondary types:**

#### **Type 1 diabetes**

Type 1 diabetes is due to beta cell loss, in which the pancreas is unable to produce adequate insulin. This condition was known as "insulin-dependent diabetes mellitus" or "juvenile diabetes". An autoimmune reaction is responsible for beta cell loss. The exact etiology of this autoimmune reaction is uncertain (**WHO, 2013**).

#### **Type 2 diabetes**

Type 2 diabetes is the most widespread form of diabetes, which accounts for nearly 90 per cent of the total cases. It is often defined by insulin resistance, which occurs when the body does not effectively react to insulin. Because insulin is unable to function effectively, blood glucose levels rise, causing more insulin to be released. This can over time overload the pancreas, resulting in the body generating a decreasing amount of insulin, causing even higher blood sugar levels (hyperglycemia) in certain persons with T2D (**International Diabetes Federation, 2020**).

#### **Gestational diabetes**

Gestational diabetes (GDM) is a kind of diabetes that has elevated levels of blood sugar throughout pregnancy and is linked to difficulties for the mother as well as the baby. GDM normally goes away after pregnancy, but women who have it and kids who have it are at a higher risk of having T2D later in life (**International Diabetes Federation, 2020**).

**Other types of diabetes include:****Type 3c diabetes**

Diabetes caused by pancreatic disorders (also known as pancreatogenic diabetes) impacts the exocrine and digestive processes of the pancreas. Pancreatic disorders account for 5-10% of diabetes cases in the Western world. The most common cause is chronic pancreatitis (**Hart et al., 2016**).

**Latent autoimmune diabetes in adults**

Slowly growing immune-mediated diabetes, also known as latent autoimmune diabetes in adults (LADA), is a kind of diabetes that shares clinical characteristics with both T1D and T2D, and is also known as type 1.5 diabetes. It is an autoimmune type of diabetes, similar to T1D, however, people with LADA frequently exhibit insulin resistance, similar to T2D, as well as several risk factors for the condition. According to research, LADA patients have specific antibodies against insulin-producing cells, and these cells quit releasing insulin more slowly than T1D patients (**Buzzetti, 2017**).

**Maturity-onset diabetes of the young**

Maturity-onset diabetes of the young (MODY) is a monogenic illness defined by an autosomal dominantly transmitted insulin-independent form of diabetes that typically manifests in adolescence or young adulthood before the age of 25. MODY is an uncommon form of diabetes (1% of all cases) that is frequently misinterpreted as T1D or T2D (**Anik, 2015**).

**Brittle diabetes**

It was first used to describe a life that had been "disrupted by episodes of hypoglycemia or hyperglycemia." Early descriptions concentrated on short case reports of largely young women suffering from psychosocial instability, recurrent diabetic ketoacidosis, poor patient compliance, or maladaptation. We describe "brittle diabetes" as four discrete life periods, each with its own set of traits and accompanying problems that result in severely unpredictable glucose control and poor outcomes (**Hirsch et al., 2021**).

**Complications****I. Diabetes Complications on the Short Term:****1. Hypoglycemia:**

Low blood sugar can develop when diabetics take too much insulin or other diabetes drugs, skip meals, or participate in intense physical activity without altering their treatment plan properly. Shaking, dizziness, sweating, bewilderment, and irritation are some of the symptoms. Immediate treatment with glucose or carbs is required to restore normal blood sugar levels (**Abraham et al., 2022**).

## **2. Hyperglycemia:**

Often known as high blood sugar, occurs when blood glucose levels exceed the specified range. It can be caused by an inadequate supply of insulin or medicine, an excess of food, sickness, anxiety, or a lack of physical activity. Extreme thirst, frequent urination, weariness, and hazy vision are some of the symptoms. Controlling blood sugar levels with medication and lifestyle changes is critical to avoiding problems (**Blonde et al., 2022**).

## **3. Diabetic Ketoacidosis:**

Diabetic Ketoacidosis (DKA) is a serious illness that primarily affects people with T1D but can also occur in people with T2D under specific conditions. It is caused by a shortage of insulin, which causes the breakdown of lipids for energy, resulting in an increase of ketones in the blood. DKA is a medical emergency that must be treated right away to avoid life-threatening complications (**Ramphul et al., 2020**).

## **4. Hyperosmolar Hyperglycemic State:**

Hyperosmolar Hyperglycemic State (HHS) is a condition that is most common in T2D. It happens whenever blood sugar levels get dangerously high, causing dehydration and a spike in blood osmolality. HHS also represents a health crisis that necessitates immediate medical attention and hospitalizations (**Mustafa et al., 2023**).

## **II. Diabetes Complications on the Long Term:**

### **1. Cardiovascular Complications:**

For those who have diabetes, cardiovascular problems are a big concern, particularly if blood glucose levels are continuously high over an extended period of time. Atherosclerosis, a disorder in which fatty deposits called plaques grow up inside the arterial walls, constricting and hardening the arteries, is brought on by chronic hyperglycemia, which can harm blood vessels throughout the body. There is increased risk of various major cardiovascular illnesses as Coronary Artery Disease (CAD), Heart attacks (myocardial infarction) and angina (chest pain) can both be brought on by decreased blood supply to the heart. An ischemic stroke or hemorrhagic stroke may occur when a blood vessel in the brain gets blocked or bursts, causing damage to the brain's tissue and possibly long-term neurological problems (**Martín-Timón et al., 2014**).

### **2. Diabetic Retinopathy:**

People with diabetes are susceptible to the degenerative eye disease known as diabetic retinopathy. The retina, the light-sensitive tissue in the back of the eye, has blood vessels that are damaged as a result. If

ignored, irregular blood vessel growth, swelling, and vascular leakage brought on by high blood sugar levels over time can damage eyesight or ultimately result in blindness. Vision loss, black patches, and blurred vision are possible symptoms. In order to stop or slow the development of diabetic retinopathy, early detection and care of diabetes are essential. For optimum eye health, routine eye exams and keeping blood sugar levels within a reasonable range are crucial (**National Eye Institute, 2022**).

### **3. Diabetic nephropathy:**

Diabetic nephropathy is a kidney disorder brought on by diabetes that damages the kidneys. In extreme circumstances, it can lead to end-stage renal failure. Dialysis or kidney transplantation may be required to treat the condition's reduced kidney function, which is a serious consequence of diabetes. Since diabetic nephropathy represents a significant risk to the general health and quality of life (QoL) of those who are affected, early detection and strict glycemic management are essential in stopping or delaying the advancement of the condition (**Lim, 2014**).

### **4. Diabetic neuropathy:**

Neuropathy is a persistent and crippling consequence of diabetes mellitus. It is a disorder that develops when the body's nerves are continuously exposed to excessive blood sugar levels. Although the nerve injury can affect any area of the body, it most frequently affects the peripheral nerves, which causes discomfort in the extremities like the hands and feet manifests as tingling, numbness, burning sensations, pain, and weakness. As the loss of sensation worsens over time, unrecognized wounds, ulcers, and infections in the foot may develop, leading to problems like gangrene and amputations (**Feldman et al., 2019**). Diabetes-related neuropathy is caused by a number of conditions, such as persistently high blood sugar levels, inflammation, and reduced blood flow to the nerves. In addition, other risk factors like smoking, drinking alcohol, and kidney illness might make the situation worse (**Callaghan et al., 2015**).

### **5. Diabetic foot complications:**

Diabetic foot refers to a wide variety of major health problems brought on by peripheral artery disease (PAD) and nerve damage (neuropathy) brought on by diabetes. Diabetics are more prone to foot injuries and infections due to diminished sensitivity and sluggish wound healing caused by high blood sugar levels. These side effects might result

in foot ulcers, gangrene, and even amputation if left untreated. To avoid difficulties, regular foot care is crucial. This includes daily inspection, good hygiene, and comfortable footwear. Effective management of diabetic foot difficulties also requires maintaining stable blood sugar levels, regular medical checkups, and timely treatment for any foot issues (**Wang et al., 2020**).

#### **6. Skin Complications:**

Diabetes can cause different skin issues as high blood sugar levels encourage the growth of bacteria and fungi, leaving the skin more vulnerable to diseases including candidiasis and cellulitis. Diabetes can also alter the normal moisture balance of the skin, resulting in dryness and irritation. Slow-healing wounds, diabetic ulcers, and diabetic dermopathy are typical signs. In order to reduce these skin issues and preserve general skin health, proper diabetes management is necessary. This includes blood sugar control, routine foot and skin care, and quick infection treatment (**Blonde et al., 2022**).

The chance of having these long-term consequences can be considerably decreased by effectively managing diabetes by a combination of medication, blood sugar monitoring, a balanced diet, moderate exercise, and regular medical checkups. To stop or delay the onset of these consequences and enhance the general QoL for people with diabetes, early detection and management are essential.

#### **Management**

The basic treatment of diabetes is achieved by diet, hypoglycaemic drugs and insulin. Diabetic patients should follow a proper diet plan that provide sufficient energy intake including carbohydrates, fat and proteins. The conventional treatment of diabetes include oral hypoglycaemic drugs like alpha-glucosidase inhibitors (**Dardano et al., 2013; Van Belle et al., 2013**). Insulin is prescribed for patients with T1D in addition to T2D with insulinopenia whose hyperglycemia does not respond to diet therapy alone or in combination with oral hypoglycemic medications. The use of insulin to control blood glucose has the potential to be the most successful blood glucose-lowering medication (**Whitmer et al., 2009; Donnor et al., 2023**).

#### **Physiotherapy roles in diabetes**

Patients with diabetes are encouraged to maintain their physical activity in addition to the treatment procedures indicated above. Due to long-term consequences, social and financial load, and inadequate glycaemia control, patients with DM have a low QoL. Therefore, it is

necessary to search for specific treatment regimens that assist DM patients in enhancing their QoL performance and physical activity (**Kaur et al., 2015**).

Physiotherapists can create personalized fitness programs for diabetic patients. Regular physical activity improves insulin sensitivity, glucose management, and weight maintenance. These workout programs are adapted to the fitness level, age, and special health demands of the individual (**Cannata et al., 2020**). Exercise has been shown to have a considerable impact on blood sugar levels. Physiotherapists can teach diabetic patients about how different types of exercise affect blood glucose levels and assist them in developing exercise routines that optimize blood sugar control. They can also tell you when to monitor your blood sugar levels before, during, and after exercise (**Shah et al., 2021**).

According to **Harris-Hayes et al., (2020)**, Physiotherapy is essential in the management of diabetes, whether it is T1D or T2D. Here's an outline of physiotherapy's function in diabetes care:

#### **1- Exercise and Musculoskeletal Health in diabetes:**

Diabetic patients may develop musculoskeletal difficulties such as joint discomfort, muscle imbalances, and decreased flexibility. These difficulties can be addressed by physiotherapists using manual therapy, therapeutic exercises, and stretching routines (**Harris-Hayes et al. 2020**).

#### **2- Exercise and quality of life in diabetes:**

According to **Nicolucci et al. (2011)**, exercise training improves the QoL of life in people with T2D. Various studies have been conducted to determine the effectiveness of exercise on QoL, but the outcomes have been inconsistent. In a study by **Myers et al., (2013)**, they investigated the effects of aerobic exercise, strength training, and a combination of the two on patients' QoL and discovered that while all three exercise programs increased their physical well-being. Additionally, according to this study's findings, individuals with T2D benefit more from an exercise program than an exercise modality.

#### **3- Exercise and muscle Strength in Diabetes**

The muscle quality can be improved by exercises. Muscle quality refers to “maximal force production per unit of muscle mass of specific compartment may be a better indicator of muscle function rather than strength alone”. **Park et al. (2006)** reported that although muscle mass of patients with DM was greater in upper and lower limb when compared to

non-diabetic patients but muscle quality of diabetics was lower as compared to non-diabetics.

Evidence suggests that patients with diabetes mellitus have weaker muscles than those without the disease, which further discourages them from exercising (**Hatef et al. 2014**). This is corroborated by the fact that weaker muscles are more likely to have lower glucose absorption and blood hyperglycemia. However, muscle strength may be increased as a result of physical activity, whether it is resistance, aerobic, or a combined effect of the two (**Sayyer et al., 2005**).

Previous studies have investigated the effect of resistance training in patients with diabetes. These studies concluded that, resistance training results in improved muscle strength (**Ibanez et al., 2005; Hameed et al.; 2012**). Other studies reported that, combination of exercises i. e both strength as well as aerobic exercises should be incorporated in rehabilitation. **Tokmakidis et al. (2004)** performed a study to examine the effect of combined strength and aerobic exercise, the aerobic training included walking / jogging on treadmill two times per week for 75 min along with warm up and cool down program, whereas strength training included six resistance exercises which were performed in 3 sets with 12 repetition with intensity of 60% of 1 RM. The exercise protocol resulted in better glycemic control and improved exercise tolerance and muscular strength.

#### **4- Neuropathy Management:**

Diabetic neuropathy can result in symptoms such as numbness, tingling, and pain in the extremities. Physiotherapists can teach you exercises and procedures to help you control your neuropathic symptoms and enhance your nerve function (**Pop-Busui et al., 2022**).

#### **5- Balance Exercises in Diabetes:**

Balance impairment is prevalent with problems such as neuropathy in the feet and legs. This can increase the likelihood of falling and sustaining injuries. Individuals with diabetes can benefit greatly from physiotherapy in terms of balance and fall prevention. Physiotherapists create specialized exercise programs to improve muscle strength, proprioception, and coordination. Balance training activities, gait analyses, and functional motions may all be included in these programs. By addressing these concerns, physiotherapy not only reduces the probability of falls, but also improves overall mobility and QoL for diabetics, contributing to their long-term well-being (**Kluding et al., 2017**).

**6- Exercises, Muscle Quality and Glucose in Diabetes:**

The muscle quality can be improved by exercises. Muscle quality refers to “maximal force production per unit of muscle mass of specific compartment may be a better indicator of muscle function rather than strength alone”. Exercises play important role in improving muscle quality and it is the predictor of health status and mortality. Exercises play an important role in controlling blood glucose. It has become one of the ideal means of rehabilitation for patients with diabetes. Anything that increases the level of ADLs helps in controlling complication related to the disease. Simple exercise like walking can be effective in regulating blood glucose levels (**Kaur *et al.*, 2015**).

When the duration and intensity increase there is increase in uptake of glucose by muscles and is balanced by hepatic glucose. Furthermore, moderate aerobic exercise also reduces risk of post exercise hypoglycaemia by decreasing plasma insulin levels (**Colberg *et al.*, 2012**). Various authors have undergone studies analyzing effect of exercise be it aerobic, resistance or combination of both on blood glucose. Each reported fall in blood glucose and increase in uptake of glucose by muscles (**Church *et al.*, 2010**; **Subramaniam & Venkatesan, 2012**; **Yardley *et al.*, 2013**).

**7- Pain Management in Diabetes:**

Some diabetics endure persistent pain, particularly in their feet or hands. Manual therapy, therapeutic exercises, and modalities such as heat or cold therapy are all examples of physiotherapy procedures that can help manage pain and improve general function (**Geneen *et al.*, 2017**).

**8- Lifestyle modification**

Physiotherapists help patients understand the value of living a healthy lifestyle. They can advise patients on how to control diabetes effectively through exercise, nutrition, and other lifestyle changes. Physiotherapists evaluate an individual's present fitness level and physical abilities. They then develop customized workout routines that cater to any physical limits or consequences associated with diabetes (**Dalle Grave *et al.*, 2010**).

**9- Stress Management:**

Stress has been shown to have a deleterious impact on blood sugar levels. Stress-reduction strategies such as deep breathing exercises, progressive muscular relaxation, and mindfulness practices may be introduced by physiotherapists. These approaches assist diabetics in

managing stress and maintaining more stable blood sugar levels (Zamani-Alavijeh *et al.*, 2018).

### CONCLUSION

The present review enlists the importance of exercises in diabetics and its effect on muscle strength, QoL, blood glucose levels, balance and general wellbeing in patients with diabetes. Various studies have proved that combination of aerobic and resistive exercises are beneficial when compared to aerobic and resistive exercises individually. It is recommended that physical therapists and other health professionals should consider the effect of implementing physical exercises for improving muscle strength, QoL, blood glucose levels and functional performance in patients with diabetes.

#### Conflict of interest

The authors have declared no conflict of interest.

#### Compliance with Ethics Requirements

This article does not contain any studies with human or animal subjects.

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### طرق العلاج الطبيعي للأطفال المصابين بداء السكري: مقالة مرجعية

محمد السيد محمد عبدالصديق<sup>1</sup> ، أسماء اسامة سيد<sup>1</sup> ، أميرة محمود عبدالمنعم<sup>1</sup>  
و شيماء عاطف محمد<sup>2</sup>

<sup>1</sup>قسم العلاج الطبيعي للأطفال , كلية العلاج الطبيعي, جامعة القاهرة

<sup>2</sup>قسم غدد صماء أطفال, كلية الطب, جامعة القاهرة

مرض السكري هو حالة صحية معقدة متعددة الخواص تتميز بارتفاع تركيزات الجلوكوز في البلازما نتيجة لمقاومة الأنسولين، أو عدم كفاية إنتاج الأنسولين، أو كليهما. داء السكري هو حالة معقدة ودائمة تتطلب علاجًا طبيًا مستمرًا و طرق متعددة للتحكم في الجلوكوز لمنع حدوث مضاعفات حادة وتقليل فرصة حدوث مشاكل طويلة الأمد. أصبح مرض السكري مصدر قلق صحي كبير في جميع أنحاء العالم بسبب ارتفاع معدل الإصابة به والمضاعفات الصحية المصاحبة له بما في ذلك الاعتلال العصبي وأمراض شبكية العين و أمراض الكلي، وكلها تؤثر على الأنشطة الوظيفية و جودة الحياة. يمكن أن يؤثر مرض السكري على الأداء الوظيفي بعدة طرق: الضعف الحسي والبصري، وضعف العضلات، وعدم الإلتزان، وانخفاض القدرة على تحمل التمارين الرياضية، وانخفاض القدرة الوظيفية. تلعب التمارين دورًا مهمًا في التحكم في نسبة الجلوكوز في الدم. لقد أصبح أحد الوسائل المثالية لإعادة تأهيل مرضى السكري.