RAMADAN FASTING AND IMPACT ON GLYCAEMIC CONTROL IN DIABETES; A NARRATIVE REVIEW

Abstract

Muslims all around the world commemorate Ramadan as a month of fasting, but for diabetics, fasting can be difficult because it may affect their blood sugar levels and diabetes control. This review attempts to investigate how Ramadan fasting affects diabetics' ability to control their blood sugar levels. With 8.8% of the world's population affected, diabetes is a growing global health issue. Making effective diabetes management plans is essential during Ramadan because fasting may raise the risk of hyperglycemia and hypoglycemia. The body employs alternate energy sources, such as ketone bodies made from fat stored in adipose tissue, to make up for the depletion of its glucose reserves that occur during Ramadan fasting. Fasting lowers insulin levels, which can increase the risk of hypoglycemia while also improving insulin sensitivity in healthy people. Hyperglycemia, a metabolic disease brought on by irregularities in insulin synthesis or activity, characterizes diabetes. The Ma-Pi 2 diet, which is high in fiber and complex carbs, as well as dates, which have a low glycemic index and are high in dietary fiber, are recommended for persons with diabetes who are fasting during Ramadan. These eating habits can enhance overall health and assist in controlling blood sugar levels. The management of blood sugar levels throughout Ramadan can be affected in different ways by various insulin therapies and glucose monitoring techniques, with continuous subcutaneous insulin infusion (CSII) being more efficient than conventional insulin (CI) at maintaining glycemic levels. Exercise is proven to improve glycemic management and cardiovascular risk factors, although it might be difficult during Ramadan due to changes in routine and energy levels. The effects of physical activity on glycemic control can vary, so it's important to take into account things like increased insulin sensitivity, greater muscle glucose uptake, the danger of hypo- and hyperglycemia, and when to engage in physical activity during Ramadan. Planning ahead, staying hydrated, picking the correct type and timing of physical activity, keeping an eye on blood glucose levels, and changing insulin doses and frequency are all methods for keeping up physical activity while fasting during Ramadan. Diabetes sufferers may find it difficult to fast during Ramadan, so effective diabetes care strategies should be created beforehand. Glycemic control can be affected differently by dietary suggestions, various insulin therapies, glucose monitoring techniques, and

physical exercise when fasting during Ramadan.

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Chapter One: Introduction

1.1 Introduction

Around 1.5 billion people worldwide practice Islam as their religion (Hackett et al., 2015). Observing the month of Ramadan, when Muslims who have reached puberty and are in good health are required to fast from dawn to sunset for around 30 days, is one of the core traditions of the faith. People must abstain from ingesting food, liquids, and other necessities throughout the daytime during this one-month fast (Afandi et al., 2023). Fasting during Ramadan can be particularly difficult for diabetics to regulate their blood sugar levels and their condition. Ramadan requires cautious blood glucose management because studies have indicated that people with diabetes may have hyperglycemia or hypoglycemia during this time (Afandi et al., 2023).

A large number of individuals worldwide are affected by diabetes, which is a health problem. According to estimates from Afandi et al. in 2023 and Hanif et al. in 2020, there are 425 million persons with diabetes globally, which translates to an 8.8% prevalence rate. The rise in diabetes cases can be attributed to risk factors like obesity, sedentary behavior, and bad eating habits. According to Sheard and Clark (2000), diabetes is linked to a number of problems, such as heart disease, kidney failure, blindness, and amputations. Therefore, it's imperative to develop efficient methods for treating the illness and lowering the likelihood of complications.

In addition, diabetes incidence is predicted to treble in countries where Islam is the prevalent religion during the next 25 years, indicating a substantially greater prevalence rate (Al-Arouj et al. 2010). Fasting during Ramadan, which is a requirement for Muslims, presents particular difficulties for those who have diabetes since it may impact blood glucose regulation and diabetes management (Afandi et al., 2023).

According to research, the changes in food and exercise habits that take place during

Ramadan put people with diabetes at higher risk of both hyperglycemia and hypoglycemia (Hui and Devendra, 2010; Teoh et al., 2022). Ramadan requires people to fast from dawn until sunset, which has an impact on meal schedules, food intake, and physical activity. As a result, it may be more challenging for those who have diabetes to control their condition, and their chances of developing hyper- and hypoglycemia may rise (Lee et al., 2018; Beshyah et al., 2021). Therefore, it's critical to create secure and efficient diabetes management plans during Ramadan.

In order to prevent problems in people with poorly managed diabetes or a history of complications, it is crucial to take into account the special risks and challenges associated with managing diabetes during Ramadan and to devise efficient methods for safe diabetes management. Both Teoh et al. (2022) and Hui and Devendra (2010) draw attention to this. Patients with diabetes should speak with their doctor before opting to fast during Ramadan to make sure it is safe to do so and to create a strategy for controlling their diabetes throughout this time (Lee et al., 2018; Hassanein et al., 2022).

The option to refrain from fasting throughout Ramadan exists for those who have the disease, and they shouldn't feel compelled to do so if doing so might jeopardize their health (Beshyah et al. 2017). This demonstrates how crucial individualized and patient-centered treatment is for those with diabetes throughout Ramadan.

1.2 Prevalence of Diabetes in the Muslim Population

Studies such as those by Salti et al. (2004), Ramachandran (2012), and Bener and Yousafzai (2014) indicate that the prevalence of diabetes in Muslim nations is comparable to that in western nations and is rising at a rate of 10% annually as a result of urbanization and socioeconomic growth. According to Islamic law, during the holy month of Ramadan, more than one billion Muslims worldwide refrain from eating or drinking between the hours of dawn and sunset for one lunar month each year, with the exception of those who are ill or whose health may be adversely affected by fasting (Akbani et al., 2005). Many diabetic individuals choose to fast throughout Ramadan despite medical advice and religious approval. There have been several large-scale epidemiological studies on diabetes care in Muslim countries, including Asia (Pathan et

al., 2012; Hanif et al., 2020), the Middle East (Al-Arouj et al., 2005; Jabbar et al., 2017; Tahapary et al., 2020), and Africa (Salti et al., 2004), but there is still a lack of knowledge regarding the management of diabetes during Ramadan.

Studies by M'guil et al. (2008), Salti et al. (2004), and Hassanein et al. (2019) have looked into the biochemical changes that occur in diabetics during Ramadan fasting. Most studies indicate no improvement in glycemic control, although some have reported a reduction in blood lipid levels and body weight (Chowdhury, 2017; Ismail et al., 2021; Abushady et al., 2019).

The study by Kul et al. (2013) found that maintaining a healthy diet during Ramadan can have a positive impact on blood glucose levels in people with diabetes. Following a strict dietary plan that includes reducing high glycemic index foods can help stabilize fasting blood glucose levels during the month of Ramadan. Type 2 diabetics can safely take oral diabetes medications such as glibenclamide and repaglinide during Ramadan to regulate blood glucose levels, as highlighted by Salti et al. (2004). However, patients should consult with their healthcare providers before making any changes to their medication regimen. Certain insulin derivatives, such as rapid-acting insulin analogs and long-acting insulin preparations, may be utilized to control type 1 diabetics' conditions if they desire to fast throughout Ramadan (Salti et al., 2004). Type 1 diabetics must collaborate closely with their healthcare team to create a specialized treatment plan that takes into consideration both their unique requirements and the difficulties of fasting during Ramadan.

A global conference was held in Morocco in 1995 to provide guidelines for controlling diabetes during Ramadan. The panel identified patient groups who should be exempt from fasting, including expectant mothers, the elderly, and people with co-occurring or unstable degenerative illnesses. The conference also set guidelines for fasting diagnostics. However, it's unclear how well these suggestions are being implemented. Additionally, there is a lack of information on lifestyle changes, issues that might arise during fasting during Ramadan, and adjustments to treatment schedules (Salti et al., 2004).

1.3 The Impact of Ramadan Fasting on Diabetes Control

Muslims fast throughout the holy month of Ramadan from sunrise to dusk for around 30 days. However, because fasting can influence blood glucose management, patients with diabetes confront particular difficulties during this time. The modifications to their food and exercise routines may make it more challenging to control their condition and raise their risk of developing hyper- or hypoglycemia. It can be difficult to manage diabetes during Ramadan since it necessitates careful preparation and adjustments to diet, exercise, and medication (Davidson 2006; Kieu and Iles 2023). To create individualized management plans that take into consideration distinct medical histories, medication schedules, and dietary requirements, consulting with healthcare specialists beforehand is essential. People with diabetes may observe Ramadan safely while maintaining their health and well-being with the right preparation and assistance.

Before fasting during Ramadan, people with diabetes should make the necessary plans and preparations because it may be difficult to maintain their condition. The main tactic is to check with a medical professional to see if fasting is safe (Kieu and Iles 2023). A good diet, blood glucose monitoring, and creating a plan for controlling diabetes during this time are all essential. People with diabetes can safely fast throughout Ramadan and maintain excellent diabetes control by using the measures mentioned above. To control blood glucose levels throughout Ramadan, type 2 diabetics can safely use oral diabetes drugs such as glibenclamide and repaglinide (Mafauzy 2002). Before making any modifications to their prescription regimen, individuals should first speak with their healthcare practitioners. During Ramadan, type 1 diabetics may use certain insulin derivatives, such as long-acting insulin preparations and rapid-acting insulin analogs, to manage their blood glucose levels (Mafauzy 2002; Cesur et al. 2007). It's also crucial to keep in mind that persons with diabetes have the option of not fasting throughout Ramadan and shouldn't feel compelled to if doing so will put their health at risk.

1.4 Aims and Objectives of the Study

The aim of this narrative review is to examine the difficulties and dangers involved in managing diabetes during the fasting days of Ramadan and to create plans for secure

and efficient diabetes management.

The objective of this narrative review is to provide safe and effective approaches for persons with diabetes as well as healthcare professionals while thoroughly analyzing the dangers and difficulties associated with treating diabetes throughout the month of Ramadan. The following are the specific objectives:

1. To assess the prevalence of diabetes among Muslims and investigate the factors that increase the risk of diabetes during Ramadan.

2. To assess the effect of a balanced diet on blood sugar levels throughout Ramadan and to offer patients with diabetes dietary guidance based on scientific data.

3. To investigate alternative methods for altering medicine during Ramadan and evaluate the security and efficiency of various diabetes medications while fasting, including oral medications and insulin derivatives.

4. To provide thorough instructions on how diabetes patients and medical professionals may properly manage their condition throughout Ramadan, including creating individualized management plans, employing monitoring procedures, and recognizing crucial elements for those with co-morbidities.

Chapter Two: Physiology of Fasting and Diabetes

2.1 Physiology of Fasting

Muslims all throughout the globe follow the spiritual and religious tradition of Ramadan fasting (Pathy et al., 2010). During daytime hours, the practice requires forgoing food, liquids, and other necessities of life. Typically, the fast lasts from sunrise to sunset, lasting 12 to 16 hours, depending on the time of year and region. (Hui et al., 2010; Lessan and Ali, 2019). The physiological repercussions of Ramadan fasting on the body are detailed here.

The body's glucose reserves are exhausted during Ramadan fasting, and it uses alternative energy sources to power its metabolic functions. (Maughan et al., 2010; Lessan and Ali, 2019; Rahman, 2022; Joaquim et al., 2022). Fatty acids and glycerol from the fat stored in adipose tissue are broken down and transformed into ketone bodies in the liver. (Jaleel et al. 2011; Kersten 2023). The brain and other organs use these ketone bodies as an alternate energy source. (Kersten 2023). Weight loss results from the shift in metabolism from glucose to fat during fasting; however, this weight loss is caused by more than just the utilization of fat as an energy source and the depletion of glycogen reserves. (Anton et al., 2017; de Cabo and Mattson, 2019). Other elements, including calorie restriction and increased physical activity, also help people lose weight during Ramadan. (Hallak and Nomani 1988; Meckel et al. 2007; Lessan and Ali 2019).

Another physiological effect of fasting is a reduction in insulin levels throughout

Ramadan. The pancreas secretes the hormone insulin, which is essential for controlling the body's blood glucose levels. (Meckel et al. 2007; Bouhlel et al. 2008; Lessan and Ali 2019). After eating, our blood sugar levels increase. With the help of insulin, the glucose is then carried into our cells, where it can be converted to energy or stored as glycogen. Insulin levels fall as the body absorbs less glucose after fasting. Blood glucose levels may therefore drop, which may have both favorable and unfavorable impacts on the body.

Conversely, a drop in insulin levels might aid in raising the body's sensitivity to the hormone. Maintaining healthy blood glucose levels depends on the body's receptivity to insulin, also known as insulin sensitivity (Polonsky et al., 1996; Kahn et al., 2006). Blood glucose levels may stay high when insulin sensitivity is low, and the body's cells may develop resistance to insulin's effects. Numerous health issues, including type 2 diabetes, might result from this. Ramadan fasting has been found to improve insulin sensitivity in healthy people, potentially reducing the risk of developing type 2 diabetes (Shariatpanahi et al., 2008; Gnanou et al., 2015).

Conversely, a drop in insulin levels can result in hypoglycemia, a condition marked by low blood sugar levels. Fatigue, headaches, lightheadedness, and disorientation are all signs of hypoglycemia. (Ahmad et al., 2012; Abdelrahim et al., 2021). In extreme circumstances, seizures, comas, or even death might happen. Ramadan fasting raises your chance of developing hypoglycemia, particularly if you have diabetes or another underlying medical condition. As a result, it is crucial for people who are fasting to regularly check their blood glucose levels and to get in touch with a doctor if they experience signs of hypoglycemia.

2.2 Pathophysiology of Diabetes

Hyperglycemia, or increased blood glucose levels, are a hallmark of diabetes mellitus (DM), a complicated metabolic condition brought on by abnormalities in insulin production, action, or both (Lee and Pervaiz, 2007; Sameer et al., 2020). Micro- and macrovascular problems that result in damage, malfunction, and organ failure are brought on by hyperglycemia and its accompanying metabolic dysfunctions, which

interfere with numerous organs' normal activities. The organs primarily impacted by these issues are the eyes, kidneys, heart, and nerves. Common consequences of diabetes include retinopathy, nephropathy, hypertension, coronary heart disease, and neuropathy. Diabetes is a serious health problem that affects people all over the world, and its incidence rises in lockstep with urbanization, economic growth, and contemporary lifestyle choices. 463 million people worldwide were anticipated to have diabetes in 2019, and that figure is projected to rise to 578 million by 2030 and 700 million by 2045. Diabetes is thought to have contributed to at least 4.2 million deaths in 2019 and cost the healthcare system at least 760 billion USD, or 10% of all adult spending (Kusuhara et al. 2018; Harrison et al. 2023).

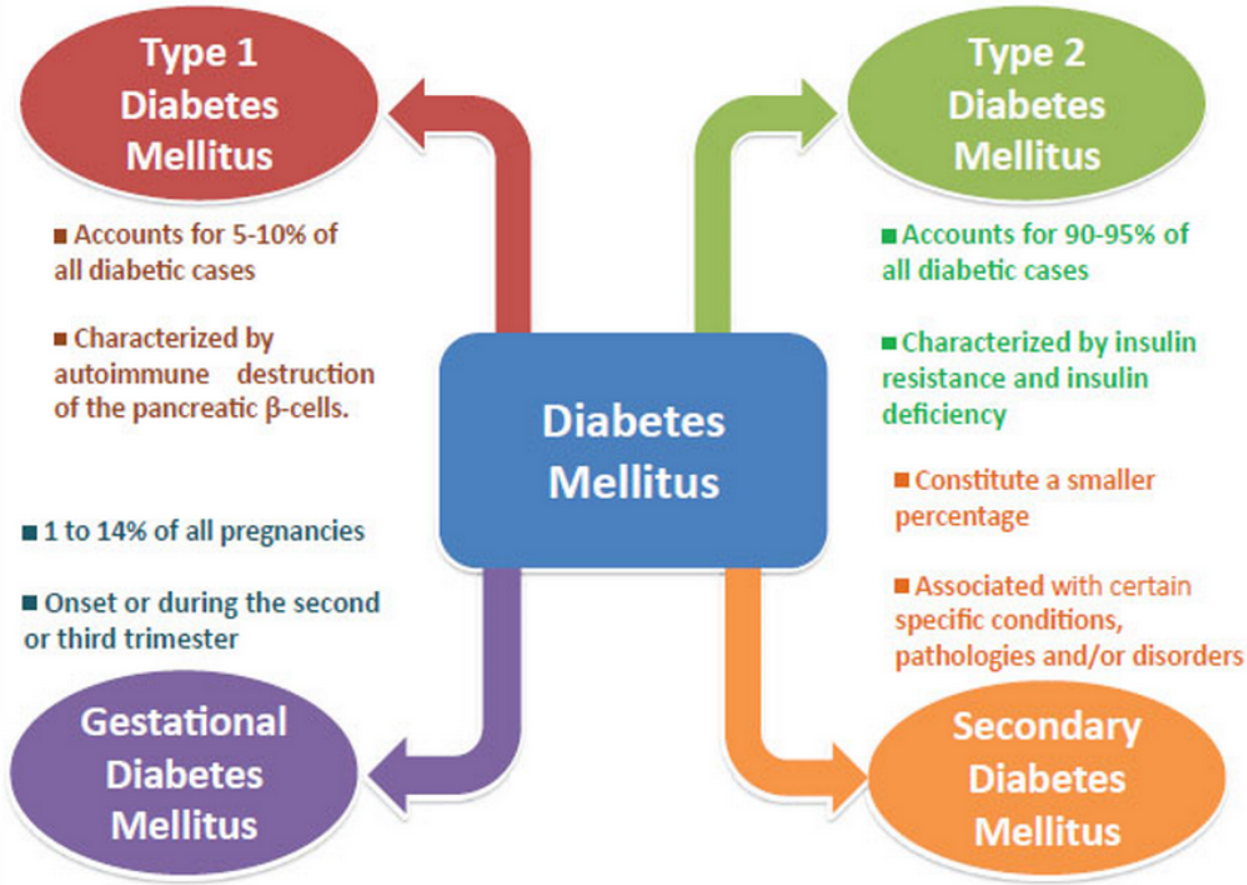

Figure 2.1: Types of DM (Sameer et al. 2020)

2.2.1 Mechanisms of Type 1DM

An autoimmune condition known as type 1 diabetes mellitus (T1DM) affects 5–10% of diabetic people (Sameer et al., 2020). β -cell-mediated destruction of pancreatic beta-cells, which causes insulin insufficiency and hyperglycemia, is what leads to T1DM. Both hereditary and environmental variables affect the etiology of this illness. T1DM progresses differently in each person, but the eventual outcome is invariably a severe or complete lack of insulin, which is reflected in low or undetectable plasma C-peptide levels (Vergès, 2015; Kusuhara et al., 2018; Karamat et al., 2010). Autoantibodies are one of the immunological markers that define T1DM and can be utilized to make a clinical diagnosis (Hirano, 2018; Cunha-Vaz, 1978; Kusuhara et al., 2018; Al-Arouj et al., 2010; Al-Arouj et al., 2005). The immune-mediated β-cell destruction that is a defining feature of this illness is connected to the autoantibodies.

2.2.2 Mechanisms of Type 2DM

Insulin resistance and β-cell dysfunction are two features of the predominant form of diabetes known as type 2 diabetes mellitus (T2DM) (Sameer et al. 2020). The condition generally goes undetected until the usual symptoms linked to high hyperglycemia arise because it advances slowly and without signs. T2DM is a complicated etiology that includes both significant environmental factors and genetic predispositions (Cunha-Vaz, 1978; Pivonello et al., 2010; Karamat et al., 2010; Al-Arouj et al., 2010; Al-Arouj et al., 2005). Insulin resistance and hyperglycemia are two conditions that are significantly influenced by obesity. T2DM is linked to a number of cardiovascular risk factors and issues, including hypertension, changes in lipoprotein metabolism, and micro- and macrovascular problems.

Figure 2.2: Risk factors for type 2 DM (Sameer et al. 2020)

2.2.3 Mechanisms of Gestational DM

Diabetes or glucose intolerance that is diagnosed during pregnancy, often in the second or third trimester, is known as gestational diabetes mellitus (GDM). It differs from diabetes that already exists and normally goes away after giving birth. Age, obesity, and past pregnancies all have an impact on the prevalence of GDM, which affects which racial or ethnic groups are more likely to experience it (Cunha-Vaz, 1978; Al-Arouj et al., 2010; Al-Arouj et al., 2005). Regular screening is crucial for early detection as type 2 diabetes is more likely to develop in women with GDM over the course of their lives.

2.2.4 Mechanisms of other DM

In addition to T1DM, T2DM, and GDM, there are several different forms of diabetes that are linked to distinct illnesses such as endocrinopathies, exocrine pancreatic pathologies, monogenic deficiencies in β-cell function, genetic anomalies in insulin action, and other disorders (Sameer et al., 2020). Only a small portion of all instances of diabetes are caused by monogenic abnormalities in β-cell function, such as maturity-onset diabetes of the young (MODY) and neonatal diabetes. MODY is a category of primarily non-insulin-dependent diabetes that is genetically and clinically diverse and is caused by mutations in certain genes involved in pancreatic β-cell activity (Al-Arouj et al., 2010; Al-Arouj et al., 2005). MODY develops early, frequently before the age of 25, and is frequently misdiagnosed as either T1DM or T2DM. The vertical transmission of MODY normally occurs across at least three generations and has an autosomal dominant inheritance pattern. The most prevalent types are MODY2 and MODY3, which together account for more than 80% of all cases (Sameer et al., 2020).

2.3 Fasting and Glucose Metabolism in Diabetes

In diabetics, fasting has both beneficial and detrimental effects on glucose metabolism (Kul et al., 2013; Afandi et al., 2023). While fasting can lower blood glucose levels and enhance insulin sensitivity in type 2 diabetics, it can cause hypoglycemia in type 1 diabetics (Salti et al., 2004). Fasting can also have an effect on glucose production, lowering it in people with type 2 diabetes while potentially causing hypoglycemia in

people with type 1 diabetes (Mafauzy, 2002). Furthermore, medication dosages may need to be changed for diabetics who fast, as fasting might impair the efficiency of blood glucose-management drugs (Cesur et al., 2007).

2.3.1 Impact of Fasting on Glucose Metabolism

In people with diabetes, fasting can affect how their bodies process glucose in both favorable and unfavorable ways (Kul et al., 2013; Afandi et al., 2023). When someone fasts, their body uses glucose that has been stored in the liver and muscles as a source of energy. It may lower blood glucose levels as a result. This drops in blood sugar levels in persons with type 2 diabetes may aid in enhancing insulin sensitivity, which may enhance glycemic management. However, fasting can cause serious hypoglycemia in people with type 1 diabetes (Mafauzy, 2002).

2.3.2 Effects of Fasting on Insulin Sensitivity

The body's capacity to react to insulin is referred to as insulin sensitivity. In type 2 diabetics, fasting has been proven to increase insulin sensitivity. Fasting lessens the requirement for insulin because the body burns stored glucose for energy (Kahn et al., 2006). As a result, glycemic management can be enhanced, and insulin sensitivity increases. For those who have type 1 diabetes, fasting may have the opposite impact. Hyperglycemia can result from a decrease in insulin synthesis brought on by fasting (Shariatpanahi et al., 2008; Gnanou et al., 2015).

2.3.3 Effects of Fasting on Glucose Production

The liver produces glucose, which is referred to as glucose production. Glucose production may be significantly impacted by fasting (DeFronzo et al., 1989; Bergman et al., 2007). When someone fasts, their body uses glucose that is already stored as energy. The liver generates less glucose as a result, which can lower blood glucose levels. For those who have type 2 diabetes, this decrease in glucose production may aid in better glycemic control. Fasting, however, may cause type 1 diabetics to produce less glucose, which may result in hypoglycemia (Bergman et al. 2007).

2.3.4 Fasting and Medication

Medication efficacy may be affected by fasting (Siaw et al., 2014). When fasting, diabetics who use medication to reduce blood sugar levels may need to change their dosage. To prevent hypoglycemia, for instance, persons who use insulin may need to lower their dosage when fasting. On the other hand, those who take medications like sulfonylureas—which stimulate the production of insulin—might need to up their dosage when fasting to avoid hyperglycemia.

2.4 Factors Affecting Glycemic Control During Fasting in People with Diabetes

Diabetes patients' glycemic control during fasting is influenced by a number of variables, such as insulin sensitivity, stress, smoking, and potassium levels (Ohkuma et al. 2015; Khafaie et al. 2017; Hodaei et al. 2019). Insulin resistance, which refers to cells that do not react appropriately to insulin, is a prevalent problem in type 2 diabetes. As insulin sensitivity increases during fasting, blood glucose levels may drop (Hodaei et al., 2019). However, because type 1 diabetes does not produce enough insulin, fasting might result in hypoglycemia. For all kinds of diabetes, thorough blood glucose monitoring and medication adjustments may be required while fasting.

Another element that has an impact on glucose management when fasting is psychological stress (Kirschbaum et al., 1997; Faulenbach et al., 2011). The neuroendocrine system controls extended reactions to stress, whereas the sympathetic nervous system controls fast responses to stress (Buijs and Van Eden, 2000). The release of catecholamine chemicals, including adrenaline, noradrenaline, and dopamine, from the adrenal gland is triggered by the activation of the hypothalamus nuclei in response to stressful stimuli. If the stress continues, the hypothalamus generates corticotropin-releasing hormone, which stimulates the anterior pituitary and the adrenal cortex, releasing the hormone cortisol (Buijs and Van Eden, 2000). If the stress continues, the hypothalamic-pituitary-adrenal axis is engaged. As opposed to prolonged and severe stress, which can increase blood glucose levels through gluconeogenesis and the suppression of insulin action, mild or moderate stress can release endorphins and growth hormones (Faulenbach et al., 2011). As a result, people with diabetes

should avoid stress or successfully manage it when fasting to maintain optimal glycemic control.

Smoking can increase oxidative stress and inflammation, which can interfere with the function of pancreatic β-cells (Fagard and Nilsson, 2009). Smoking is a substantial risk factor for diabetes. By preventing insulin secretion, cigarettes' high nicotine content may cause insulin resistance. Nicotine-related substances interact with the nicotinic acetylcholinesterase receptor, activating the target of rapamycin in the process (Fagard and Nilsson, 2009; Tonstad, 2009)). To maintain glycemic control, patients with diabetes must stop smoking or reduce their nicotine intake while fasting.

Potassium levels are important for maintaining glycemic control during fasting. Potassium is found in intracellular compartments and is necessary for the electrolyte water balance. The balance between potassium intake and excretion through the kidney and intestinal systems allows the body to closely regulate potassium levels in a small range of 3.5–5.0 mmol/L. While serum insulin is also required for potassium to enter cells, its affinity for doing so is weaker than that for absorbing glucose (Asmar et al., 2012; Shibata and Uchida, 2021). Gradually, increased potassium levels are proportionately correlated with increasing blood glucose levels. Diabetes patients who are insulin-dependent have hypertonicity, which leads to the translocation of intracellular potassium to the extracellular compartments. So, it's essential to keep an eye on potassium levels when fasting to keep glycemic management under control.

In type 2 diabetes, fasting may increase insulin sensitivity and lower blood sugar levels, while in type 1 diabetes, it may result in hypoglycemia. For proper glycemic control, stress management, stopping smoking, and keeping an eye on potassium levels while fasting are all crucial. In order to control their blood glucose levels, people with diabetes should consult with healthcare specialists for advice and direction.

Chapter Three: Glycaemic Control during Ramadan Fasting in Diabetes

3.1 Ramadan fasting's effect on glycemic control in diabetes

According to Hill et al. (2011), Yazdanpanah et al. (2017), and Al-Ozairi et al. (2020), many approaches are used to measure glycemic management, including mean blood glucose, HbA1c, fructosamine, mean interstitial glucose, MAGE, and mean continuous glucose monitoring. According to Tavares Ribeiro et al. (2015) and Wang and Hng (2021), although HbA1c measures an average plasma glucose level over an extended time of 12-16 weeks, fructosamine offers an average plasma glucose level during a shorter period of 2-3 weeks. As a result, according to Al-Ozairi et al. (2020), fructosamine may be a more exact measure of glycemic control during the shorter fasting periods of Ramadan.

Several studies have found that serum fructosamine levels fall significantly during Ramadan, indicating better glycemic control. Cesur et al. (2007) conducted a study with 49 insulin infusion pump users and discovered that more than half of them reduced their pre-fasting basal insulin dose by 5-50% during Ramadan. Similarly, in their research, Lessan et al. (2015) and M'guil et al. (2008) found a significant drop in serum fructosamine levels, implying improved glycemic management. Furthermore, Ekhzaimy et al. (2022) discovered a substantial reduction in serum fructosamine levels during Ramadan, indicating improved glycemic management.

In contrast, Khalil et al. (2012) discovered a non-significant increase in fructosamine levels immediately after Ramadan in the glargine group when comparing two oral hypoglycemic medicines to insulin glargine in ten individuals. These findings imply that the efficiency of different drugs for glycemic management during Ramadan may vary. Several studies have found a decrease in serum fructosamine levels during Ramadan, indicating improved glycemic control.

According to Khalil et al. (2012), depending exclusively on HbA1c as a measure of glycemic control during Ramadan may be insufficient. Hui et al. (2010), on the other hand, investigated the effects of two kinds of insulin, Humalog Mix 50 and Human Insulin Mix 30, on HbA1c levels in 52 people with type 2 diabetes. They discovered that the Humalog Mix 50 group had a significant reduction in HbA1c levels prior to Ramadan. Several other studies have found that different insulin treatments and glucose monitoring systems an have different impacts on glucose management during Ramadan. Alabbood et al. (2017), Nor Azlin et al. (2010), and Ahmedani et al. (2014) all found a significant decrease in mean blood glucose levels (MBG) during Ramadan, indicating better glycemic control. These data imply that there is no one-size-fits-all approach to glycemic management during Ramadan, and that different tactics may assist different people.

Several studies on the effect of Ramadan fasting on HbA1c levels have been conducted, with three of them revealing no significant effect, including Kassem et al. (2005), Cesur et al. (2007), and AlAlwan and Banyan (2010). These studies, however, have drawbacks, including small sample sizes and infrequent HbA1c assessments. Lessan et al. (2015), on the other hand, discovered that during Ramadan, the measurement of blood glucose volatility (MAGE) was considerably higher in the insulin group, indicating poorer glycemic control. Despite this, there were several limitations to the study, including a small sample size and only monitoring glucose levels for two days during Ramadan.

Continuous subcutaneous insulin infusion (CSII) is more successful than conventional insulin (CI) in managing glycemic levels, as evidenced by the mean HbA1c (Elbarbary 2016). The study's sample size, however, was limited to only nine patients. AlAlwan and Banyan (2010) discovered that using Lispro insulin resulted in a much lower glucose excursion two hours after iftar when compared to standard insulin. Furthermore, Mattoo et al. (2003) conducted randomized crossover research with a large sample size at 13 sites in seven countries, indicating that Lispro Mix 30 caused a substantially smaller glucose excursion than human insulin.

Finally, studies have demonstrated that fasting during Ramadan has no harmful effect

on glycemic control in insulin-dependent diabetics and may even enhance it. Mean blood glucose, HbA1c, fructosamine, mean interstitial glucose, MAGE, and mean continuous glucose monitoring are all ways to assess glycemic management. Fructosamine may be a more reliable marker of glycemic control during Ramadan's shorter fasting periods. However, the effectiveness of various drugs for glycemic control during Ramadan may vary, and there is no one-size-fits-all glycemic control method. Different insulin treatments and glucose monitoring methods can have different effects on glucose management throughout Ramadan, with continuous subcutaneous insulin infusion (CSII) being more effective than conventional insulin (CI) in maintaining glycemic levels. Lispro-containing insulin formulations, such as Lispro Mix 50, Mix 25, or pure Lispro, provide more precise glucose management throughout Ramadan because to its faster onset of action than human normal insulin. Furthermore, when combined with an insulin pump that can detect and halt infusion during hypoglycemia, continuous glucose monitoring provides insulin users with flexibility and safety when fasting.

3.2 Factors Impacting Glycemic Control in Diabetics When Fasting During Ramadan

3.2.1 Effect of Diabetes Type

Due to potential effects on glucose control during the Ramadan fast (Alfadhli 2018; Hassanein 2010; Lee et al. 2016), diabetes type is an important factor to take into account. Patients with type 1 diabetes can have more difficulty than those with type 2 diabetes keeping their blood glucose levels steady (Alfadhli 2018). Lee et al. (2016) claim that type 1 diabetes is an autoimmune disease in which the patient develops severe insulin insufficiency as a result of the body attacking and destroying the pancreatic cells that produce insulin. People with type 2 diabetes may have an easier time keeping their blood glucose levels stable throughout Ramadan fasting since they produce some insulin and can control their levels with diet, exercise, and oral medication (Lee et al. 2016).

3.2.2 Managing Diabetes Medications

Diabetes medications can have a significant impact on the ability to maintain glycemic control throughout the Ramadan fast. Some treatments, such as taking specific prescriptions with meals or modifying to account for changes in physical activity, may need to be altered or scheduled differently to avoid hypoglycemia (Ibrahim et al. 2015; Davidson 2006; Grindrod and Alsabbagh 2017). Furthermore, faster-acting insulin can be administered via a basal-bolus regimen, while basal insulin dosages can be reduced or divided into smaller doses. Before modifying their prescription regimen, diabetics should consult with their healthcare provider (Karamat et al. 2010).

3.2.3 Managing Glycemic Control

Fasting during Ramadan means abstaining from food and drink from dawn to sunset, which alters the meal schedule and can cause blood glucose levels to fluctuate (Grindrod and Alsabbagh 2017). Changes in Ramadan meal composition, such as an increase in high-carbohydrate and high-fat foods, can also have an impact on dietary management (Ibrahim et al. 2015). Diabetic individuals should consult with their healthcare providers to modify their dietary intake and change their medication and insulin dosages in order to maintain optimal glycemic control (Ibrahim et al. 2015).

3.2.4 Physical Activity

Physical activity during the Ramadan fast can have a substantial impact on the control of glucose in diabetic individuals. While inactivity can result in insulin resistance and poor glycemic management, regular exercise can increase insulin sensitivity and lower blood glucose levels (Karamat et al. 2010). Additionally, physical activity scheduling has been shown to have an impact on blood glucose levels (Grindrod and Alsabbagh 2017). Diabetes patients must be aware of their physical activity levels and modify their exercise plan and schedule as necessary to maintain adequate glycemic control when fasting during Ramadan (Davidson 2006).

3.2.5 Dehydration and Hypoglycemia Risks

Muslims fast during Ramadan from sunrise till sunset, with varied fasting times based on the season and region. Dehydration brought on by longer fasting intervals can make it more difficult for diabetics to maintain their blood sugar levels (Lee et al. 2016). This could lead to an increase in hypoglycemia and blood glucose levels after the fast (Grindrod and Alsabbagh 2017; Ali et al. 2016). To avoid this, people with diabetes should change their medications, increase their water intake, and monitor their heart glucose levels (Ibrahim et al. 2015).

3.3 Managing Diabetes During Ramadan Fasting

Individuals with diabetes should examine the risks of fasting, consider religious exemptions, and consult their doctor before fasting. Although it is generally not suggested for diabetes patients to fast, those who do should be informed of the hazards and follow their healthcare provider's advice to ensure a safe fasting experience. When evaluating the risk of fasting-related disorders, the severity and quantity of risk variables for each patient should be addressed (Al-Arouj et al. 2010; Abdelrahim et al. 2021). Personalized care, which tailors' treatment strategies to each patient's specific needs, is critical. Patients who use insulin should check their blood glucose levels multiple times per day.

3.3.1 Managing Body Weight and Physical Activity During Ramadan for Diabetics

Individuals with diabetes should take a nutritious and balanced diet during Ramadan, avoiding high-carb and high-fat items, especially towards sunset, to maintain a stable body weight. Instead, complex carbs should be consumed before fasting, and simple carbohydrates should be consumed before sundown (Al-Arouj et al. 2005; Karamat et al. 2010). It is also advised to drink more water during non-fasting hours and to postpone the pre-dawn meal. Normal levels of physical activity are permissible throughout Ramadan, although excessive exertion should be avoided, particularly within a few hours of the evening meal, as it may increase the risk of hypoglycemia. If diabetic patients experience hypoglycemia or have a blood glucose level less than 70 mg/dl (3.9

mmol/l) within the first few hours of fasting, the fast should be broken. They should also stop fasting if their blood glucose level surpasses 300 mg/dl (16.7 mmol/l). Fasting should not be practiced by patients on "sick days" (Al-Arouj et al. 2005).

3.3.2 Diabetes Educational Counseling for Patients Fasting During Ramadan

Diabetes patients who wish to fast during Ramadan should exercise caution to protect their safety. This comprises a medical assessment as well as educational therapy. The medical examination should focus on the patient's overall health and glycemic control, as well as any drug or food regimen changes that are required. Educational therapy is particularly useful in teaching patients and their families about self-care, including as recognizing hyperglycemia and hypoglycemia symptoms, monitoring blood glucose levels, planning meals, exercising, and dealing with acute effects (Karamat et al. 2010; Hassanein et al. 2022). Patients should be prepared to treat hypoglycemia immediately with glucose gel, glucose-containing liquids, glucose tablets, or glucagon injections if necessary.

3.3.3 Patients with Type 1 Diabetes and the Danger of Fasting During Ramadan

Patients with type 1 diabetes are discouraged from fasting during Ramadan, particularly if their diabetes is poorly controlled, due to the significant risk of severe consequences. Those who are reluctant or unable to regularly monitor their blood glucose levels should avoid fasting as well. Patients should have aggressive glycemia management medication, as research has shown that it protects against long-term microvascular problems (Ahren 2013; Misra et al. 2018; Mohan et al. 2019). Ramadan fasting may necessitate numerous daily insulin injections or continuous subcutaneous insulin infusions through pump therapy. Typically, one injection of intermediate- or long-acting insulin is insufficient to cover a complete day of fasting. To cover meal intake, patients may require two daily injections of intermediate-acting insulin in addition to short-acting insulin. Long-acting insulin analogs such as glargine or detemir, as well as premeal rapid-acting insulin analogs, could be beneficial. In a study, insulin glargine exhibited positive results in individuals with type 1 diabetes who fasted for 18 hours during Ramadan when paired with premeal rapid-acting insulin analogs (Al-Arouj et al. 2010; Al-

Arouj et al. 2005). According to study, administering insulin lispro or insulin as part of a combination with intermediate-acting insulin provided twice daily improves postprandial glycemia and leads to fewer hypoglycemic episodes in people with type 1 diabetes (Lalli et al. 1999; Silver et al. 2018). While subcutaneous insulin pump management appears to be more appealing, it is also more expensive and requires frequent blood glucose testing.

3.3.4 Managing Hypoglycemia Risk in Patients with Type 2 Diabetes During Ramadan

In the case of type 2 diabetes, intermediate- or long-acting insulin should be combined with short-acting insulin before meals (Al-Arouj et al. 2010). Patients with type 2 diabetes who take metformin can safely fast throughout Ramadan, but the time of their dosages must be altered. Glitazones are less likely to cause hypoglycemia than sulfonylureas, particularly chlorpropamide, which is contraindicated (Al-Arouj et al. 2010). Short-acting insulin secretagogues should be administered prior to dusk and before breakfast. Patients who are only controlled by diet have a lower fasting risk, but postprandial hyperglycemia is still a possibility (Del Prato 2002). Oral medications should be chosen with care, with those that improve insulin sensitivity being the safest. Metformin can be taken safely during fasting provided the dose schedule is adjusted (Ibrahim et al. 2015). Medication dosages, particularly insulin, should be adjusted based on weight fluctuations throughout Ramadan (Al-Arouj et al. 2010). Insulin-treated patients are at risk of hypoglycemia, and older individuals with type 2 diabetes are especially vulnerable.

Chapter Four: Nutritional Management during Ramadan Fasting in Diabetes

4.1 Nutritional Recommendations During Ramadan Fasting for People with Diabetes

One of the dietary plans that have been shown effective in the management of type 2 diabetes is the Ma-Pi 2 diet, which is heavy in fiber and complex carbs (Fallucca et al. 2014; Porrata-Maury et al. 2014; Fallucca 2015; Ibrahim et al. 2015). It is worthwhile to look at this Ramadan diet because it complies with both the ADA and European dietary recommendations (Fallucca 2015; Ibrahim et al. 2015). Whole grains, vegetables,

legumes, and fermented foods are prioritized on the Ma-Pi 2 diet whereas unrefined sea salt, green tea, animal fat and protein (including milk and dairy products), and added sweets are restricted (Ibrahim et al. 2015). The Macrobiotic Diabetes Study (MADIAB), the first randomized controlled experiment contrasting the Ma-Pi 2 diet to a regular diet advised for type 2 diabetes patients, showed a significant positive effect of the Ma-Pi 2 diet on numerous health markers (Soare et al. 2014; Fallucca 2015; Ibrahim et al. 2015; Soare et al. 2016). This was shown by a multivariate analysis that controlled for age, gender, BMI, and physical activity. Inflammatory markers, insulin resistance, HbA1c levels, total cholesterol, LDL cholesterol, the LDL-HDL ratio, body weight, waist circumference, and hip circumference were all measured.

Following the Ma-Pi 2 diet led to increased fasting and postprandial glucose target levels after the 21-day dietary intervention. Target concentrations of 6.1 and 7.8 mmol/L (110 and 140 mg/dL, respectively) were reached. In addition, they observed a substantial decline in inflammatory markers and insulin resistance. The Ma-Pi 2 diet may be a beneficial dietary intervention for people with type 2 diabetes, according to these data, since it has the potential to enhance blood sugar management and other health outcomes (Soare et al. 2014; Ibrahim et al. 2015; Soare et al. 2016). These findings emphasize the significance of following the Ma-Pi 2 diet during Ramadan as a diabetic dietary prescription. Following this diet, people with type 2 diabetes may have improvements in their blood sugar levels and general health.

Dates are suitable for those with type 2 diabetes who are fasting during Ramadan since they have a low glycemic index and are high in dietary fiber (Soare et al. 2014; Alalwan et al. 2020; (Assaad Khalil et al. 2021; Mohd Yusof et al. 2021). After breaking the fast, the evening meal includes fewer complex carbs whereas the breakfast meal has more. Dates are a great way for Ramadan patients with type 2 diabetes to maintain their blood sugar levels since they may both aid with blood sugar regulation and provide them a feeling of fullness during non-fasting hours.

Dates are frequently taken at Iftar and Suhoor meals, generally with yogurt or other delicacies, as part of a long-standing Muslim custom. Tamer dates are rich in

unsaturated fatty acids (0.2-0.5%), minerals, salts, vitamins, proteins (2-6%), fiber (6-12%), and carbs (total sugars: 44-88%), meeting 50-100% of the daily fiber need in just 100g (Ibrahim et al. 2015). Contrarily, dates have a high sugar content and a fructose-to-glucose ratio of 1:1, which can raise blood sugar levels. Research indicates that dates can still be beneficial for those with type 2 diabetes despite having a moderate glycemic index that ranges from 35 to 55, with an average of 42. According to studies, eating dates can reduce the risk of cardiovascular disease and help control blood sugar and cholesterol levels (Ibrahim et al. 2015; Assaad Khalil et al. 2021; Mohd Yusof et al. 2021). Particularly for diabetics, including dates in one's diet may offer a lot of health advantages.

4.2 Potential Benefits and Risks of Different Dietary Patterns During Ramadan Fasting for People with Diabetes

In order to preserve their health and efficiently control their blood sugar levels throughout Ramadan, people with diabetes must have a comprehensive nutrition plan since they encounter unique dietary obstacles. The Ma-Pi 2 diet, which is high in fiber and complex carbohydrates, is one of the eating regimens that has been demonstrated to be useful in the management of type 2 diabetes. Dates, on the other hand, have a low glycemic index and are rich in dietary fiber, making them an excellent choice for those with type 2 diabetes who are fasting throughout Ramadan.

Improved blood sugar regulation is one of the Ma-Pi 2 diet's possible advantages during the Ramadan fast. According to studies, the Ma-Pi 2 diet can improve fasting and postprandial glucose levels as well as significantly lower HbA1c levels, a measure of long-term blood sugar management (Ibrahim et al. 2015; Soare et al. 2016). This is crucial for those with diabetes who are fasting throughout Ramadan since it can prevent hazardous blood sugar spikes or decreases. According to many studies (Fallucca et al. 2014; Porrata-Maury et al. 2014; Fallucca 2015; Ibrahim et al. 2015), the Ma-Pi 2 diet lowers cholesterol and saturated fat levels while increasing fiber and antioxidant intake. For diabetics, who are more likely to experience cardiovascular issues, this is crucial.

Animal protein and dairy products, which may be significant sources of minerals like

calcium, vitamin D, and vitamin B12, are among the items that the Ma-Pi 2 diet forbids. Hypoglycemia, or low blood sugar, is yet another possible side effect of the Ma-Pi 2 diet during the fasting month of Ramadan. For diabetics, fasting during Ramadan already raises their risk of hypoglycemia, and eating a low-carbohydrate diet like the Ma-Pi 2 diet may make this risk much higher. People who adhere to this diet throughout Ramadan must regularly check their blood sugar levels and adapt as necessary to avoid hypoglycemia (Fallucca 2015). For certain diabetics, the Ma-Pi 2 diet may not be suitable. This diet may need to be modified or avoided by those with specific medical issues, such as renal disease or digestive difficulties. Before beginning any new diet, including the Ma-Pi 2 diet, it is crucial for diabetics to speak with their healthcare professional.

Dates, a common fasting meal during Ramadan, have been shown to provide potential diabetes advantages. Because they have a low glycemic index and are high in dietary fiber, they are a suitable option for people with type 2 diabetes who are fasting throughout Ramadan.

Dates' capacity to regulate blood sugar levels is one of the most important benefits for diabetes. Dates include simple carbohydrates like fructose and glucose, but they also have a lot of fiber, which slows down the body's absorption of these sugars and lessens their impact on blood sugar levels (Hassanein et al. 2017). Dates also contain flavonoids and phenolic acids, both of which have been shown to have antioxidant and anti-inflammatory properties. Both of these characteristics have the potential to improve overall health and blood sugar control. Dates include a lot of vitamins, minerals, and antioxidants (Ibrahim et al. 2015; Hassanein et al. 2017). For instance, they are rich in potassium, magnesium, and calcium, all of which are necessary for preserving normal blood pressure. Additionally, they include vitamins B6 and A, both of which are crucial for the development of red blood cells and maintaining eye health. According to Mohd Yusof et al. (2002), dates' antioxidant content may also help lower the chance if developing chronic illnesses including cancer and heart disease.

Dates do, however, contain a lot of sugar and should be taken in moderation, especially

by those who have diabetes. Date overconsumption may make it difficult to control blood sugar levels and cause a quick rise in blood sugar levels. As a result, it is advised that people with diabetes consume no more than 2-3 dates per day and check their blood sugar levels as necessary (Assaad Khalil et al., 2021). Furthermore, during Ramadan dates are frequently combined with other high-carbohydrate and high-fat meals, which might further raise the risk of blood sugar rises and interfere with blood sugar regulation. It is vital for patients with diabetes to be conscious of their total dietary intake during Ramadan and to pick a range of nutrient-dense, low-glycemic index meals in suitable quantities (Alalwan et al., 2020).

4.3 Diabetes Patients' Ideas for Changing Insulin Frequency and Dose During the Ramadan Fast

A crucial hormone for regulating blood sugar levels is insulin. Insulin doses and frequency must be changed when fasting, because it affects the glucose levels of diabetes patients who need it in order to prevent issues like hypoglycemia and hyperglycemia (Al-Arouj et al., 2010; Suh and Park, 2017). The following are recommendations for adjusting insulin frequency and dose during Ramadan:

1. Seek advice from a healthcare professional: Before modifying the frequency or dose of insulin, consult with a healthcare professional. A healthcare practitioner can examine a patient's health, diabetes treatment, and pharmaceutical regimen to change insulin dosages and frequency during Ramadan fasting (Salti et al., 2004; Hassanein et al., 2022).

2. Adjust the insulin injection schedule: For persons who take insulin once or twice a day, altering the injection schedule can be beneficial (Al-Arouj et al. 2010; Pathan et al. 2012). To prevent hypoglycemia during the day, someone who usually takes insulin in the morning might try taking it at night. To minimize hyperglycemia during the day, an individual who typically takes insulin at night may want to think about doing it in the morning (Pathy et al. 2010).

3. Consider changing the type of insulin you use: Rapid-acting insulin users may

need to modify their insulin dosage and administration schedule. Rapid-acting insulin is frequently given before meals to help manage postprandial glucose levels (Pathan et al., 2012; Ali et al., 2016). During Ramadan, people could decide to postpone or skip meals, which makes it challenging to take rapid-acting insulin. To help maintain glucose control throughout the day, people in this condition might opt to switch to a longer-acting insulin, like insulin glargine or insulin detemir.

4. Regularly check glucose levels: It's crucial to regularly check glucose levels during Ramadan. Individuals should measure their glucose levels before and after meals, as well as before going to bed, to ensure that they are within the target range. Individuals can change their insulin doses and frequency with frequent monitoring to maintain glucose control and avoid problems (Al-Arouj et al. 2010).

5. Modify the insulin dosage: Individuals who take insulin may need to adjust their insulin dose during Ramadan fasting (Al-Arouj et al. 2010). Based on an individual's glucose readings and medication regimen, a healthcare expert can make recommendations on how to adjust insulin doses. Sudden changes in insulin doses must be avoided because they can result in problems like hypoglycemia and hyperglycemia (Biermann et al. 2008; Suh and Park 2017).

Individuals with diabetes must adjust insulin doses and frequency during Ramadan fasting to maintain glucose control and avoid complications. It is critical to check with a healthcare expert before making any modifications to insulin doses or frequency. Altering the timing of insulin injections, thinking about changing the kind of insulin, monitoring glucose levels often, and altering the dose of insulin can all help with glucose control during Ramadan fasting. Individuals with diabetes can safely observe Ramadan fasting while maintaining good health by following these strategies.

Chapter Five: Physical Activity and Diabetes during Ramadan Fasting

5.1 The Impact of Physical Activity on Glycaemic Control During Ramadan Fasting

For a very long time, physical activity has been seen as a crucial part of managing diabetes. It has been demonstrated to have a favorable effect on cardiovascular risk factors and glycaemic control (Physical Activity/Exercise and Diabetes Mellitus. 2003). Physical exercise can, however, become more difficult when fasting during Ramadan, and its effects on glycaemic management might vary depending on a number of circumstances (Al-Arouj et al. 2010). Even though physical activity is good for diabetics, fasting during Ramadan can present some difficulties.

There are a number of variables that might affect glycemic control during fasting during Ramadan. The following are some ways that exercising while fasting during Ramadan could impact glycemic management.

1. Improved insulin sensitivity: Studies have indicated that exercise improves insulin sensitivity, allowing the body to use insulin to control blood sugar levels more efficiently (Borghouts and Keizer 2000; Bradley et al. 2008; Dubé et al. 2012). This may result in better glycemic control throughout the fasting month of Ramadan.

2. Enhanced muscle glucose uptake: Physical exercise can enhance muscle glucose uptake, which lowers blood glucose levels (Al-Arouj et al. 2010; Gnanou et al. 2015). This may result in better glycemic control throughout the fasting month of Ramadan.

3. Hypoglycemia risk: Engaging in physical exercise might raise your chance of developing hypoglycemia, especially if you use insulin or another glucose-lowering medicine (Ibrahim et al. 2015; Ibrahim et al. 2020). The increased risk of hypoglycemia during the Ramadan fast may be brought on by dietary and exercise changes.

4. Risk of hyperglycemia: Physical activity, particularly high-intensity exercise, can raise the risk of hyperglycemia (Afandi et al. 2020). The risk of hyperglycemia may rise during Ramadan fasting as a result of dietary and exercise changes.

5. Physical activity time: The timing of physical exercise while fasting during Ramadan can also affect glycemic management. Exercise that is done closer to when the fast is broken (iftar) may have a greater effect on blood sugar levels than exercise that is done earlier in the day (M'guil et al. 2008; Ismail et al. 2021).

5.2 Strategies for Maintaining Physical Activity During Ramadan Fasting for People with Diabetes

Even during the month of Ramadan when Muslims fast from sunrise to sunset, physical exercise is a crucial part of managing diabetes. Participating in physical exercise throughout Ramadan can enhance insulin sensitivity, glycaemic management, and general health (Eid et al. 2017). Ramadan, however, can be difficult for maintaining physical exercise owing to changes in habit and energy levels. The following are suggestions for diabetes sufferers on how to keep up their physical activity levels while fasting during Ramadan.

1. Plan ahead

To continue engaging in physical exercise while fasting during Ramadan, preparation is essential. Setting attainable objectives for physical exercise is crucial, as is planning ahead. This can make sure that during the fasting month of Ramadan, physical activity is incorporated into the daily schedule. When planning physical activity during the fasting month of Ramadan, it is crucial to take the time of day into account. It could be more beneficial to plan physical exercise for right before iftar or right after taraweeh, the evening meal (Al-Arouj et al. 2010). By doing this, you can prevent being tired and dehydrated when exercising.

2. Stay hydrated

It's crucial to stay hydrated when fasting during Ramadan, especially when exercising.

Dehydration can result in weariness, vertigo, and other problems. During the non-fasting hours, it's crucial to consume lots of water and other liquids. This can assist in preserving energy levels and avoiding dehydration when engaging in physical exercise (Eid et al. 2017). Additionally, since they can cause dehydration, caffeine and sugary beverages should be avoided.

3. Choose the right time for physical activity

It's crucial to pick the correct time to exercise while fasting during Ramadan. To prevent weariness and dehydration, physical activity should be arranged during the non-fasting hours (Almulhem et al. 2020). It is advised to arrange physical exercise either before the suhoor (morning meal) or after the taraweeh (evening meal). To sustain energy levels throughout the day, low-intensity exercises like yoga or walking can be done.

4. Choose the right type of physical activity

It's important to pick the correct kind of exercise when fasting during Ramadan. Selecting low- to moderate-intensity activities that can be carried out inside or in a cool environment is advised (Almulhem et al. 2020). Walking, cycling, and swimming are suggested activities since they don't need a lot of energy and can be done at any time of the day. Running and other strenuous activities should be avoided during the Ramadan fast since they might cause exhaustion and dehydration.

5. Monitor glucose levels

It's critical to keep an eye on your blood sugar during Ramadan fasting, especially while you're exercising (Eid et al. 2017). To make sure that blood glucose levels are within the desired range, it is crucial to check them before and after physical exercise. By doing this, hypo- or hyperglycemia during exercise may be avoided. Before engaging in physical exercise, it is advised to have a snack or beverage with carbs if blood glucose levels are low.

6. Adjust insulin doses and frequency

Individuals who take insulin should adjust their insulin doses and frequency during

Ramadan fasting. It is important to consult with a healthcare professional before making any changes to insulin therapy. Insulin doses and frequency should be adjusted based on glucose levels, physical activity levels, and meal patterns during Ramadan fasting. This can help prevent hypoglycaemia or hyperglycaemia during physical activity and can help maintain glycaemic control (Al-Arouj et al. 2010).

7. Use technology to track physical activity

Keeping track of physical activity while fasting during Ramadan may be made easier with the use of technology like a pedometer or fitness tracker. This can assist those who have diabetes in tracking their development and establishing reasonable physical activity objectives. Additionally, it can support people in maintaining their commitment to exercise while fasting during Ramadan.

8. Get support from family and friends

Maintaining physical exercise while fasting during Ramadan can be made easier by having the support of family and friends. It is crucial to let family and friends know how vital it is to exercise while fasting during Ramadan and how they may help. They can assist in planning physical exercise or offer support and motivation.

5.3 Potential Risks and Complications of Physical Activity During Ramadan Fasting for People with Diabetes

Even though exercise is a crucial part of managing diabetes, fasting during Ramadan can present risks and complications. During Ramadan, which can last up to 30 days, Muslims fast from dawn to dark. The body goes through major changes in energy levels and fluid balance during this period, which might have an impact on physical activity. The hazards and issues associated with physical exercise for diabetics during the fasting month of Ramadan will be discussed.

1. Hypoglycaemia

Exercise during fasting during Ramadan is frequently complicated by hypoglycemia, or low blood sugar. Exercise can improve insulin sensitivity and muscle glucose

absorption, which can both reduce blood sugar levels (Ahmad et al. 2012). For diabetics on blood glucose-lowering drugs like insulin or sulfonylureas, this can be very risky. Dizziness, disorientation, and even unconsciousness is among the signs of hypoglycemia (Bravis et al. 2010). Before and after physical exercise, blood glucose levels should be checked, and medication dosages should be adjusted correspondingly.

2. Hyperglycaemia

Physical exercise while fasting during Ramadan can also have the risk of causing hyperglycemia, or elevated blood sugar. The liver may release glucose into the circulation as a result of exercise to fuel the muscles. If insulin is not present to transfer glucose into the cells, this might result in high blood glucose levels in diabetics (Bravis et al. 2010). To avoid hyperglycemia, it's critical to periodically check blood glucose levels and modify medication dosages as necessary.

3. Dehydration

A frequent side effect of physical exercise during the fasting month of Ramadan is dehydration. Muslims refrain from eating or drinking during the hours of fasting, which span from sunrise to nightfall. Dehydration may result from increased perspiration and fluid loss brought on by physical exertion. Thirst, fatigue, wooziness, and even fainting are symptoms of dehydration (Al-Arouj et al. 2010; Bravis et al. 2010). While not fasting, it's important to stay hydrated, and it's best to avoid strenuous exercise while fasting.

4. Heat exhaustion

In hot and humid locations, heat exhaustion is a risk factor for physical exertion during the Ramadan fast. Exercise can raise body temperature, and if the body is unable to cool itself off, this can result in heat exhaustion. Fatigue, nausea, dizziness, and even fainting are signs of heat exhaustion. In order to avoid heat exhaustion, it's crucial to limit your physical activity during the warmest parts of the day and drink enough of water.

5. Muscle injury

Exercise during Ramadan fasting may result in muscle damage, particularly if suitable warm-up and cool-down activities are not performed. Muscle strains or rips can result from physical activity's impact on the muscles. It's crucial to start off cautiously with physical exercise and progressively build up both duration and intensity over time. Exercises for warming up and cooling down properly might also assist to avoid muscular injuries.

6. Cardiovascular complications

Fasting throughout Ramadan increases the risk of cardiovascular complications, particularly for individuals who already have a cardiovascular disease (Almulhem et al. 2020). Exercise can put strain on the heart and increase the risk of a heart attack or stroke. It is critical to seek medical counsel before commencing any physical activity while fasting during Ramadan, especially if there is a family history of cardiovascular disease.

Physical activity is vital for diabetes management even when fasting during Ramadan. However, at this time, it is vital to be aware of any hazards or challenges that may develop from physical activity. It is crucial to regularly monitor your blood sugar levels, drink enough of water, avoid strenuous activity while fasting, and consult with a doctor before modifying your prescription or exercise regimen. Physical activity, with adequate preparation and safeguards, can be a safe and dependable strategy to maintain glycemic control during Ramadan fasting.

Chapter Six: Conclusion

6.1 Summary of the Key Findings

Making effective diabetes management plans is essential during Ramadan because fasting may raise the risk of hyperglycemia and hypoglycemia. Before beginning a fast, diabetic patients should speak with their doctors to develop a plan for managing their disease. The body employs alternate energy sources, such as ketone bodies made from fat stored in adipose tissue, to make up for the depletion of its glucose reserves that occur during Ramadan fasting. Additionally, fasting lowers insulin levels, which can increase the risk of hypoglycemia while also improving insulin sensitivity in healthy people. Hyperglycemia, which is a metabolic disease brought on by irregularities in insulin synthesis or activity and results in micro- and macrovascular issues as well as organ failure, characterizes diabetes. 5–10% of diabetics have type 1 diabetes, an autoimmune disease that is defined by insulin insufficiency and hyperglycemia brought on by the death of pancreatic beta-cells by β-cells.

Keeping up a balanced diet during Ramadan will help diabetics with their blood glucose

levels. The Ma-Pi 2 diet, which is strong in fiber and complex carbs and meets with both American Diabetes Association and European dietary recommendations, is beneficial in controlling type 2 diabetes. Dates are good for persons with type 2 diabetes who are fasting during Ramadan since they have a low glycemic index and are strong in dietary fiber. Dates and the Ma-Pi 2 diet can help control blood sugar levels and enhance overall health outcomes. The glycemic management of diabetic patients throughout the Ramadan fast is assessed using a variety of methods, including mean blood glucose, HbA1c, fructosamine, mean interstitial glucose, MAGE, and mean continuous glucose monitoring. During shorter fasting intervals, fructosamine may be a more reliable indicator of glycemic control. The management of blood sugar levels throughout Ramadan can be affected in different ways by various insulin therapies and glucose monitoring techniques, with continuous subcutaneous insulin infusion (CSII) being more efficient than conventional insulin (CI) at maintaining glycemic levels. Additionally, studies have shown that fasting during Ramadan may help insulin-dependent diabetics' glycemic control, and that the effectiveness of various medications for glycemic control during Ramadan may vary. Due to its quicker beginning of action than human regular insulin, lispro-containing insulin formulations have been found to provide more accurate glucose management throughout Ramadan, and continuous glucose monitoring can give insulin users flexibility and safety when fasting.

Exercise improves glycemic management and cardiovascular risk factors, although it might be difficult during Ramadan due to shifts in routine and energy levels. Variables including higher insulin sensitivity, increased muscle glucose uptake, risk of hypoglycemia and hyperglycemia, and the timing of physical activity during Ramadan can all have an impact on how physical exercise affects glycemic control. Planning ahead, staying hydrated, picking the correct type and timing of physical activity, keeping an eye on blood glucose levels, and changing insulin doses and frequency are all methods for keeping up physical activity while fasting during Ramadan.

In conclusion, fasting throughout Ramadan can have a major effect on how well people with diabetes control their blood sugar. Diabetes sufferers must speak with their doctors before fasting and develop a plan to control their condition during Ramadan.

Different insulin treatments and glucose monitoring techniques can be used to manage diabetes during Ramadan, as can maintaining a healthy diet and getting regular exercise.

6.2 Implications for Clinical Practice and Future Research

Maintaining a balanced diet is crucial for managing diabetes throughout Ramadan. Dietary suggestions like the Ma-Pi 2 diet, which prioritizes fiber and complex carbs, and adding dates to meals can have a good effect on blood glucose levels in diabetics. To effectively treat diabetes during Ramadan, a range of methods, including continuous glucose monitoring, can be used to check glycemic control.

Exercise is essential for managing blood sugar, but Ramadan may make it challenging. Diabetes patients can keep up their levels of physical activity while fasting by employing techniques including planning, staying hydrated, and choosing the right time and kind of exercise. To develop a strategy that takes into account each patient's particular requirements and limitations, healthcare practitioners should work closely with patients.

Future research should look at how different Ramadan diabetes management plans perform and how fasting during Ramadan affects glycemic control in patients with various types of diabetes. Studies on the physiological effects of fasting on the body and the pathophysiology of diabetes during Ramadan can be used to learn more about the best approaches to treat diabetes during this time. Overall, additional study may lead to more effective therapy methods and improved outcomes for diabetics who observe the Ramadan fast.

6.3 Limitations and Strengths of the Narrative Review

One benefit of narrative reviews is their ability to provide a comprehensive overview of the literature on a particular subject. The review covers a variety of subjects relating to treating diabetes while fasting during Ramadan, including dietary recommendations, methods for monitoring glycemic control, and the impact of physical activity on glycemic control. It also covers the physiological consequences of fasting on the body. One of the main strengths of the narrative review is its ability to identify gaps in the literature and suggest new study areas. For instance, the study recommends further

investigation into the efficacy of different drugs for glycemic control during Ramadan and the impact of physical exercise on glycemic control during fasting.

One of the shortcomings of the narrative review is that it depends on the quality and quantity of research that is available in the literature. A bias in favor of studies with positive results could result from the review's lack of a systematic search for relevant studies. It is challenging to estimate the overall effect size of the interventions covered by the narrative review since it does not provide a quantitative synthesis of the results.

The narrative review provides important information regarding how Ramadan fasting impacts diabetics' capacity to regulate their blood sugar levels, but additional research is necessary to close knowledge gaps and yield more accurate findings.

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