

Physiological Changes and Recommended Management Plan for Patients with Diabetes during Ramadan Fasting: A Review Article

Abeer Alhaj¹, Omar F Shatnawi²

ABSTRACT

BACKGROUND AND AIM - Ramadan is a holy month for Muslims. Muslims fast off any food, solid or liquid, including medication and smoking. Ramadan Fasting (RF) can cause many physiological changes in people with diabetes. Therefore, they should have special care and management plan during Ramadan.

METHODS - We searched the following data for recent publications and clinical recommendations for physiological and management plans for patients with diabetes during RF. Examples: Journal of the Royal Society of Medicine, Diabetes research and clinical practice, The Journal of Clinical Endocrinology and Metabolism, International Journal of Sport Studies for Health, etc.

RESULTS - IDF and other guidelines are now acceptable for properly managing patients with diabetes during RF.

CONCLUSION - Patients with diabetes must be prepared well before RF and given a proper management plan and advice to minimize the risk of complications during Fasting. The management plan should be fully integrated with essential educational advice, nutritional consultation, physical activity, and medication dosing personalizing.

KEYWORDS - Ramadan, Fasting, insulin, risk stratification

¹ Rashid Hospital, 315 Umm Hurair, 2nd street, Dubai, UAE PO Box 4545

² Internal Medicine Department, Sarah Specialty Hospital, Al-Manshia, Al-Manarah street, Al-Mafraq, Jordan PO Box 00962

Financial support/ funding source: None
Conflict of interest: No conflict of interest.

Corresponding Author:
Abeer Alhaj

MBBch (RCSI), BOI (RCSI Ireland), FRCP (Edin), ArBIM. Arab board of internal medicine specialty (Damascus)

Rashid Hospital
Dubai, UAE

315 Umm Hurair, 2nd street, Dubai, UAE
PO Box 4545

Email: abeerabdalhaj@gmail.com

INTRODUCTION

Ramadan is the ninth month of the Muslim lunar calendar. Muslims fast off any food, solid or liquid, including medication and smoking, from sunrise to sunset for 29-30 days. The fasting hours are about 12-14, depending on the geographical area and the season that Ramadan will fall in. The time of Ramadan changes ten days back from year to year [1].

Over two billion Muslims comprise 24.7% of the world's population [2]. Muslims change their lifestyle during Ramadan, including the timing of eating, food type, and sleeping hours. In addition, to their social habit and other spiritual practice. Muslims during Ramadan have two primary meals, one at the time of breaking their fast at sunset, called Iftar, and another meal before starting a new day of Fasting, called Suhoor [3].

Those exempted from fasting Ramadan include pre-puberty children, menstruating, pregnant, and breastfeeding women in addition to travelers and sick people. Despite these exemptions, some people would put themselves at risk by fasting in Ramadan for the sake of enjoying all the spiritual and ceremonial aspects of this holy month [4,5].

Most chronic diseases have strict management plans, including a special diet. The diet change during RF might put patients with diabetes at risk of higher diabetes-related complications. As a result, the International Diabetes Federation (IDF) and the Diabetes and Ramadan (DAR) International Alliance have collaborated to recommend measures ensuring the safety of diabetic patients while fasting Ramadan. This review article highlights the physiological changes during RF and the recommended management for patients with diabetes [6,7].

METHODS

The following databases were used: google scholar, Pubmed, Scopus, Institute for Scientific Information (ISI), Web of Science, Up to date, Access medicine, and clinical key.

Keywords such as Fasting during Ramadan, Islam, physiological changing, Risk stratification, Diabetic management, pregnancy, and diet between 2010-2022 were searched. We identified 150 articles and classified them according to evidence and chronicle date as follows:

- Systemic reviews of a randomized controlled trial
- Randomized controlled trials;

- Controlled observational studies, cohort and case-control studies;
- Uncontrolled observational studies

Due to the paucity of data available from other types of studies, the main points included in this review were taken from international guidelines, recommendations, and other observational studies.

To avoid bias, articles and review papers from different journals were included, such as:

Journal of the Royal Society of Medicine, Diabetes research and clinical practice, The Journal of Clinical Endocrinology and Metabolism, International Journal of Sport Studies for Health, British Journal of Sports Medicine, Diabetes Care, BMJ Open Diabetes Research and Care, International journal of clinical practice, Endocrine Development, Cardiovascular Diabetology, The Journal of Biochemistry, endocrine review and others.

DISCUSSION

3.1 PHYSIOLOGICAL CHANGE DURING RF AND PATIENTS WITH DIABETES

1. Mealtimes and food choices:

The changing mealtimes and social habits affect muslims' food choices during Ramadan. International guidelines are helpful for patient management; however, they do not account for geographical and behavioral dietary changes. Herein comes the importance of having additional national guidelines to customize them to specific population needs. Table 1 shows the differences in food choices between different countries.

2. Fluid loss and balance:

Proper fluid intake is essential to maintain the regular physiological function of the human body, as 60 % of the adult weight is water [8]. During RF, our bodies can compensate and modify their needs by increasing urine concentration, decreasing urine volume, and salt retention. Therefore, after two weeks of Fasting, the fluid balance will be negative. Still, as the compensatory mechanism takes over, the fluid balance returns to the baseline at the three weeks of RF. Moreover, dehydration during Fasting seems to be over-estimated, as was concluded by many clinical trials, including Daneilsson et al's study, where healthy volunteers were instructed to avoid any fluid intake for a time similar to the RF time [9]. Under normal circumstances, no harmful effects were observed for healthy and uncomplicated diabetic patients [10]. The primary concern for

dehydration and electrolyte disruption during Ramadan is mainly seen among people who exercise strenuously and work in hot, humidified weather, in addition to poorly controlled patients with diabetes and diabetic-related chronic kidney disease patients [11].

3. Weight change:

Muslims consider RF a chance to lose excess weight; recent research showed that most Muslims lose weight and get better lipid composition profiles during RF. However, many people may gain weight due to unhealthy diet practices; in addition, 2-3 weeks after RF, many regain the lost weight [12,13].

Patients with diabetes can also benefit from RF in reducing their weight and fat storage. Although the change in patients with diabetes weight during Ramadan is minimal compared to ordinary healthy people, it is still beneficial and safe. Glycemic-controlled patients with diabetes, including those on oral hypoglycemic medication, can fast without concerns about weight change [14].

4. Sleeping pattern:

Our body's homeostasis is affected by sleeping hours and time. Multiple changes were seen during RF; total sleep time and period time (REM sleep and its proportions) decreased. In contrast, the proportion of non-REM sleep increases [15].

Nighttime sleeping is better for our different physiological and metabolic activities. Shorter sleeping hours lead to what is called subchronic sleeping SQ. Subchronic sleeping increases the risk for insulin resistance through alteration in the cortisol and metanephrine levels [15,16].

Many Muslims, during Ramadan, change their sleeping pattern with variations among Muslim countries worldwide. This can be attributed to the new modern lifestyle, such as participating in late social occasions, watching TV, and changing the working hour [3].

5. Changes in daily hormonal balance and insulin sensitivity:

The circadian rhythm of hormones involved in fat metabolism, energy production, glucose homeostasis, and insulin sensitivity changes during RF, reflecting the effect of changing mealtimes and sleeping patterns.

- Cortisol : The secretion of cortisol hormone in the body is highly linked to the circadian sleeping cycle and meal time. Compared to non-fasting periods, morning cortisol levels are slightly lower, and eve-

ning levels are significantly higher than in fasting periods [17].

Although these findings mimic what is seen in chronic stress disorder and other metabolic disorders [18], metabolic parameters like TG, LDL, HDL, and serum glucose do not change during RF. In other words, RF causes changes in the cortisol cycle, but it does not mean it will be harmful. However, this physiological change will be apparent in poorly controlled DM [19].

- Leptin, ghrelin, and Adiponectin : Leptin concentrations in plasma depend mainly on mealtimes. Peak concentrations are recorded between 22.00 and 3.00 am [20]. With the shift in mealtimes during RF, certainly, leptin concentrations will change accordingly. There will be a reduction in leptin concentration during fasting at 22:00 and 02:00. On the other hand, there were no apparent changes to ghrelin levels during fasting. Adiponectin decreases during the night, with minimum concentrations in the early mornings. Whereas in Ramadan, there will be a change in the mean level of Adiponectin, this may affect the general insulin resistance in patients with uncontrolled diabetes [21].

- GH : GH secretion varied throughout the day, being higher during the night. GH level is affected by the cortisol level in a complex way with circadian rhythm and sleep cycle to maintain an average glucose level [20].

As the circadian rhythm, sleep cycle, and even cortisol level change, a fast-induced GH secretion pattern will be seen on RF through a combined frequency (discrete pulses) and an amplitude (sinusoidal periodicities) modulation [22]. These changes do not necessarily mean that the new pattern of GH secretion will increase insulin resistance during RF [21].

6. Glucose homeostasis and variability during RF:

Three possible phases take place during RF. A phase of post absorption lasts up to 24 hours; gluconeogenesis lasts up to 10 days, and the proteolysis phase results if fasting is longer than ten days. Hence, RF is an overlap between the post-absorptive and gluconeogenic phases [3].

Our body maintains normal glucose levels depending on our feeding status. When the glucose level increases after meals, insulin is secreted. It gets the glucose back to its normal

range by giving the liver and muscles a chance to store it [23]. During fasting, and as the glucose level drops, insulin secretion decreases, and the level of catecholamine and glucagon in the blood increases. Therefore, Glycogenolysis is activated, providing glucose supplies for 10 hours to the target tissues, primarily the brain, before depleting it [24]. After the glycogen storage is depleted, the body will start making glucose from a fatty acid. That will be oxidized to the ketone body, leaving the remaining glucose for the brain and erythrocytes [25].

RF is a form of intermittent fasting where glucose production from glycogen and ketones occurs [26]. The ketone body level will vary depending on the lifestyle followed during RF. People who take their primary meal late at night near dawn or eat their largest meal at sunset (Iftar) and do not wake up for Suhoor will prolong their starvation, and thus produce more ketone bodies [3,27].

- Insulin sensitivity during RF: the available data are few, and controversy between different studies was reported. Some studies concluded that RF causes an increase in insulin resistance. Ajabnoor et al. used the HOMA-IR index to compare the insulin resistance before and after RF. His results showed increases in the HOMA-IR from 1.98 to 4.51 before and after RF. And from 4.9 to 12.01 before and during Ramadan in the evening [3,21].

On the other hand, in another study, the metabolic indices were tested before and after RF. Improvements in reading multiple indices were observed—blood pressure, waist circumference, and body weight. In addition to HDL-cholesterol, FPG, fasting blood insulin, insulin resistance indices (quantitative insulin sensitivity check index (QUICKI), and reciprocal index of HOMA-IR (1/HOMA-IR). However, there was no change to the HOMA-IR index [28].

3.2 RISK STRATIFICATION OF PATIENTS WITH DIABETES FOR RF

Before starting Ramadan, it is necessary to stratify the patient's risk of Fasting. Many risk elements were used, type of DM, duration since the diagnosis, the current level of control by HbA1c levels, and others, as seen in table 2. The patient's situation may vary yearly, so they must be assessed annually. IDF-DAR Practical Guidelines 2021 categorize patients' risk for fasting into three major groups [3]:

- High-risk: these patients will get > 6 points in the IDF-DAR score; those patients are considered unsafe to fast and have a significant risk for complications. Therefore, special care and a strict management plan must be followed if they insist on Fasting.

- Moderate risk: uncertain about fasting safety, as moderate risk 3.5 to [6]. These patients are advised against RF, but they may decide to fast if they get exceptional care, and follow up cautiously for any worsening of their conditions or complications.

- Low risk: safe to fast patients carry less than 3 points in the risk score. They can fast with minimal risk of getting complications. However, they must follow certain diet precautions and take their medication.

3.3 THE POSSIBLE COMPLICATIONS OF RF AMONG PATIENTS WITH DIABETES

Patients with diabetes must be educated about the potential difficulty and risks during RF.

1. Hypoglycemia

Even though the mortality rate of hypoglycemia among patients with diabetes is low, it remains one of the most feared complications for both patients and clinicians. Hypoglycemia events are more frequent among DM I patients because of their primary dependence on insulin. During RF, as the mealtime changes, the hypoglycemic attack becomes 1.6 times higher during Fasting than during non-fasting periods, especially among DM1 patients. Hypoglycemic events increased among DM I patients by 4.7 fold which counts from 3 -14 even per 100 patients, and 7.5 fold in DM2 from 0.4-3 events per 100 patients on RF 6. The events are much higher as the cases counted were only from hospitalized patients [29].

Changing the dosage of the oral hypoglycemic agent or insulin and changing the lifestyle during RF are the major causes of increasing hypoglycemic attacks [30]. Thus the need for better education of the patients and encouraging awareness about the importance of following up on Diabetes Self-Management Education and Support (DSMES) recommendations, including self-test sugar levels frequently, wearing diabetic identification like a bracelet or necklace, carrying carbohydrates, glucagon therapy training, and educating the patient's mates or family [3].

2. Hyperglycemia

The risk of hyperglycemia might increase in patients with diabetes during RF, as they cannot take their medication at its regular time. In addi-

tion, many patients increase their consumption of high-sugar meals [31]. The incidence of hyperglycemia that needs hospitalization will jump fivefold during Ramadan in patients with type 2 diabetes, with 1 to 5 events per 100 patients, and an approximately threefold increase in the hyperglycemia with or without ketoacidosis patients with type 1 diabetes, 5 to 17 events per 100 [6].

3. Diabetic ketoacidosis (DKA)

DKA is one of the most dangerous and lethal complications of diabetes. DKA is seen more commonly among DM I patients due to the complete deficiency of basal insulin [6,31].

It is crucial to spend enough time counseling the patients and providing them with all the needed regimes to minimize the risk of getting DKA. For example, recent researchers showed no increase in the number of DKA events during Ramadan compared with the other months of the year among patients who followed the integral education program on diabetes management before RF versus patients who did not adhere to the needed instruction and management plans [32].

3.4. MANAGEMENT OF PATIENTS WITH DIABETES DURING RAMADAN FASTING

Many factors must be considered when managing patients with diabetes while fasting Ramadan. There is a multidisciplinary approach, educational role, individualized nutritional plan, and pharmacological management.

1. Ramadan-focused education

Studies have shown that education improves diabetes outcomes during RF. Instruction should emphasize monitoring BG levels, Self-Monitoring of Blood Glucose (SMBG), or continuous glucose monitoring (CGM) throughout the day. A 7-point BG testing is proposed to start from the pre-dawn (Suhoor) time, then in the early morning, mid-day, mid-afternoon, pre-sunset (Iftar), and 2 hours after Iftar (breakfast). Additional reading may be obtained if the patient felt unwell or if symptoms of hypoglycemia developed³. Health care physicians need to explain that SMBG does not break a fast. Advice should be given about healthy diet choices, physical activity, adequate oral hydration, and adjusting the doses and space of the anti-diabetic medications as well as recognizing the possible complications with Fasting and the need for breaking a fast if hyperglycemia develops [3,33].

In a meta-analysis and systemic review of the effect of Ramadan-focused education on T2DM patients, sixteen studies were included out of 770 records with a total number of 11402 partic-

ipants. The results have shown that Ramadan-focused education improves HbA1c and LDL with a slight rise in TG and body weight. They were also decreasing in hypoglycemia events after Ramadan-focused education was observed [7].

2. Nutritional management of Patients with diabetes during RF

A daily calorie of 1800-2000kcal/day is usually needed for weight maintenance in men and 1500-2000 in women. A less calorie diet plan may follow if the aim is to lose weight [34].

Most Muslims break their fast with dates, an Islamic tradition in most Muslim countries. Dates itself as a fruit rich in nutritious value, mentioned in the Holy Quran, adds a great deal of gratitude by Muslims to the palm tree [31,35]. The fear is that the consumption of dates by Patients with diabetes may worsen their glycemic control since dates contain >70% sugar³⁶—however, Dr. Tariq A Alalwan et al. conducted research in Bahrain to study the effects of daily three-date consumption on HbA1c levels, Lipid profile, BMI, and quality of life assessment using the Short Form 36 (SF-36) index. Their results suggested that low, moderate date consumption may impact lipid profile without worsening glycemic control [37].

Moreover, the balanced daily intake of dates can decrease oxidative stress on the pancreas and improve insulin secretion; also, it can reduce hyperglycemia and does not affect the glycemic index [36].

Multiple recommendation regarding the diet plan for patients with diabetes during RF can be summarize as the following:

- Fast-breaking should be with plenty of water, and three-dates which raise blood glucose gradually. Encouraging oral hydration and avoiding sugary drinks are crucial, and a healthy snack can be eaten between the two meals [31].
- Carbohydrate intake of about 40-45% of daily caloric intake, about 130g/day. Therefore, selecting options with Low glycemic index foods, such as most vegetables, whole grains, and legumes, is preferable. In addition, fruits, vegetables, and seeds of about 14g/1000KCAL are recommended to provide the feeling of satiety and benefit from the high fiber content [3,38].
- Protein intake of about 10-35% of total daily caloric intake to maintain body mass is recommended—examples: nuts, milk, and dairy products [39].

- Furthermore, 30-35% of total daily caloric intake is as fat, limiting dietary cholesterol to <200mg/day if the patient's LDL > 2.6mmol/l [40].
- Suhoor to be delayed as possible, with food choices of unsaturated fat and rich in protein; this will reflect better postprandial BG levels and a longer duration of satiety [3].

The Ramadan Nutrition Plan (RNP) is a website program to plan medical nutrition therapy (MNT) for Patients with diabetes during RF. It is designed to help control BG readings and help lose weight for T2DM patients. The plan includes focused education before Ramadan with individualized diet planning, considering any underlying comorbidities to ensure adequate nutrient intake during Ramadan, to minimize the risk of hypoglycemia and hyperglycemia postprandial, and to avoid dehydration [40].

3. Physical activity and exercise

Physical activity and exercise are crucial in controlling diabetes and improving glycemic control [3]. However, during RF, the exercise intensity must be moderate. It is necessary to avoid any intense physical activity during Fasting, especially for patients who use sulfonylureas or insulin [29]. In addition, rigorous exercise should be avoided during the last hours of Fasting. The patients must be encouraged to perform a workout at the non-fasting time as a pre-bed prayer (Traveeh Salaath). The patient must be educated that Taraveeh salat is considered an exercise form [26].

4. Treatment approaches for DM1 and DM2

Management of T1DM during RF

Despite discouraging T1DM patients from fasting, some patients still fast [3]. Those patients will need to be monitored closely, re-educated, and asserted on the risks of Fasting. Patients must be prepared 6-8 weeks before Ramadan, starting from risk stratification. Then, depending on the duration of diabetes, current medical plan, underlying complications, and other comorbidities. The program should be individualized; however, general approaches can be used to maintain reasonable glycemic control and reduce the risk of complications during Ramadan fasting [3,41]:

- The IDF-DAR recommends that BG levels must be checked regularly during fasting hours and whenever not feeling well.
- Dosing and insulin type are summarized in graph (1).

- The use of an insulin pump is another way of DM1 management. It is considered a better treatment method. It gives the patient more flexibility in modifying their daily insulin requirement depending on their Insulin carbohydrate ratio (ICR) and Insulin sensitivity factors (ISF). In addition, the using of insulin pump reduces the risk of complications, help patients avoid hypoglycemic attacks [42] and the need to break fasting [41]. However, special care must be taken during RF. It is recommended to reduce the basal dose by 20-40% for the last 2-4 hr of Fasting and increase it later after Iftar to 10-30%. In contrast, no changes to the bolus doses are needed; the patient should only watch the ICR and ISF [3].

Management of T2DM on insulin during RF

DM2 management during Ramadan should be started the same way as DM1. Firstly, the patient must be met 4-6 weeks before Ramadan to have risk stratification done. It is crucial to focus on the type of treatment the patient is following, oral anti-diabetic medication versus insulin or combined. Generally, it is not recommended to change any medication or treatment plan shortly before Ramadan or during Ramadan [3].

All oral anti-diabetic medications are considered safe and can be used during Ramadan fasting with no need for dose adjustment except for Sulfonylureas medication class due to the high risk of hypoglycemia. The other anti-diabetic medication can maintain the same dose by changing the administration time between iftar and suhoor time. For instance, patients who take Metformin twice daily can take one at Iftar and one during Suhoor or even take the two pills simultaneously at Iftar. In addition, a patient who takes SGLT2 (Dapagliflozin) should be encouraged to maintain good hydration [31,43].

If possible, sulfonylurea should be stopped or reduced during RF to minimize the risk of hypoglycemia, depending on kidney function and the last A1c. It is recommended to use the new generation of this family (e.g., Glicazide, Gliclazide MR, and Glimepiride). In addition to reducing the medication dose if possible at iftar time if the patient is on tab per day, but if the patient is using the medication twice daily, it is safer to reduce the suhoor dose [31].

The second categories are for patients on NPH or premixed insulin to take the usual morning dose at Iftar and reduce the remaining dose at Suhoor by 50%. Moreover, for patients on multiple daily doses (MDI), to take the basal insulin dose at Iftar after reducing the dose to 15-30%. Do daily

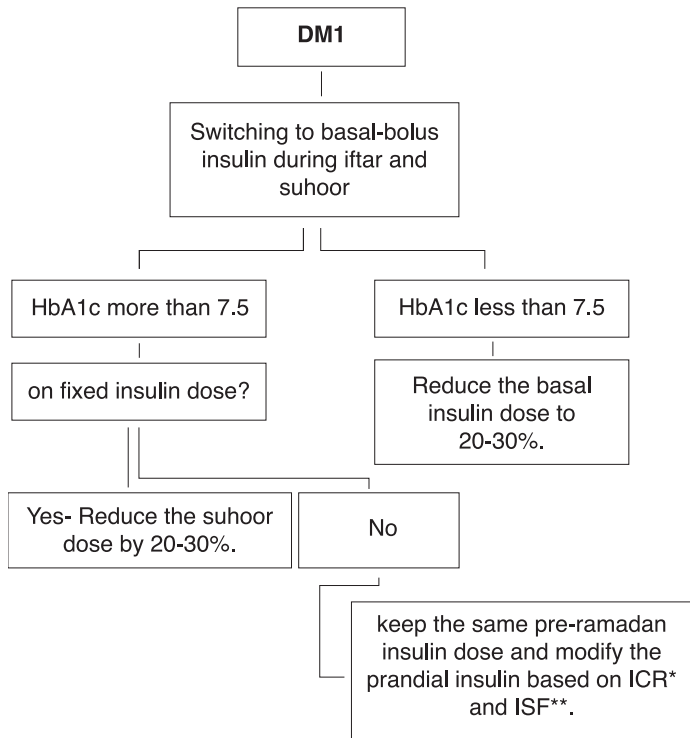
self-glucose test 2 hours after Iftar to adjust the basal dose accordingly. Additionally, skipping the short-acting insulin pre-lunch doses, keeping the same dose at Iftar and decreasing the suhoor dose to 30-50% reduce the risk for hypoglycemia [3]. Multiple studies have shown that using lispro before meals instead of mixed insulin is a better way to control glucose and more minor hypoglycemic events during Ramadan fasting [44].

The third category is for the patient who uses combined insulin and Sulfonyurea. Those patients carry a high risk for hypoglycemia. Therefore, reducing the insulin dose to 25-50% is recommended depending on the glucose reading and if hypoglycemia events happen [3].

CONCLUSION

RF leads to many physiological changes that affect most of the metabolic processes. Diabetes is a type of metabolic error defined as the human body's inability to process and regulate glucose storage and consumption. Diabetes carries a high risk of morbidity and mortality, especially cardiovascular diseases, so diabetes should be well treated and handled. In addition, during RF and as the fasting people's eating time and behavior, exercise, and sleeping time change, the glucose control may be altered. As a result, Patients with diabetes must be prepared well before RF and given a proper management plan and advice to minimize the risk of complications during Fasting. The management plan should be fully integrated with essential educational advice, nutritional consultation, physical activity, and medication dosing personalizing.

Graph 1. DM I management.



Insulin to carbohydrate ratio (ICR)*
 Insulin sensitivity factors (ISF)**

Table 1. The differences in food choices between different countries

Author	Country	Food choices
Maughan RJ, Fallah JS, Coyle EF. [45]	UAE	Fat intake increases, protein decreases
A. Norouzy et al. [46]	Lebanon	Cereal intake, eggs, pasta, dairy, oils, and fat were lower. On the other hand, the intake of dried fruit, vegetables, Arabic sweets, pastries, and sugary drinks was higher
Zhaleh Shadman et al. [47]	Tehran (Iran)	Unique food patterns during Ramadan consist of large consumption of Halim, soups, porridges, legumes and whole grains, soft drinks, Zoolbia, and Bamieh
Chandalia, H. B.[48]	India	People generally take fewer calories, higher carbohydrates, and a low-fat diet than pre-fasting.

Table 2. Risk stratification score.

Diabetic type and duration	DM1:1 DM2:0
Duration of diabetes	More than ten years>1 Less than ten years<0
Presence of hypoglycemia	Hypoglycemia unawareness: 6.5 Recent Severe hypoglycemia: 5.5 Multiple weekly Hypoglycaemia:3.5 Hypoglycemia less than one time per week:1 No hypoglycaemia:0
Level of glycaemic control	HbA1c levels > 9% (11.7 mmol/L):2 HbA1c levels 7.5–9% (9.4–11.7 mmol/L):1 HbA1c levels < 7.5% (9.4 mmol/L):0
Type of treatment	Multiple daily mixed insulin Injections: 3 Basal Bolus/Insulin pump: 2.5 Once-daily Mixed insulin: 2 Basal Insulin: 1.5 Glibenclamide: 1 Gliclazide/MR or Glimepride or Repeganide: 0.5 Other therapy not including SU or Insulin: 0
Self-Monitoring of Blood Glucose (SMBG)	Indicated but not conducted: 2 Indicated but conducted sub-optimally: 1 Conducted as indicated: 0
Acute complications	DKA/ HONC in the last three months: 3 DKA/ HONC in the last six months: 2 DKA/ HONC in the last 12 months: 1 No DKA or HONC: 0
MVD Complications/ Comorbidities	Unstable MVD: 6.5 Stable MVD: 2 No MVD: 0
Renal Complications/ Comorbidities	eGFR < 30 mL/min: 6.5 eGFR 30–45 mL/min: 4 eGFR 45–60 mL/min: 2 eGFR >60 mL/min: 0
Pregnancy	Pregnant not within targets: 6.5 Pregnant within targets: 3.5 Not pregnant: 0
Frailty and Cognitive function	Impaired cognitive function or Frail:6.5 > 70 years old with no home support:3.5 No frailty or loss in cognitive function:0
Physical Labour	Highly Intense physical labour:4 Moderate Intense Physical Labour:2 No physical labour:0
Previous Ramadan Experience	Overall negative experience:1 No negative or positive experience:0
Fasting hours (location)	>16 hours: 1 <16 hours: 0

REFERENCES

- 1 Abolaban H, Moujahed A Al. Muslim patients in Ramadan: A review for primary care physicians. *Avicenna J Med*. 2017;07(03):81-87. doi:10.4103/ajm.ajm_76_17
- 2 WPR. Muslim population by country 2022. World Population Review. Published 2022. Accessed April 20, 2022. <https://worldpopulationreview.com/country-rankings/muslim-population-by-country>
- 3 IDF-DAR Practical Guidelines 2021 – Diabetes and Ramadan. Accessed April 21, 2022. <https://www.daralliance.org/daralliance/idf-dar-practical-guidelines-2021/>
- 4 Who Is Exempt from Fasting during Ramadan? - Islam Question & Answer. Accessed April 20, 2022. <https://islamqa.info/en/answers/23296/who-is-exempt-from-fasting-during-ramadan>
- 5 Surah Al-Baqarah - 185 - Quran.com. Accessed April 20, 2022. <https://quran.com/2/185?translations=17,18,20,101,95,85,22,84,21,19>
- 6 Salti I, Bénard E, Detournay B, et al. A Population-Based Study of Diabetes and Its Characteristics During the Fasting Month of Ramadan in 13 Countries Results of the Epidemiology of Diabetes and Ramadan 1422/2001 (EPIDIAR) study. *Diabetes Care*. 2004;27(10):2306-2311. doi:10.2337/DIACARE.27.10.2306
- 7 Gad H, Al-Muhannadi H, Purra H, Mussleman P, Malik RA. The effect of Ramadan focused education on patients with type 2 diabetes: A systematic review and meta-analysis. *Diabetes Res Clin Pract*. 2020;162. doi:10.1016/J.DIABRES.2020.108122
- 8 Chin P, Fung W, Kit R, Kong C, Fung PCW, Kong RKC. The Integrative Five-Fluid Circulation System in the Human Body. *Open J Mol Integr Physiol*. 2016;06(04):45-97. doi:10.4236/OJMIP.2016.64005
- 9 Danielsson EJD, Lejbman I, Åkeson J. Fluid deficits during prolonged overnight Fasting in young healthy adults. *Acta Anaesthesiol Scand*. 2019;63(2):195-199. doi:10.1111/aas.13254
- 10 Leiper JB, Molla AM, Molla AM. Effects on health of fluid restriction during Fasting in Ramadan. *Eur J Clin Nutr* 2003 572. 2003;57(2):S30-S38. doi:10.1038/sj.ejcn.1601899
- 11 Sa M, Hassan A. Physiological changes during Fasting in Ramadan. *Artic J Pakistan Med Assoc*. Published online 2015. Accessed May 1, 2022. <https://www.researchgate.net/publication/277412926>
- 12 Sadeghirad B, Motaghipisheh S, Kolaheidoz F, Zahedi MJ, Haghdoost AA. Islamic fasting and weight loss: a systematic review and meta-analysis. *Public Health Nutr*. 2014;17(2):396-406. doi:10.1017/S1368980012005046
- 13 Hajek P, Myers K, Dhanji AR, West O, McRobbie H. Weight change during and after Ramadan fasting. *J Public Health (Bangkok)*. 2012;34(3):377-381. doi:10.1093/PUBMED/FDR087
- 14 Sulimani RA, Laajam M, Al-Attas O, et al. The effect of Ramadan fasting on diabetes control in type II diabetic patients. *Nutr Res*. 1991;11(2-3):261-264. doi:10.1016/S0271-5317(05)80126-5
- 15 Roky R, Chapotot F, Hakkou F, Benchekroun MT, Buguet A. Sleep during Ramadan intermittent fasting. *J Sleep Res*. 2001;10(4):319-327. doi:10.1046/J.1365-2869.2001.00269.X
- 16 Rao MN, Neylan TC, Grunfeld C, Mulligan K, Schambelan M, Schwarz JM. Subchronic Sleep Restriction Causes Tissue-Specific Insulin Resistance. *J Clin Endocrinol Metab*. 2015;100(4):1664. doi:10.1210/JC.2014-3911
- 17 Altered cortisol levels in relation to Ramadan - PubMed. Accessed May 4, 2022. <https://pubmed.ncbi.nlm.nih.gov/3396527/>
- 18 Guillems TG, Edwards L. The Stress Response System Chronic Stress and the HPA Axis: Clinical Assessment and Therapeutic Considerations.
- 19 Bahjiri S, Borai A, Ajabnoor G, et al. Relative Metabolic Stability, but Disrupted Circadian Cortisol Secretion during the Fasting Month of Ramadan. *PLoS One*. 2013;8(4). doi:10.1371/journal.pone.0060917
- 20 Boyle PJ, Scott JC, Krentz AJ, Nagy RJ, Comstock E, Hoffman C. Diminished brain glucose metabolism is a significant determinant for falling rates of systemic glucose utilization during sleep in normal humans. *J Clin Invest*. 1994;93(2):529. doi:10.1172/JCI117003
- 21 Ajabnoor GM, Bahjiri S, Borai A, Abdulkhalik AA, Al-Aama JY, Chrousos GP. Health impact of fasting in Saudi Arabia during Ramadan: Association with disturbed circadian rhythm and metabolic and sleeping patterns. *PLoS One*. 2014;9(5):e96500. doi:10.1371/journal.pone.0096500
- 22 Ho KY, Veldhuis JD, Johnson ML, et al. Fasting enhances growth hormone secretion and amplifies the complex rhythms of growth hormone secretion in man. *J Clin Invest*. 1988;81(4):968-975. doi:10.1172/JCI113450
- 23 Thiebaud D, Jacot E, DeFronzo RA, Maeder E, Jequier E, Felber JP. The Effect of Graded Doses of Insulin on Total Glucose Uptake, Glucose Oxidation, and Glucose Storage in Man. *Diabetes*. 1982;31(11):957-963. doi:10.2337/DIACARE.31.11.957
- 24 Greenberg CC, Jurczak MJ, Danos AM, Brady MJ. Glycogen branches out: New perspectives on the role of glycogen metabolism in the integration of metabolic pathways. *Am J Physiol - Endocrinol Metab*. 2006;291(1):1-8. doi:10.1152/AJPENDO.00652.2005/ASSET/IMAGES/LARGE/ZH10070645650002.JPEG
- 25 Balasse EO, Féry F. Ketone body production and disposal: effects of Fasting, diabetes, and exercise. *Diabetes Metab Rev*. 1989;5(3):247-270. doi:10.1002/DMR.5610050304

- 26 Norouzy A, Salehi M, Philippou E, et al. Effect of fasting in Ramadan on body composition and nutritional intake: a prospective study. *J Hum Nutr Diet.* 2013;26 Suppl 1(SUPPL.1):97-104. doi:10.1111/JHN.12042
- 27 Alsubheen SA, Ismail M, Baker A, et al. The effects of diurnal Ramadan fasting on energy expenditure and substrate oxidation in healthy men. *Br J Nutr.* 2017;118(12):1023-1030. doi:10.1017/S0007114517003221
- 28 Shariatpanahi VZ, Shariatpanahi VM, Shahbazi S, Hossaini A, Abadi A. Effect of Ramadan fasting on some indices of insulin resistance and components of the metabolic syndrome in healthy male adults. *Br J Nutr.* 2008;100(1):147-151. doi:10.1017/S000711450787231X
- 29 Ibrahim M, Abu Al Magd M, Annabi FA, et al. Recommendations for management of diabetes during Ramadan: update 2015. *BMJ Open Diabetes Res Care.* 2015;3(1):e000108. doi:10.1136/BMJDR-2015-000108
- 30 Ahmad J, Pathan MF, Jaleel MA, et al. Diabetic emergencies including hypoglycemia during Ramadan. *Indian J Endocrinol Metab.* 2012;16(4):512. doi:10.4103/2230-8210.97996
- 31 Ibrahim M, Davies MJ, Ahmad E, et al. Recommendations for management of diabetes during Ramadan: update 2020, applying the principles of the ADA/EASD consensus. *BMJ Open Diabetes Res Care.* 2020;8(1):e001248. doi:10.1136/BMJDR-2020-001248
- 32 Beshyah AS, Beshyah SA. The incidence of diabetic ketoacidosis during Ramadan fasting: A 10-year single-centre retrospective study. *Diabetes Res Clin Pract.* 2019;150:296-300. doi:10.1016/J.DIABRES.2019.01.018
- 33 Tourkmani AM, Alharbi TJ, Bin Rsheed AM, et al. Impact of Ramadan Focused Education Program on medications adjustment for patients with type 2 diabetes in a primary health care institution in Saudi Arabia. *Diabetes Metab Syndr.* 2019;13(1):161-165. doi:10.1016/J.DSX.2018.07.012
- 34 Mattes RD, Pierce CB, Friedman MI. Daily caloric intake of normal-weight adults: response to changes in dietary energy density of a luncheon meal. *Am J Clin Nutr.* 1988;48(2):214-219. doi:10.1093/AJCN/48.2.214
- 35 The topic Date Palm mentioned in Quran - The Last Dialogue. Accessed May 30, 2022. <https://www.thelastdialogue.org/article/the-topic-date-palm-mentioned-in-quran/>
- 36 Saryono S. Date Seeds Drinking as Antidiabetic: A Systematic Review. *IOP Conf Ser Earth Environ Sci.* 2019;255(1):012018. doi:10.1088/1755-1315/255/1/012018
- 37 Alalwan TA, Perna S, Mandeel QA, et al. Effects of Daily Low-Dose Date Consumption on Glycemic Control, Lipid Profile, and Quality of Life in Adults with Pre- and Type 2 Diabetes: A Randomized Controlled Trial. *Nutrients.* 2020;12(1). doi:10.3390/NU12010217
- 38 Burke LM, Cox GR, Cummings NK, Desbrow B. Guidelines for daily carbohydrate intake: Do athletes achieve them? *Sport Med.* 2001;31(4):267-299. doi:10.2165/00007256-200131040-00003/FIGURES/3
- 39 Deer RR, Volpi E. Protein Intake and Muscle Function in Older Adults. *Curr Opin Clin Nutr Metab Care.* 2015;18(3):248. doi:10.1097/MCO.000000000000162
- 40 Dar Alliance. Accessed May 29, 2022. <https://daralliance.me/>
- 41 Al Awadi FF, Echtay A, Al Arouj M, et al. Patterns of Diabetes Care Among People with Type 1 Diabetes During Ramadan: An International Prospective Study (DAR-MENA T1DM). *Adv Ther.* 2020;37(4):1550-1563. doi:10.1007/s12325-020-01267-4
- 42 Cooper MN, O'Connell SM, Davis EA, Jones TW. Insulin Pumps. <https://home.liebertpub.com/dia>. 2014;16(SUPPL.1). doi:10.1089/DIA.2014.1503
- 43 Beano AM, Zmaili MA, Gheith ZH, et al. Predetermined Anti-Diabetic Drug Regimen Adjustments during Ramadan Fasting: An Observational Study of Safety. *Endocrinol Metab.* 2017;32(2):265-273. doi:10.3803/ENM.2017.32.2.265
- 44 Mattoo V, Milicevic Z, Malone JK, et al. A comparison of insulin lispro Mix25 and human insulin 30/70 in the treatment of type 2 diabetes during Ramadan. *Diabetes Res Clin Pract.* 2003;59(2):137-143. doi:10.1016/S0168-8227(02)00202-4
- 45 Maughan RJ, Fallah JS, Coyle EF. The effects of fasting on metabolism and performance. *Br J Sports Med.* 2010;44(7):490-494. doi:10.1136/BJSM.2010.072181
- 46 Shatila H, Baroudi M, El Sayed Ahmad R, et al. Impact of Ramadan Fasting on Dietary Intakes Among Healthy Adults: A Year-Round Comparative Study. *Front Nutr.* 2021;8:457. doi:10.3389/fnut.2021.689788
- 47 Shadman Z, Poorsoltan N, Akhoundan M, et al. Ramadan major dietary patterns. *Iran Red Crescent Med J.* 2014;16(9). doi:10.5812/IRCMJ.16801
- 48 Chandalia HB, Bhargav A, Kataria V. Dietary pattern during Ramadan fasting and its effect on the metabolic control of diabetes. *Pract Diabetes Int.* 1987;4(6):287-290. doi:10.1002/PDI.1960040610