

# ISPAD Clinical Practice Consensus Guidelines: Fasting during Ramadan by young people with diabetes

Asma Deeb<sup>1</sup> | Nancy Elbarbary<sup>2</sup> | Carmel E Smart<sup>3</sup> | Salem A Beshyah<sup>4</sup> |  
Abdelhadi Habeb<sup>5</sup> | Sanjay Kalra<sup>6</sup> | Ibrahim Al Alwan<sup>7</sup> | Amir Babiker<sup>8</sup> |  
Reem Al Amoudi<sup>9</sup> | Aman Bhakti Pulungan<sup>10</sup> | Khadija Humayun<sup>11</sup> | Umer Issa<sup>12</sup> |  
Mohamed Yazid Jalaludin<sup>13</sup> | Rakesh Sanhay<sup>14</sup> | Zhanay Akanov<sup>15</sup> |  
Lars Krogvold<sup>16</sup> | Carine de Beaufort<sup>17,18</sup>

<sup>1</sup>Paediatric Endocrinology Department, Mafraq Hospital, Abu Dhabi & Gulf University, Ajman, UAE

<sup>2</sup>Diabetes Unit, Department of Pediatrics, Ain Shams University, Cairo, Egypt

<sup>3</sup>Pediatric Endocrinology, John Hunter Children's Hospital & School of Health Sciences, University of Newcastle, Newcastle, Australia

<sup>4</sup>Department of Medicine, Dubai Medical College, Dubai, UAE

<sup>5</sup>Pediatric Department, Prince Mohammed Bin Abdulaziz Hospital for National Guard, Madinah, KSA

<sup>6</sup>Department of Endocrinology, Bharti Hospital, Karnal, India

<sup>7</sup>Department of Pediatrics, King Abdulaziz Medical City, Ministry of National Guard Health Affairs, Riyadh, Saudi Arabia

<sup>8</sup>King Saud Bin Abdulaziz, University for Health Sciences, Riyadh, Saudi Arabia

<sup>9</sup>Department of Medicine, King Abdulaziz Medical City, King Saud Bin Abdulaziz University for Health Sciences, King Abdullah International Research Center, Ministry of National Guard Health Affairs, Jeddah, Saudi Arabia

<sup>10</sup>Endocrinology Division, Child Health Department, Faculty of Medicine University of Indonesia, Cipto Mangunkusumo Hospital, Jakarta, Indonesia

<sup>11</sup>Department of Pediatrics & Child Health, Aga Khan University, Karachi, Pakistan

<sup>12</sup>Department of Paediatrics, Bayero University & Aminu Kano Teaching Hospital, Kano, Nigeria

<sup>13</sup>Department of Paediatrics, Faculty of Medicine, University of Malaya, Kuala Lumpur, Malaysia

<sup>14</sup>Department of Endocrinology, Osmania Medical College, Hyderabad, Telangana, India

<sup>15</sup>Kazakh Society for Study of Diabetes, Almaty, Republic of Kazakhstan

<sup>16</sup>Division of Pediatric and Adolescent Medicine, Oslo University Hospital, Oslo, Norway

<sup>17</sup>Department of Pediatric Diabetes and Endocrinology, Centre Hospitalier Luxembourg, Luxembourg

<sup>18</sup>Department of Pediatrics, Free University Brussels (VUB), Brussels, Belgium

## Correspondence

Asma Deeb, Paediatric Endocrinology Department, PO Box 2951, Mafraq Hospital, Abu Dhabi & Gulf University, Ajman, UAE.

Email: adeeb@seha.ae

## 1 | EXECUTIVE SUMMARY AND RECOMMENDATIONS

### PRE-RAMADAN COUNSELING

- Children and adolescents with type 1 diabetes mellitus (T1DM) who want to fasting during Ramadan should receive pre-Ramadan counseling and diabetes education. (E)

- Pre-Ramadan education should address insulin type and action, glucose monitoring, nutrition, physical activity, sick day and hyperglycemia, and recognition and treatment of hypoglycemia. (E).
- The education should be directed to both the young person and his/her family by experts in diabetes management for this age group (E).
- Counseling on the permissibility and necessity of skin pricking for glucose monitoring or insulin injection during fasting to prevent acute complications must be given prior to Ramadan (E).

- Optimizing glycemic control before Ramadan is an essential measure to ensure safe fasting (C).
- Hypoglycemia unawareness needs to be excluded pre-Ramadan and monitored during Ramadan (C).

#### GLUCOSE MONITORING

- Frequent blood glucose measurement or continuous glucose monitoring (CGM) is necessary during Ramadan to minimize the risk of hypoglycemia and detect periods of hyperglycemia (B).
- Using CGM or intermittently scanned continuous glucose monitoring (isCGM) may facilitate the adjustments of insulin during Ramadan fasting (E).

#### NUTRITIONAL MANAGEMENT

- Consideration of the quality and quantity of food offered during Ramadan is needed to guard against acute complications, excessive weight gain, and adverse changes in lipid profile (C).
- Meals should be based on low glycemic index carbohydrates and include fruit, vegetables, and lean protein. Monounsaturated and polyunsaturated fats should be used instead of saturated fat. Sweets and fried foods should be limited and sweetened drinks avoided (C).
- The pre-dawn meal (*Suhoor*) should be as late as possible (E).
- Carbohydrate counting particularly at the pre-dawn (*Suhoor*) and sunset (*Iftar*) meals enables the rapid-acting insulin dose to be matched to the carbohydrate intake (C). Hydration should be maintained by drinking water and other non-sweetened drinks at regular intervals during non-fasting hours (E).

#### BREAKING THE FASTING

- Breaking fasting immediately in hypoglycemia is recommended regardless of the timing. This recommendation applies to symptomatic hypoglycemia and asymptomatic hypoglycemia below 70 mg/dl (3.9 mmol/L) (E)

#### PRINCIPLES OF CARE

- Care for young people with T1DM during Ramadan should be undertaken by experts in the management of diabetes in this age group (C).
- Regular supervision by health-care professionals during the month of Ramadan is necessary to minimize potential risks including hyperglycemia, hypoglycemia, ketoacidosis, and dehydration (C).

#### MEDICO RELIGIOUS RECOMMENDATIONS

- We recommend that a consensus/guideline on the minimum age of fasting is established by task-force members with knowledge and interest in Ramadan. This should be endorsed by religious scholars to unify rules on fasting licensing and exemption.

- Proper understanding of Islamic rules on fasting and sickness, which allows individuals with medical conditions to not fasting, is important. Liaison with religious scholars should help to persuade those who do not qualify for fasting and avoid their feelings of guilt.

## 2 | GENERAL RULES OF ISLAM ON RAMADAN

Ramadan fasting is one of the five pillars of Islam and is obligatory for all healthy adult and adolescent Muslims from the time of completing puberty.<sup>1</sup> As per the Islamic rules and guidance from *Sunnah* (the way of prophet Mohamed), an individual becomes subject to *Shari'a* rulings that apply when specific features of puberty are attained. These are one of the following: wet dreams, growth of coarse hair in the pubic area, reaching the age of 15, or onset of menstruation.<sup>2</sup>

Approximately 1.9 billion Muslims celebrate the ninth month of the Hijri (lunar) calendar notable for Ramadan fasting all over the world.<sup>3</sup> Epidemiology of Diabetes and Ramadan (EPIDIAR), a population-based study conducted among 13 countries, showed that 78.7% of patients with type 2 diabetes (T2DM) and 42.8% of T1DM fasting during Ramadan. Saudi Arabia had the maximum number of patients with T1DM who chose to fasting.<sup>4</sup> The purpose of fasting in Islam is to gain self-restraint, arouse spiritual consciousness, and to better understand the plight of the poor, hungry, and sick.

The duration of fasting varies based on geographical location and season but is mandated to be between dawn and dusk. During this period, Muslims abstain from eating, drinking, use of oral medications, and smoking. However, there are no restrictions on food or fluid intake between dusk and dawn.<sup>1,5</sup> Fasting in Ramadan is not intended to bring excessive difficulty or cause any adverse effect to the individual. Islam has allowed many categories of people to be exempted from fasting; for example, prepubertal children, the elderly, individuals whose acute illness can be adversely affected by fasting, menstruating, pregnant or breastfeeding women, individuals with chronic illnesses, in whom fasting may be detrimental to health, individuals with an intellectual disability, or those individuals who are travelling.<sup>1</sup> These principles formed the basis of all the consensus statements by several groups.<sup>6-8</sup> The provisions of *al-Fitr* (ie, *Not to observe the fasting*) in Ramadan apply to the excuse of sickness according to the Almighty saying: "Whoever is sick of you or on a journey, and some of the other days, and on those who support him, ransom poor food."<sup>1</sup> If a person fasts, however, and experiences harm or serious hardship while he is fasting, he may be committing a sin with the validity of his fasting.<sup>5</sup>

Various beliefs regarding diabetes management practices during Ramadan exist. In a study of over 800 patients with diabetes fasting during Ramadan, 67% indicated that pricking skin to measure blood glucose breaks the fasting.<sup>9</sup> Such a belief might endanger patients and predispose to acute complications. Medical counseling and liaison with Islamic scholars help correct interpretation and understanding and ensure safer fasting.

Ramadan fasting is obligatory for all healthy adolescents and adults, but individuals with illnesses are exempted if they feel fasting is going to adversely affect their health. However, many individuals with diabetes choose to fasting.

### 3 | WHY GUIDELINES ON FASTING FOR CHILDREN AND ADOLESCENTS WITH DIABETES?

Many reviews, consensus statements, and expert opinions detailing the principles of diabetes care during Ramadan have been published.<sup>6-8,10-12</sup> Research and reviews of the literature specifically focused on children and adolescents are limited.<sup>13</sup> Also, there are variations among physicians in the perception, beliefs, general management, and the practice of insulin therapy in children and adolescents during Ramadan fasting.<sup>14</sup> A comprehensive guide has been put forward by the International Islamic Fiqh Academy, along with the Islamic organization of health sciences after a thorough literature review of possible risks to patients with diabetes associated with Ramadan fasting. Among defined risk stratification groups, T1DM is considered to be a very high risk.<sup>15,16</sup> However, this document is not specific to children, adolescents, and young adults. As a result, pediatricians face the challenge of managing children, adolescents, and young adults with diabetes, who wish to fasting during Ramadan. A recent survey by Elbarbary et al highlighted the variation between physicians, from 16 predominantly Muslim countries, in the management of children and adolescents with T1DM. The survey highlighted the difficulties of relying on data on safety and the metabolic impact of fasting based on studies conducted on adults with T2DM.<sup>14</sup>

Data on the management of children and adolescents with diabetes who choose to fasting during Ramadan are limited.

### 4 | SHOULD CHILDREN AND ADOLESCENTS WITH T1DM FASTING DURING RAMADAN?

In many diabetes centers with a Muslim population, health-care professionals agree that adolescents can fasting if they have reasonable glycemic control, good hypoglycemia awareness and are willing to frequently monitor their blood glucose levels during the fasting.<sup>17</sup> A recent survey indicated that almost 80% of physicians looking after children and adolescents with diabetes would allow their patients to fasting if they wished, provided they fulfill the above criteria.<sup>14</sup>

Although some experts would consider fasting during Ramadan a high risk for metabolic deterioration, recent studies have demonstrated that individuals with T1DM can fasting during Ramadan provided they comply with the Ramadan focused management plan and are under close professional supervision. Mohsin et al elaborated how to assess, counsel, monitor, and manage people with T1DM who wish to fasting during Ramadan.<sup>18</sup>

Children and adolescents with diabetes may fasting during Ramadan provided they fulfill certain criteria.

### 5 | PRE-RAMADAN DIABETES EDUCATION

Pre-Ramadan assessment and education are vital to ensure the suitability and safety of young people with T1DM who are planning to fasting. Many diabetes units run special education sessions prior to the month of Ramadan to ensure safe fasting.

Strategies include the following:

1. Ramadan-focused diabetes education, including nutrition, physical activity, and insulin adjustment as well as emergency management of hypoglycemia, hyperglycemia, and diabetic ketoacidosis.
2. Pre-Ramadan medical assessment including evaluation of hypoglycemia awareness.
3. Optimization of glycemic control before Ramadan to reduce the potential risks associated with fasting and minimize glucose fluctuation.
4. Frequent blood glucose monitoring or the use of CGM or isCGM technologies and the training on how to interpret and act on outcomes.
5. The requirement is to immediately break the fasting to treat hypoglycemia or to prevent acute complications.

The lack of pre-fast assessment and proper diabetes education are considered major obstacles to facilitating safe Ramadan fasting in T1DM patients.<sup>14,19</sup> Eid et al evaluated the feasibility of promoting safe Ramadan fasting through diabetes self-management education to determine the effect of education on hypoglycemic episodes. This prospective study consisted of an educational program that involved weekly sessions before and during Ramadan.<sup>20</sup> The study showed that the program was effective in enabling patients to fasting during Ramadan and the number of hypoglycemic events per month declined.

### 6 | TELEMONITORING

A pilot study evaluated the short-term benefits of a telemonitoring-supplemented focused diabetes education compared with education alone in 37 participants with T2DM who were fasting during Ramadan.<sup>21</sup>

The telemonitoring group was less likely to experience hypoglycaemia than the usual care group with no compromise of glycemic control at the end of the study. Participants viewed telemedicine as a more convenient alternative although technological barriers remain a concern. Telemonitoring offers an attractive option requiring further research in children and adolescents with T1DM.

Targeted educational program for the young person and the family before Ramadan is essential for safe fasting.

## 7 | PHYSIOLOGY OF FASTING

During fasting of healthy individuals, circulating glucose levels tend to fall, leading to decreased secretion of insulin. In addition, levels of glucagon and catecholamines rise, stimulating the breakdown of glycogen and gluconeogenesis.<sup>22</sup> In people with T1DM, hypoglycemia that occurs during fasting may not elicit an adequate glucagon response. In addition, individuals with autonomic neuropathy can have defective epinephrine secretion to counteract hypoglycemia.<sup>23</sup> The changes of sleep pattern and food intake in Ramadan are found to be associated with changes in cortisol levels, which might influence the response to hypoglycemia.<sup>24</sup> Several studies have focused on the changes in glucose homeostasis during Ramadan fasting. Pallyova et al investigated the physiological effects of Ramadan fasting in young adults without diabetes.<sup>25</sup> CGM was used 1 to 2 weeks before Ramadan, in the middle of Ramadan, and 4 to 6 weeks after Ramadan to assess glucose exposure and glucose variability based on 34 182 glucose sensor readings and 438 capillary blood glucose values. The CGM profiles showed an increase in the hyperglycemic area above the curve (above 140 mg/dL) after Ramadan, compared to both before and during Ramadan, along with an increased glucose variability after Ramadan.<sup>25</sup> However, limited data are available about the safety or the metabolic effects of fasting on children and adolescents with T1DM.<sup>4</sup>

The risk of hypoglycaemia is high during fasting in some adult data; but data on children and adolescents with diabetes are limited.

## 8 | PSYCHOLOGY AND ATTITUDE TOWARD FASTING

Many children and adolescents with T1DM prefer to fasting to feel equal to their peers without diabetes, who are fasting.<sup>26</sup> Fasting may

boost their self-esteem and make them feel happier as they are considered "mature and capable" in fulfilling their religious obligations. Considering the risk of acute metabolic complications in individuals with T1DM, they are often advised not to fasting.<sup>6-8,10,11,27</sup> However, despite the fact that having T1DM means exemption from fasting is permissible, youth with diabetes still undergo fasting based on social and cultural reasons and a religious sense of fulfillment.<sup>4</sup>

They can also be psychologically and spiritually led to fasting<sup>26</sup> and often fasting without the approval of their physicians.<sup>28</sup> Globally, a high number of children and adolescents with T1DM are passionate about fasting during Ramadan.<sup>26</sup> Predictably, there is a general perceived fear by both patients and their health-care providers about the use of insulin therapy during Ramadan. Insulin is considered to be associated with increased risk of hypoglycemia.<sup>29</sup> The risk of hypoglycemia during the daytime is the most disliked complication as its treatment entails the intake of carbohydrate with resulting premature breaking of the fasting. The interruption of fasting may induce a sense of guilt and failure by the "faithful" patients.<sup>30</sup> Fear of complications may influence the attitude of youth or their parents' toward fasting. Deeb et al assessed the attitude toward fasting in 65 children with T1DM and their expectations of complications and diabetes control. The study showed that the majority of Muslim adolescents and older children with T1DM are able to fasting during Ramadan, and a high proportion of them are encouraged by their parents to do so.<sup>30</sup> Their expectations of developing complications are realistic, but they underestimate the deterioration of diabetes control during the month. It is reassuring that the majority agree to break their fasting should complications arise, which makes fasting safer for them.

Despite their awareness of potential complications, many children and adolescents with diabetes fasting during Ramadan to feel equal to their non-diabetic peers and avoid social stigma.

## 9 | RAMADAN: POTENTIAL COMPLICATIONS AND SAFETY

Several authors have highlighted the various potential risks of fasting during Ramadan, including hyperglycemia, hypoglycemia, ketoacidosis, thrombotic episodes, and dehydration.<sup>6-8</sup> However, most of the available data are based on adult studies; data in the pediatric age group are lacking.

## 10 | IMPACT ON METABOLIC CONTROL

The results of studies on the impact of Ramadan on glycemic control have not been consistent. Some studies in children with diabetes demonstrated a significant improvement in fructosamine levels, whereas

others have shown no change or an increase in HbA1c levels.<sup>26,30-33</sup> These are all small studies and further confirmation is needed.

Both Salti et al and Al Arouj et al<sup>4,34</sup> showed that fasting by individuals with T1DM might predispose to acute complications. However, other investigators disputed these assumptions by suggesting that fasting Ramadan is safe if patients comply with frequent glucose monitoring and break their fasting should hypoglycemia or hyperglycemia arise<sup>27,35-38</sup> (Supporting Information Appendix). In addition, further studies of small populations have suggested that Ramadan fasting can safely be practiced by children and adolescents with T1DM.<sup>26,34,38</sup> The conditions for safety were pre-fasting medical assessment, focused education, appropriately adjusted insulin regimens, diet control, and management of daily activity. These conditions are considered to be applicable only to individuals without co-morbidities and have stable diabetes control.<sup>19,26,36,39-41</sup> Many studies have shown that children and adolescents are able to fasting a significant number of days during the Ramadan month.<sup>18,42</sup> However, unplanned fasting may predispose an individual with diabetes to hypoglycemia and hyperglycemia with or without ketosis.<sup>11,28</sup> Although some studies in the adult population classified patients with T1DM as a high-risk group for developing severe complications and the concluding recommendation was a strong advice against fasting.<sup>5,15</sup> Others consider fasting during Ramadan safe for T1DM patients, including adolescents and older children, with good glycemic control, regular self-monitoring and close professional supervision.<sup>41</sup>

Ramadan fasting has potential complications; however, the available data suggest that it can be safely practiced by some children and adolescents with diabetes.

## 11 | ACUTE COMPLICATIONS

### 11.1 | Hypoglycemia

Hypoglycemia can be a major complication of Ramadan fasting. The EPIDIAR study of 1070 adult patients with T1DM reported that fasting during Ramadan increased the risk of severe hypoglycemia by 7.5-fold (from 0.4 to 3 events per 100 people per month). During Ramadan, 2% of patients with diabetes experienced at least one episode of severe hypoglycemia requiring hospitalization.<sup>4</sup>

In a study of a pediatric population by Kaplan and Afandi,<sup>42</sup> symptomatic hypoglycemia resulted in breaking the fasting on 15% of the days. In addition, wide blood glucose fluctuation during fasting and eating hours and episodes of unreported hypoglycemia were observed in the CGM data.<sup>42</sup> Also, Afandi et al<sup>43</sup> evaluated the CGM data during fasting in 21 adolescents (15 ± 4 years) with T1DM for 6 ± 3 years in relation to their pre-Ramadan diabetes control. The percentages of hypoglycemia, hyperglycemia, and severe hyperglycemia were significantly higher in the group with worse diabetes control. In this study,

hypoglycemia was defined as blood glucose <70 mg (3.9 mmol/L). The overall durations of hypoglycemia, hyperglycemia, and severe hyperglycemia in the uncontrolled group were longer by 30%, 14%, and 135%, respectively, than those who had better glycemic control.<sup>43</sup>

In a study of 63 fasting young people using insulin pump therapy, 17 patients had hypoglycemia requiring breaking the fasting, but no severe hypoglycemia was reported.<sup>32</sup> Afandi et al elucidated further the frequency, timing, and severity of hypoglycemia in 25 adolescents with T1DM during fasting the month of Ramadan using the iCGM. The study showed that hypoglycemia is typically encountered during the hours preceding Iftar (sunset meal).<sup>44</sup>

### 11.2 | Breaking fasting in hypoglycemia

Monitoring blood glucose during fasting is essential to predict, prevent, and treat hypoglycemia. It is generally advised that the fasting should be interrupted if significant hypoglycemia arises. However, young people do not necessarily agree to break their fasting, particularly if hypoglycemia occurs close to sunset, which marks the end of fasting for the day. This behavior might predispose them to severe hypoglycemia. A study conducted among 33 children with T1DM in Bangladesh showed that only 3 out of 13 children broke their fasting due to development of hypoglycemia symptoms.<sup>40</sup> However, intense education might persuade these youngsters to break the fasting when hypoglycemia occurs. A study by Deeb et al<sup>30</sup> showed that the majority of fasting children and adolescents were willing to terminate their fasting on the occurrence of hypoglycemia regardless of the timing of the day. It is of paramount importance that blood glucose is checked if any symptom suggestive of hypoglycemia is experienced.

### 11.3 | Diabetes Ketoacidosis

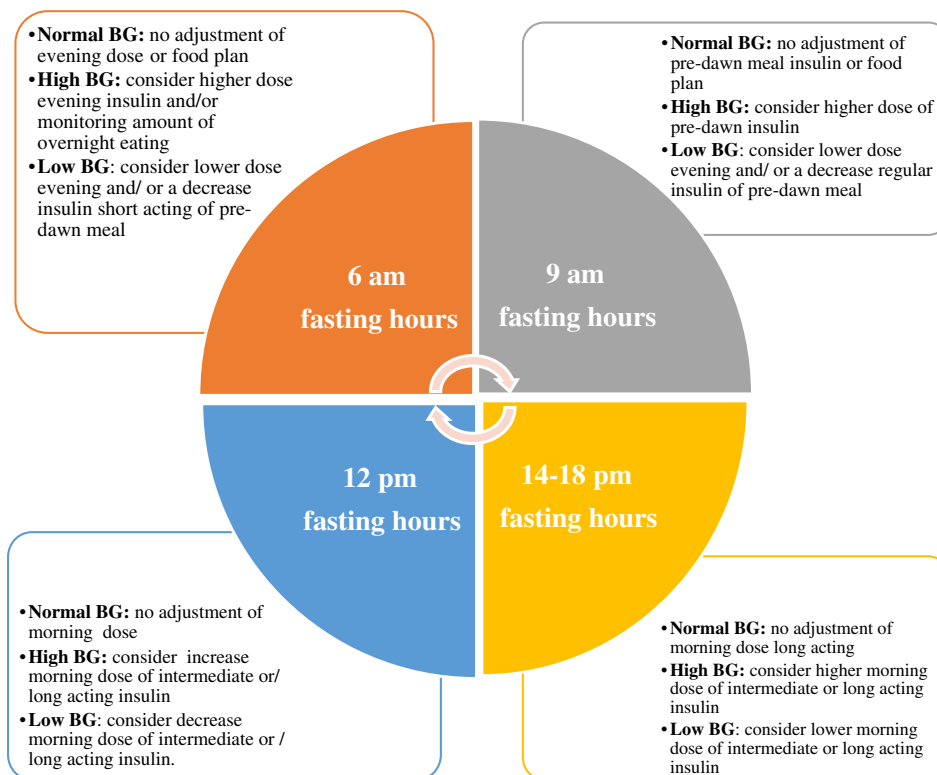
Fasting increases glucagon levels and accelerates lipolysis and ketosis. These pathophysiological changes in conjunction with fasting may lead to metabolic decompensation in diabetes. Diabetes ketoacidosis (DKA) has been reported during Ramadan fasting.<sup>45,46</sup> However, in a recent critical reappraisal of the literature, the frequency of DKA during fasting was not found to be higher than that in the non-fasting state.<sup>47</sup> The authors did not consider different age groups separately. Detection of euglycemic ketosis during fasting in Ramadan requires a proper evaluation of acid-base state, urine glucose, and ketone values (ideally finger-prick blood ketone measurements if available) to differentiate diabetic ketoacidosis from ketosis due to prolonged fasting.

Frequent blood glucose monitoring during Ramadan fasting is necessary to minimize hypoglycemia and prevent DKA. Fasting should be interrupted if hypoglycemia is detected regardless of symptoms.

## 12 | INSULIN MANAGEMENT DURING RAMADAN

Knowledge on insulin action, how to interpret the glucose measurements and how to adjust insulin for *Iftar* and *Suhoor* meals, is a prerequisite for a safe Ramadan.<sup>48,49</sup> Based on clinical experience, different therapeutic recommendations regarding how to adjust the type, dose, and timing of insulin in adults have been suggested.<sup>37,50,51</sup> Adjustment of oral glucose-lowering medication during Ramadan is extensively detailed in the recently launched International Diabetes Federation (IDF) guidelines.<sup>8</sup> However, clear evidence-based guidelines on insulin adjustment for children and adolescents with T1DM are lacking.

Current recommendations for patients treated with multiple daily injection (MDI) include a reduction of the total daily dose (TDD) of insulin to 70% to 85% of the pre-fasting TDD<sup>12,52</sup> or to 60% to 70% of the basal insulin.<sup>8</sup> For pump-treated patients, a reduction of the basal rate of insulin infusion by 20% to 40% in the last 3 to 4 hours of fasting is recommended.<sup>8</sup> The South Asian Guidelines for Management of Endocrine Disorders in Ramadan recommends reducing basal insulin by 10% to 20% during the fasting days.<sup>41</sup> However, these recommendations are not based on data from large study cohorts or randomized-controlled studies. Deeb et al<sup>53</sup> showed that reduction of basal insulin in MDI-treated patients or in those on pump therapy does not reduce the frequency of hypoglycemia, which is at variance with what was suggested by Khalil et al.<sup>54</sup> According to Hawli et al<sup>36</sup> an individualized approach, close monitoring of blood glucose and weekly follow-up with the medical team may be most important to prevent acute complications. A suggested guide for adjustment of insulin dosages is illustrated in Figure 1.



**FIGURE 1** Schematic adjustments of insulin dose and/or food considerations during fasting hours

## 13 | INSULIN REGIMENS FOR CHILDREN AND ADOLESCENTS WITH T1DM

The treatment should be discussed depending on the individual patient and the access to different insulins and technology. Culture, region, and season also affect the response to fasting. Once the fasting has started, insulin dosing should be regularly adjusted based on glucose monitoring. Frequent blood glucose measurement is essential for those who want to fasting. Only a limited number of small mainly observational studies in children and adolescents have evaluated risk/benefit of different insulin regimens (Appendix). Although none of the currently available treatments is compatible with physiological insulin replacement, the meal adjusted (basal-bolus) and pump treatment approach are the preferred options.<sup>34,48</sup> In some regions, treatment with two or three daily injections with NPH and human short-acting insulin may be used. Use of twice daily premixed insulin regimens requires a fixed intake of carbohydrates at set times because the insulin profile has two peaks of activity. This may be difficult to use safely with fasting and should not be advised.

## 14 | MEAL ADJUSTED (BASAL-BOLUS) INSULIN TREATMENT

### 14.1 | Basal

#### 14.1.1 | Long-acting insulin analogs

Most observational studies report favorable safety and efficacy of insulin analogues in relatively well-controlled patients with T1DM who fasted

an average of 17 to 19 hours/day. A significant decline in plasma glucose is demonstrated mostly near the end of breaking the fasting period with periods of hypoglycemia during fasting hours.<sup>8,26,32,37,42,55,56</sup> No severe hypoglycemic events have been reported. It is recommended that during Ramadan, the pre-Ramadan basal dose is reduced by 20% when given in the evening.<sup>6,12,18,26,34,37,38,56</sup> When taken at *Iftar*, a further reduction may be needed up to 40% of the pre-Ramadan basal dose.<sup>8,57</sup> Further individualized adjustment of the dose needs to be considered.

## 14.2 | NPH insulin

Based on the pharmacodynamic profile of NPH, there is a considerable risk of mid-day hypoglycemia and end of the day hyperglycemia. Reduction of the dose should occur to prevent hypoglycemia at the possible expense of higher blood glucose levels at the end of the day.

## 14.3 | Bolus insulin

In most studies, the pre-*Iftar* and pre-*Suhoor* insulin doses are taken to be equal to the pre-Ramadan lunch and dinner dose of rapid-acting insulin, respectively. In some reports, the pre-dawn dose is reduced by 25% to 50%.<sup>8</sup> This also depends on the carbohydrate content of the meal as well as the pre-meal blood glucose value. In an adult study, the use of short-acting insulin analogue has been associated with fewer hypoglycemic events and an improvement in postprandial glycemia compared with regular insulin.<sup>58</sup> Higher blood glucose values may require an additional dose of insulin administered as a correction dose. The correction dose is individualized and is usually based on pre-Ramadan doses. Khalil et al<sup>54</sup> reported that the TDD of insulin administered during Ramadan was not different from that in the pre-Ramadan period.

## 14.4 | Twice daily insulin treatment

Two or three daily injections with NPH and regular insulins allow less flexibility in lifestyle and nutrition with more risk of hyperglycemia and hypoglycemia. The adjustment for a 12 to 16 hour fasting with the NPH peak effect is more challenging.<sup>37</sup> During Ramadan children on a twice daily insulin regimen are more prone to develop hyperglycemia with or without ketones than those on a basal-bolus regimen. Patients continued to have hyperglycemia during the day while those on a basal-bolus insulin regimen showed a steady fall in blood glucose levels toward normal by the time of breaking their fasting.<sup>37</sup> Using twice daily insulin regimens during Ramadan is possible but requires more dose adjustments. In those on a twice daily regimen with NPH insulin, it is recommended that they take their usual morning dose before sunset meal and to take only short-acting insulin at the time of their dawn meal.

## 15 | INSULIN PUMP THERAPY

The use of insulin pumps can facilitate insulin adjustment and prevention of hypoglycemia and hyperglycemia during Ramadan.

## 15.1 | Basal rate

Lowering the basal insulin infusion rate temporarily or suspending it, can help people with T1DM to avoid major hypoglycemic events and improve diabetes control during fasting.<sup>34,36,38</sup> In most studies, basal insulin rate is reduced (10%-15% reduction of basal insulin infusion rate during the hours of fasting) and some suggest up to 40% at the end of the daily fasting.<sup>38,42,43,59</sup> However, a study by Deeb et al<sup>53</sup> did not show a difference in hypoglycemia frequency if the basal rate is reduced.

## 15.2 | Bolus

Insulin boluses covering the predawn and sunset meals have been either increased<sup>38</sup> or unchanged as per the pre-Ramadan insulin-to-carbohydrate ratio and insulin sensitivity factor.<sup>42,43,59</sup> None of the patients developed severe hypoglycemia or DKA during Ramadan fasting in any of the pediatric published studies on insulin pump therapy.<sup>36,38,42,44,53,59</sup> The benefits and risks of continuous CSII or MDI in patients with T1DM who fasting during Ramadan were examined by two independent groups recently using systematic review and meta-analysis. Loh et al<sup>60</sup> pooled data from 17 observational studies involving 1699 patients treated with either CSII or non-CSII regimens and concluded that the CSII regimen had lower rates of severe hypoglycaemia and hyperglycaemia, but a higher rate of non-severe hyperglycemia than premixed/MDI regimens. Whereas Gad et al<sup>61</sup> assessment included a total of nine observational studies and showed that there was no difference in the change of HbA1c, weight, or lipids during Ramadan.

## 15.3 | Sensor-augmented pumps

Fasting during Ramadan is feasible in patients with T1DM using an insulin pump with adequate counseling and support. Both Benbarka and Khalil et al<sup>32,54</sup> reported encouraging experience with insulin pumps augmented by CGM during Ramadan in adolescents and young adults with T1DM. Recent technology includes the potential to suspend insulin administration before hypoglycemic values have been reached (predictive low-glucose insulin suspend).<sup>62</sup> Elbarbary investigated the effect of the low-glucose suspend algorithm on the frequency of hypoglycaemia in 60 adolescents with T1DM who fasted during Ramadan and observed a significantly reduced exposure to hypoglycaemia without compromising safety.<sup>59</sup> Overall, the use of technology seems promising and potentially beneficial during Ramadan. Because most studies in youth have been small and observational, more clinical trials in this population are needed to confirm these observations and evaluate best treatment options during Ramadan in this age group.

## 16 | THE ROLE OF NEWER INSULINS

Although some experience with newer insulins in adult patients has been reported, further data will be needed in the pediatric population

to establish clear guidance around their use. These include more concentrated forms of insulin (insulin Glargine 300) and newer basal insulin degludec with flatter pharmacodynamic profiles.<sup>63,64</sup>

Insulin types and regimens should be individualized and based on local resources. Most investigators recommend lowering the insulin dose during fasting. However, recent data suggested that this did not reduce the frequency of hypoglycemia.

## 17 | NUTRITION MANAGEMENT DURING RAMADAN

### 17.1 | Pre-Ramadan nutrition education

Pre-Ramadan nutrition assessment and education is essential to ensure the safety of the young person planning for Ramadan fasting. An individualized meal plan is required based on energy requirements, commonly eaten foods during Ramadan, the timing of *Suhoor* (pre-dawn) and *Iftar* (after sunset) meals, the insulin regimen, and the exercise pattern. Ongoing monitoring of food intake with appropriate insulin adjustment is necessary during Ramadan to help prevent hypo- and hyperglycemia. It is recommended that fluids, such as water or non-sweetened fluids be consumed at regular intervals in the non-fasting hours to prevent dehydration.

### 17.2 | Meal-time routines during Ramadan

Ramadan fasting represents a major shift in meal timing and content and daily lifestyle and exercise patterns. All these changes have a direct impact on blood glucose levels.<sup>34,39</sup> The two main meals eaten during Ramadan are *Iftar*, the meal consumed after sunset usually between 6 PM to 7:30 PM, and *Suhoor*, the predawn meal usually consumed between 3 AM and 5.30 AM. Meal times vary between countries with the hours of sunrise and sunset. The predawn meal should be eaten as close to dawn as possible to minimize the fasting period. In addition, a late evening meal or supper is commonly eaten before bed (about 10 PM). This usually contains traditional sweets. A snack such as milk and dates or juice may initially be taken before *Iftar* to break the fasting.

### 17.3 | Guidelines for nutritional care and meal planning

The nutritional compositions of foods eaten during Ramadan are different from the rest of the year. Commonly eaten foods are shown in Table 1. Eltoum et al<sup>65</sup> examined the effect of Ramadan fasting on the dietary habits and nutrient intake of 54 adolescents (13-18 years old) with T1DM. The study demonstrated that young people had significant

changes in nutrient intake with higher fat and sugar intakes during Ramadan. The authors recommended that adolescents with T1DM should lower saturated fat and sugar intakes during Ramadan. Low glycemic index (GI) carbohydrates should be the basis of foods consumed at *Iftar* and *Suhoor*. Lean protein and low GI carbohydrates are particularly important at the predawn meal to enhance satiety during the day. Moderation in traditional sweet intake and fried food are strongly recommended, particularly at the sunset meal. This should be covered by prandial rapid-acting insulin to prevent rapid postprandial glycemic excursions.

For those using intensive insulin therapy, education on carbohydrate counting is recommended to allow adjustment of the prandial insulin dose to match carbohydrate intake at *Iftar*, *Suhoor* and the supper meal. Daily consistency in carbohydrate intake at *Iftar* and *Suhoor* is necessary for those on a twice daily injection regimen. Continual snacking overnight after *Iftar* should be discouraged. Pre-prandial bolus insulin is preferable to insulin administered during or after the meal.<sup>66</sup>

### 17.4 | Maintaining healthy weight and lowering of cardiovascular risk factors during Ramadan

It is important to prevent hyperlipidemia and excessive weight gain in Ramadan.<sup>31</sup> A diet rich in fruit, vegetables, dairy, legumes, and whole grains should be encouraged to reduce adverse changes in lipid profiles and to prevent excessive weight gain. A systematic review undertaken in adults to investigate alterations in cardiometabolic risk profile found the effect of Ramadan fasting on blood lipids was equivocal; some studies found a significant increase in blood fats, while others reported decreases in LDL and total cholesterol.<sup>67</sup> The IDF and Diabetes and Ramadan (DAR) International Alliance<sup>8</sup> recommend that for adults the calorie load during Ramadan fasting should be similar to the rest of the year. In children and adolescents with T1DM, both weight gain<sup>37</sup> and weight loss<sup>40</sup> have been reported in Ramadan; accordingly, an individualized plan with an appropriate energy intake to maintain growth and development is necessary.<sup>68</sup> Regular follow-up of children and adolescents undertaking fasting is needed to monitor and prevent rapid weight changes during Ramadan. Weight loss can be associated with deterioration in glycemic control and this should be monitored.<sup>68</sup>

### 17.5 | Meal-time insulin bolus

The use of an extended bolus delivered by an insulin pump, where some of the insulin is delivered promptly and the remainder over 2 to 6 hours, enables bolus insulin to match the glycemic effect of the meal. This is particularly useful for high-fat meals such those consumed at *Iftar*.

CGM is a useful tool to show the impact of meals consumed during Ramadan. It can guide changes in the timing of insulin administration and the insulin dose to match the profile of high fat foods. Studies are needed regarding ways to optimize postprandial glycemia in Ramadan particularly following the evening meal. A suggested plan to manage dietary intake and insulin dosage is detailed in figure.



**TABLE 1** List of commonly eaten food during the month of Ramadan

Food	Serving size	Carbohydrate (g)
Fruits and vegetables		
Dried Figs	2 figs (28 g)	16
Fresh dates	1 date (19 g)	6
	3 dates (57g)	18
Dried dates	1 date (6 g)	4
	3 dates (18 g)	12
Dried apricot	1 half (6 g)	2
	8 halves (48 g)	17
Sultanas	Snack pack (40 g)	30
Dried barberries	¼ cup (37 g)	20
Cakes, pastries, and sweets		
Chocodate Arabian delights (chocolate-coated dates with nut inside)	1 piece (11 g)	7
Mouhalabieh (milk flans)	1 cup (200 g)	30
Galactobureko (filo custard pastry, syrup soaked)	1 piece	28
Baklava	1 piece (50 g)	26
Turkish delight	1 piece (18 g)	15
Kanafeh	1 square, 6 tablespoons (120g)	40
Halva (nut butter-based, eg, tahini)	2 tablespoons, (50 g)	22
Ghraybeh (butter cookies)	1 cookie (15 g)	7
Ma'mool/maamoul/ma'moul (cookies stuffed with walnuts/dates)	1 cookie (35 g)	23
Basbousa (sweet semolina cake soaked in syrup)	1 slice (30g, 3 cm × 3 cm)	14
Sekerpare (butter cookie soaked in syrup)	1 piece (18 g)	16
Tulumba (fried dough soaked in syrup)	1 piece (35 g)	37
Lokma (sweet fried dough)	1 ball (13 g, 2 cm diameter)	10

Creating an individualized meal plan well before Ramadan is essential. This should aim to maintain the daily calories and avoid excessive weight changes. The plan should take into account the insulin regimen, change of the meal times and type of food consumed during Ramadan.

## 18 | RAMADAN AND PHYSICAL ACTIVITY

Exercise patterns in children and adolescents are different from adults as they vary from unpredictable play to planned sport. Typically, outside of fasting periods, additional carbohydrate is advised for spontaneous activities to avoid hypoglycemia.<sup>69</sup> During Ramadan fasting, careful attention to insulin adjustment is required to enable normal levels of physical activity during fasting hours without hypo- or hyperglycemia. Pre-Ramadan diabetes education should discuss physical activity with a plan for appropriate insulin adjustment, hydration and hypoglycemia treatment as part of individualized care.

It is recommended that a reasonable level of activity be maintained in Ramadan, with consideration of avoidance of strenuous activities in the hours before the sunset meal when hypoglycemia is most likely. Exercise patterns in Ramadan vary depending on the geographic region and the need for school attendance. The difference in sleep patterns coupled with fasting in the daylight hours impact the amount and type of physical activity youth participate in. It has been reported that in adolescents without diabetes a decrease in physical activity accompanies Ramadan fasting<sup>69</sup>; however, further studies are needed.

There are limited studies on nutrition and sports management during Ramadan that focus on children and adolescents. A review of studies conducted in healthy adult athletes who participated in Ramadan fasting concluded changes in training, fluid intake, diet, and sleep patterns can be managed to minimize, but not wholly mitigate, the impact of Ramadan on athletic performance.<sup>70</sup> The review concluded athletes with T1DM should consider a medical exemption from fasting; however, the review emphasized if an athlete chooses to fasting the need for an individual plan to optimize performance and ensure safety. Nutritional management for athletic performance in T1DM has been outlined,<sup>71</sup> however, it requires adaptation in meal timing for fuel and recovery for athletes choosing to observe the fasting. Specific guidance should be provided on meeting fluid, energy, electrolytes,

carbohydrate, and protein requirements during non-fasting hours while allowing for adequate sleep. Further studies are needed to examine the implications of Ramadan fasting on performance and ways to meet sports nutrition goals in young athletes with T1DM.

Children and adolescent are encouraged to exercise during fasting Ramadan but avoid strenuous activities closer to the sunset meal where hypoglycemia is more likely.

## 19 | MONITORING OF BLOOD GLUCOSE DURING FASTING

Optimizing glycemic control pre-Ramadan is an essential measure to ensure safe fasting. Frequent blood glucose measurements are needed for a safe fasting during Ramadan and this does not violate the observance of Ramadan. The use of CGM also facilitates the adjustments of insulin during the Ramadan. Capillary blood glucose monitoring remains the most widely used method of monitoring. The concept among Muslim communities that pricking the skin for blood glucose testing invalidates the Ramadan fasting is an incorrect interpretation.<sup>9</sup> This should be strongly emphasized in educational programs.

Glucose measurements during Ramadan are based on the same principles of monitoring outside Ramadan with the times being related to meals, medications and symptomatology. To assess adequacy of postprandial control, readings are recommended 2 hours after the main evening meal (*Iftar*) and before the predawn meal. A measurement on waking up is essential as it will enable patients to judge their basal dose as well as the *Suhoor* meal insulin coverage. Testing in the last 2 hours of the fasting period is recommended as that timing is known to be associated with an increased likelihood of hypoglycemia.<sup>43,44</sup> Additional midday monitoring is useful if morning readings were in the low-normal range or when symptoms of hypoglycemia are experienced or suspected.

## 20 | CONTINUOUS GLUCOSE MONITORING

Kaplan et al<sup>72</sup> used CGM to assess the impact of fasting on interstitial glucose concentrations in 14 adolescents with T1DM. There was no difference in the mean glucose readings or the duration of hypoglycemia, hyperglycemia, and severe hyperglycemia between the Ramadan and non-Ramadan period, respectively. Adolescents with T1DM continue to have wide glucose fluctuations during Ramadan and, when fasting, close glucose monitoring should be recommended. Lessan et al<sup>73</sup> employed CGM to assess changes in markers of glycemic excursions during Ramadan fasting in a group of patients on insulin and or other glucose-lowering medication. A significant difference in

mean CGM curve was observed during Ramadan, with a slow fall during fasting hours followed by a rapid rise in glucose level after the sunset meal (*Iftar*). The magnitude of this excursion was greatest in patients treated with insulin. Therefore, efforts should be made to decrease glycemic excursions following *Iftar*, including administering insulin 15 to 20 minutes before the meal and replacing high GI for healthier, low GI foods.<sup>68</sup>

Different studies have assessed the potential of CGM in children and adolescents with diabetes during Ramadan fasting. Beshyah et al<sup>74</sup> provided a comprehensive demonstration of glucose changes during Ramadan fasting using isCGM in eight individuals with different states of glucose tolerance. In these states, the profiles showed high glucose exposure, wide variation and marked instability after both traditional meals of *Suhoor* and *Iftar*. Ambulatory glucose profiles before, during and after Ramadan in three patients revealed distinctly different profiles reflecting the Middle Eastern meal pattern, Ramadan meal pattern, and Eid feasting, respectively. Also, Al-Agha et al<sup>33</sup> reported a prospective pilot study on 51 children with diabetes who were able to fasting 67% of the total days eligible for fasting. isCGM revealed hypoglycemia in 33% of the days. None of the participants developed severe hypoglycemia or DKA. Afandi et al<sup>44</sup> elucidated the frequency, timing, and severity of hypoglycemia in 25 adolescents with diabetes fasting Ramadan using isCGM. The authors revealed an overall time spent in hypoglycemia of  $5.7\% \pm 3.0\%$ . The incidence of hypoglycemia was 0% from 19:00 to 23:00 PM and 69% from 11:00 to 19:00. Analysis of the severity of hypoglycemia showed that 65% were between 61 and 70 mg/dl and 8% lower than 50 mg/dl. These two studies concluded that children and adolescents with T1DM who use isCGM could fasting without the risk of life-threatening episodes of severe hypoglycemia or DKA during Ramadan. Multiple devices are linked with remote connections are now available. Those might have a role in remote monitoring and detecting potential complications during fasting.

Regular glucose monitoring is essential for safe fasting and individuals should be assured that skin pricking does not invalidate fasting. CGM or isCGM are useful tools to facilitate adjustments of insulin during Ramadan fasting.

## 21 | LIMITATIONS OF RAMADAN STUDIES IN CHILDREN AND ADOLESCENTS

There are several limitations to the studies of Ramadan fasting in children and adolescents. The small numbers of subjects and retrospective designs influence the interpretation of the results. Selection bias may be created based on diabetes control, lack of data on the pre- and post-Ramadan period. Country-specific differences in physical exercise and schooling demands may impact the outcome. As the

season that Ramadan occurs changes, conclusions are not universally applicable. The impact of physicians' and diabetes educators' knowledge, attitudes, beliefs, and practices in relation to Ramadan highly influence the education and management of patients. Obtaining the approval of ethics committees to undertake such studies in children can be a challenge. This is particularly challenging because cultural and religion-sensitive issues might arise from such research. Further multicenter research studies are needed to increase the understanding of the safe management of Ramadan in children and adolescents with T1DM.

## 22 | CONCLUSIONS

The management of children and adolescents with diabetes during Ramadan fasting is a challenge as there are limited high-quality data in pediatric diabetes. Well-designed, randomized controlled trials are needed to determine optimal insulin regimens to minimize glucose fluctuations throughout the fasting and eating hours. Recent technologic developments such as the use of new insulin analogues, "smart" insulin pumps and advanced glucose monitoring devices and telemonitoring might enhance safe fasting in the future. However, these innovations are not universally accessible. At the present time, careful individual assessment and structured diabetes education remain the mainstay of ensuring safe fasting.

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## CONFLICTS OF INTEREST

None of the authors declared any conflicts of interest that may jeopardize the impartiality of these guidelines

## COMPLIANCE WITH ETHICAL PRINCIPLES

Not applicable

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## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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