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Ramadan fasting among adolescents with type 1 diabetes: a systematic review and meta-analysis

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Abstract

Objective This systematic review and meta-analysis assess the effects of Ramadan fasting in adolescents with type 1 diabetes mellitus (T1DM), on blood sugar factors such as hemoglobin A1C and problems caused by its lack of control such as hypoglycemia and DKA, and metabolic outcomes.

Methods Electronic databases including MEDLINE, Embase, and SINOMED were searched up to February 13, 2024, without language, region, or publication time restrictions. The outcomes were Acute complications, changes in Hemoglobin A1c (HbA1c) and weight changes. Meta-analyses used random-effects models to compute weighted Relative risk (RR) and standard mean differences (SMD). And to check the risk of bias of included studies, the Newcastle-Ottawa scale was used.

Results Nine studies were included, comprising 458 participants, with studies varying in quality from high to low. Meta-analysis showed no significant reduction in HbA1c levels post-Ramadan (SMD: -0.12; 95% CI: -0.38 to 0.14), indicating minimal impact on long-term glycemic control. The incidence of hypoglycemia was notably high (50.79 events per 100 observations), with hyperglycemia and diabetic ketoacidosis (DKA) also reported but less frequently. The variability in complication rates among studies was significant, reflecting the high heterogeneity across the data. Weight changes during Ramadan were minimal and not statistically significant, suggesting fasting's negligible effect on body weight among participants.

Conclusions Ramadan fasting among adolescents with T1DM does not significantly alter HbA1c levels, suggesting potential feasibility under careful monitoring and management. However, the high incidence of hypoglycemia underscores the need for vigilant glucose monitoring and tailored adjustments to diabetes management plans during fasting periods.

Keywords Ramadan, Fasting, Adolescents, Type 1 diabetes mellitus, Meta-analysis

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Introduction

Type 1 diabetes mellitus (T1DM) is a medical condition in which the body's pancreatic β cells stop producing insulin. This can happen due to autoimmune destruction and can occur at any age, although incidence peaks during puberty and early adulthood. However, adults are more likely to be affected since people with T1DM tend to live for many years. It's essential to manage the condition by optimizing glucose control to reduce both acute and long-term complications [1]. There are currently nearly half a billion people worldwide living with diabetes, and the number is expected to increase by 25% by 2030 and 51% by 2045 [2]. In 2045, the number of diabetes patients in Islamic countries, where many fast every year in Ramadan, is predicted to double [3]. Fasting during Ramadan has several potential benefits. It helps Muslims develop compassion for those less fortunate than them. Fasting also allows one to build self-control and willpower and learn to control natural desires such as hunger and thirst. These benefits help Muslims to resist the temptation of unnecessary things, like harmful substances and behaviors. Fasting also provides a time to purify the body and soul by developing a greater sense of humility, spirituality, and community involvement. Moreover, it is believed that intermittent fasting limits energy intake and promotes weight loss in obese individuals, which could be cardioprotective [4]. Considering the high prevalence of diabetes among Muslims and the significant number of people who observe the ritual of fasting every year, it is vital to systematically compile and analyze credible evidence about the impact of Ramadan fasting on diabetes [5]. Patients can be stratified into their risk of hypoglycemia and/or complications before the start of the fasting period of Ramadan. Those at high risk of hypoglycemia and with multiple diabetic complications should be advised against prolonged fasting. Even in the lower hypoglycemia risk group, adverse effects may still occur [6]. Before the start of Ramadan, patients with diabetes should be assessed to determine their risk of hypoglycemia and/or complications. Those who are at a high risk of hypoglycemia and have multiple diabetic complications should be advised not to fast for a prolonged period of time. Even in the lower risk group, there is still a possibility of experiencing adverse effects [7]. We aim to conduct a systematic review to explore the current literature on the effect of Ramadan fasting among adolescents of type 1 diabetes. This review will help to identify any gaps in knowledge on this topic, highlight them, and develop recommendations for future research.

A large part of the population of Muslim countries that fast during Ramadan is made up of adolescents [7]. Knowing whether people with type 1 diabetes mellitus can fast or not is a common question asked by doctors who deal with Muslim people. This is one of our rationales to help doctors and people who are facing these issues.

Our clear question for this study is, what effect does fasting, especially during Ramadan, have on the conditions related to glucose and its metabolism in a teenager with type 1 diabetes?

If he fasts, what will be the results and how is he different from a person with type 1 diabetes of the same age who does not fast?

Methods

The systematic review was conducted following the PRISMA guidelines to assess the effects of Ramadan fasting on the outcomes of adolescents with Type 1 Diabetes Mellitus (T1DM).

Databases and search strategy

A comprehensive search across electronic databases including Medline (through PubMed), Embase, Scopus, Cochrane Library, and Web of Science was conducted without restrictions regarding language, region, or publication date until February 13, 2024. The search strategy involved using specific keywords related to our topic of interest: "Ramadan fasting", "Type 1 Diabetes Mellitus", "HbA1c", "adolescents", "glycemic control", and related terms. For instance, in the Medline database, we employed the following search strategy: ("Ramadan" AND "fasting") AND ("Type 1 Diabetes" OR "T1DM") AND ("adolescents" OR "young adults" OR "child*"). Additionally, reference lists from selected articles were screened for further relevant studies.

Population and study design

We included studies that focused specifically on adolescents diagnosed with Type 1 Diabetes Mellitus (T1DM). The mean age of participants across selected studies ranged from 10 to 19, which reflects typical adolescent demographics within this population group. Observational studies and randomized controlled trials (RCTs) were considered eligible for inclusion in our analysis.

Studies published between May 2001 and February 13, 2024, that reported outcomes related to Acute complications of Ramadan fasting were included in this study.

Inclusion and exclusion criteria

We included studies that focused specifically on:

(1) Population: T1DM patients between 10 and 24 years old.
(2) Exposure: fasting during Ramadan.

(3) Study type: observational studies (e.g., cohort studies, case-control studies, cross-sectional studies).
(4) Outcomes: hyperglycemia, hypoglycemia, diabetic ketoacidosis, changes in HbA1c, and weight changes.

The following exclusion criteria were applied: studies that did not assess Ramadan fasting as an exposure, animal studies, case reports, and systematic reviews.

Study selection and data extraction

Two independent reviewers, Afshin Heidari and Fatemeh Esmaeilpur Abianeh, screened the titles and abstracts using the EndNote software of the selected articles for eligibility before screening their full texts. They collected data regarding participant demographics (including mean age), intervention details (duration of fasting), follow-up duration, and outcomes such as the occurrence of hypoglycemia, hyperglycemia, or diabetic ketoacidosis, changes observed in HbA1c levels or variations of body weight noted within respective studies. Any discrepancies were resolved through discussion. A standardized data extraction form was developed to extract information from the included articles. The following data were extracted: author(s), publication year, country, population, mean age of the population, sample size, mean duration of confirmed T1DM, insulin regimen during Ramadan, HbA1c(before and after Ramadan), weight(before and after Ramadan), and the number of complications.

Quality assessment

The methodological quality and risk of bias of the included articles were independently assessed by two reviewers, Fatemeh Nafarzadeh and Dlnya Aminzadeh, using appropriate scales. The Newcastle-Ottawa Scale(NOS) was used for assessing the quality of cohort and case-control studies and the risk of bias based on the outcomes.

Data analysis

The study presented the effect of an intervention as the mean difference (MD) and standard deviation (SD) before and after the fasting. Meta-analyses used random-effects models to compute weighted Relative risk (RR) and standard mean differences (SMD). To test for heterogeneity, I2 was used. A two-sided P value of < 0.05 was considered statistically significant. Funnel plots were used to evaluate publication bias for outcomes with at least 10 effect sizes. The meta-analysis was performed using R.

Results

Study characteristics and quality assessment

The included studies comprised three conference abstracts and six journal articles (Fig 1), consisting of eight observational studies (seven being prospective in design) and one case-control [8–16]. Together, these studies comprised 458 T1D children and adolescents who intended to fast during Ramadan, with a mean age ranging from 13.5 to 23.3 years. The mean duration of T1D among participants was reported in seven studies, ranging from 4.9 to 8.6 years. The mean body weight and HbA1c levels were reported in two and seven studies, respectively, with some of them reporting data both before and after Ramadan fasting. Table 1 delivers a summarized characterization of the studies.

The quality assessment of the studies included in this review was assessed separately for cohort and case-control studies utilizing the Newcastle-Ottawa Scale (NOS). According to the NOS criteria, two were deemed high-quality, five were judged as ones with fair quality, and two were rated as low-quality studies. In the Comparability domain, all of the studies failed to gain 2 scores of a total of two, while six of them achieved a score of 3 out of potential score of three in the Outcome domain. The quality assessment and scoring process is demonstrated in detail in Table 2.

Acute complications

Our meta-analysis synthesized data from several studies to assess the incidence of various complications during Ramadan fasting. The outcomes were stratified into three types: hypoglycemia, hyperglycemia, and diabetic ketoacidosis (DKA).

- -Hypoglycemia: The pooled event rate per 100 observations was 50.79 (95% CI [30.36, 71.10]). The largest contribution to the weight of this outcome came from Sh Abdelghaffar 2022, with an event rate of 78.95 per 100 observations (95% CI [68.43, 88.17]).
- -Hyperglycemia: The combined event rate per 100 observations for hyperglycemia was 41.81 (95% CI [3.11, 88.09]). The study by Sh Abdelghaffar 2022 reported the highest event rate of 86.84 per 100 observations (95% CI [77.13, 93.51]).
- -Diabetic Ketoacidosis (DKA): DKA had the fewest reported events. The event rate per 100 observations for DKA was 11.02 (95% CI [0.36, 30.78]), with Sh Abdelghaffar 2022 again having the highest event rate at 19.74 per 100 observations (95% CI [10.27, 29.81]).

The heterogeneity among the studies was high for all three complication types, with I^2 values of 89%, 97%, and 81% for hypoglycemia, hyperglycemia, and DKA,

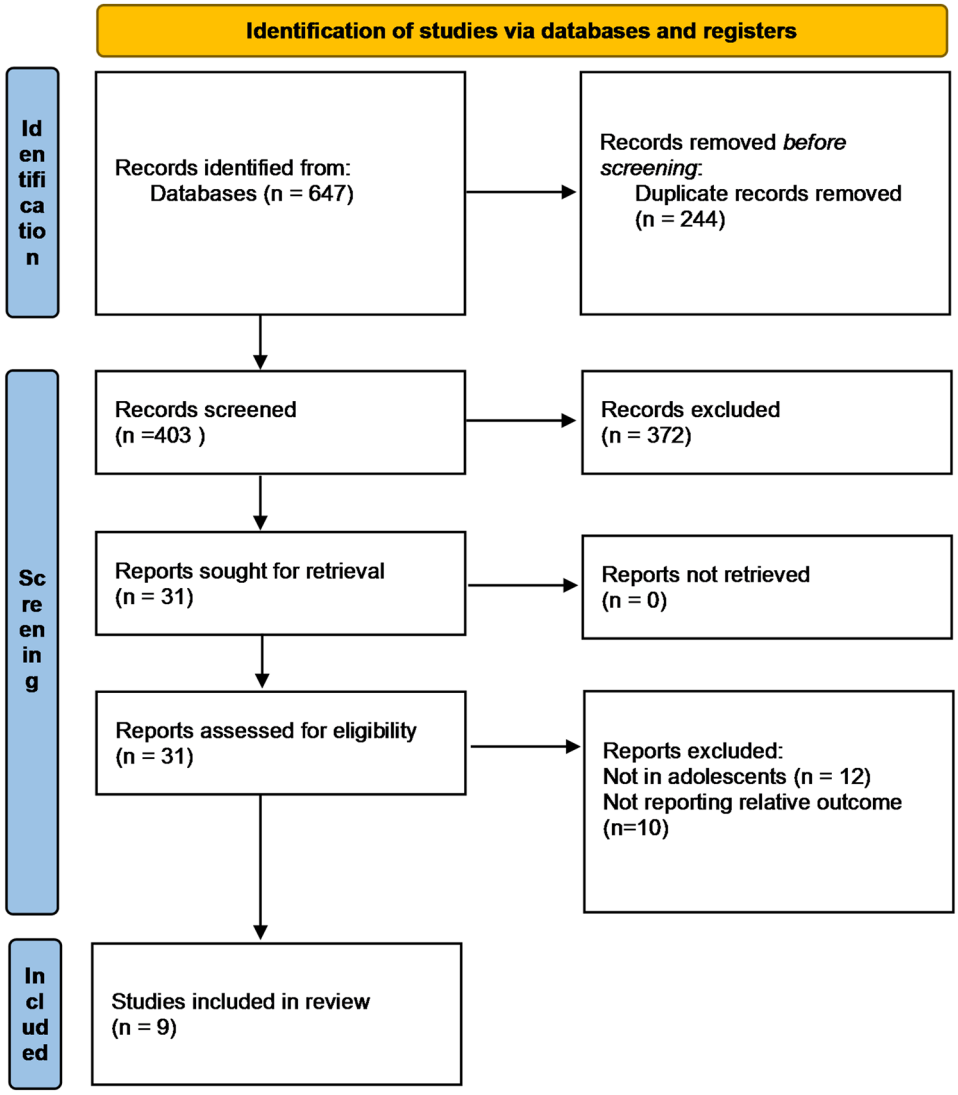

Fig. 1 PRISMA flow diagram

respectively. This indicates substantial variability in the effect estimates.

The overall pooled effect estimates for the total complications (hypoglycemia, hyperglycemia, and DKA combined) was 38.87 events per 100 observations (95% CI [20.30; 59.20]), with a high degree of heterogeneity (I^2 = 95%).

The test for subgroup differences was significant (χ^2 = 7.62, df = 2, p = 0.02), suggesting that the rates of complications significantly differed between the types of complications studied (Fig 2).

HbA1C changes in ramadan

The effect of Ramadan fasting on HbA1c levels was examined across three studies. The pooled SMD from the random-effects model across all studies was −0.12 (95% CI [-0.38; 0.14]), suggesting a small and not statistically significant reduction in HbA1c levels due to Ramadan fasting. Heterogeneity between the studies was low, I^2 = 0%, τ^2 = 0, p = 0.60, indicating consistency among the study results (Fig 3).

Weight changes in Ramadan

The impact of Ramadan fasting on body weight was evaluated through a comparison of mean weights in two studies. The pooled data from the random-effects model indicated an overall SMD of 0.05 (95% CI [-0.30; 0.40]), demonstrating a small and non-significant effect of Ramadan fasting on weight change. The heterogeneity across studies was non-existent (I^2 = 0%, τ^2 = 0, p = 0.76), suggesting no variability in the effect size estimates between the studies (Fig 4).

Table 1 Characteristics of included studies

Reference (Publication Type)	Participants *N* (% Male)	Mean Age (± SD) [Years]	T1D Duration (± SD) [Years]	Insulin Treatment Regimen	Mean Body Weight (± SD) [kg]	Mean HbA1c (± SD) [%]	Fasting-Related Complications
A Deeb 2017 (Journal Article)	67 (38)	14.52 (2.51)	7.35 (4.62)	58% IP 42% MDI	NS	Pre: 8.6 Post: 8.8	Number of participants encountered complications: • *Hypoglycemia: 34 out of 65* • *Hyperglycemia: 19 out of 65*
B Afandi 2017 (Journal Article)	21 (28.57)	15 (4)	6 (3)	85.71% CSII 14.28% MDI	NS	Pre: 8.5 (1.0) Post: NS	Complications incidence rate (per total participant days): • *Hypoglycemia: 6.2%* • *Hyperglycemia: 27.15%* • *Severe Hyperglycemia:12.05%*
A Deeb 2016 (Journal Article)	75 (38)	14.52 (2.51)	7.35 (4.62)	60% IP 40% MDI	NS	Pre: 8.09 (1.25) Post: NS	Number of participants encountered complications: • *Hypoglycemia: 39 out of 68*
AE Al-Agha 2017 (Journal Article)	51 (43.1)	14.2 (2.6)	NS	35% IP 65% MDI	NS	Pre: 8.16 (1.64) Post: 8.2 (1.63)	Number of complications-related non-fasting days (out of 1123 total participant days): • *Hypoglycemia: 173 days* • *Severe hypoglycemia: 0 days* • *DKA: 0 days*
NS Elbarbary 2014 (Conference Abstract)	37 (62.16)	15.6 (3.3)	4.9 (2.4)	56.75% IP with LGS 43.24% IP without LGS	NS	NS	Number of participants encountered complications: • *Severe hypoglycemia: 0* • *DKA: 0*
F Alawadi 2020 (Journal Article)	30 (46.7)	23.3 (7.85)	8.6 (NS)	91.66% basal bolus insulin 8.33% IP	Pre: 70.2 (17.9) Post: 69.6 (16.7)	Pre: 8.2 (1.0) Post: 7.9 (0.9)	Number of participants encountered complications: • *Hypoglycemia: 16 out of 24* • *Severe hypoglycemia: 0* • *DKA: 1 out of 24*
T Muammar 2022 (Journal Article)	47 (64.3)	13.5 (2.4)	4.9 (3.1)	45.2% CSII 54.8% MDI	Pre: 53.3 (18.0) Post: 54.9 (19.3)	Pre: 9.0 (1.7) Post: 8.7 (1.3)	Frequency of complications occurrence in mean (± SD): • *Hypoglycemia: 1.1 (2.3)* • *DKA: 0.02 (0.15)*
W Kaplan 2015 (Conference Abstract)	21 (NS)	15 (5)	6 (3)	85.71% CSII 14.28% MDI	NS	Pre: 8.6 (1.0)	Frequency of complications occurrence based on CGM: • *Hypoglycemia: 14%* • *Hyperglycemia: 10%* • *Severe hypoglycemia: 0%* • *DKA: 0%*
Sh Abdelghaffar 2022 (Conference Abstract)	109 (NS)	NS	NS	NS	NS	NS	Number of participants encountered complications in fasting group: • *Hyperglycemia: 66 out of 76* • *Hypoglycemia: 60 out 0f 76* • *DKA: 15 out of 76*

Note This table summarizes the characteristics and findings of the studies included in this systematic review and meta-analysis, focusing on individuals with Type 1 Diabetes (T1D) who fast during Ramadan. Due to the heterogeneity of the studies in terms of reporting complications, this table outlines the definitions and parameters used by each study separately. The reported complications are quantified here as either the count of participants who experienced events or the incidence rate relative to the total number of participant days observed, whether in percentage or mean (± SD). Abbreviations and short forms: CGM: Continuous Glucose Monitoring; CSII: Continuous Subcutaneous Insulin Infusion; DKA: Diabetic Ketoacidosis; HbA1c: Hemoglobin A1c; IP: Insulin Pump Therapy; LGS: Low Glucose Suspend; MDI: Multiple Daily Injections; N: Number; NS: Not Specified; % Male: Percentage of Male Participants; Post: Post-Fasting; Pre: Pre-Fasting; ±SD: Plus-Minus Standard Deviation; T1D: Type 1 Diabetes

Discussion

To our knowledge, this study is the first systematic review and meta-analysis that evaluated the association between fasting and glycemic control indexes in adolescent T1DM patients.

Fasting and hypoglycemia and hyperglycemia in young type 1 diabetes (T1DM) patients

The possible consequences of fasting for adolescent T1DM patients have been a subject of controversy for a while and a variety of adverse effects have been reported for fasting among T1DM patients. Kaplan et al. monitored the blood glucose levels of 21 individuals with a mean age of 15 (SD:5) who fasted in Ramadan for 3 days. It was observed that only 14% of subjects

Table 2 Quality Assessment of included studies using the Newcastle-Ottawa Scale

Reference (Study Design)	Selection	Comparability	Outcome (Cohort) / Exposure (Case-Control)	Total Score	Quality
	NOS QA for Cohort Studies (Max score: 4) *1. Representativeness of the exposed cohorts (score: 0–1)* *2. Selection of the non-exposed cohorts (score: 0–1)* *3. Ascertainment of exposure (score: 0–1)* *4. Demonstrating outcome of interest not being present at the start of the study (score: 0–1)*	NOS QA for Cohort Studies (Max score: 2) • *Comparability of cohorts on the basis of the design or analysis controlled for cofounders (score: 0–2)*	NOS QA for Cohort Studies (Max score: 3) *1. Assessment of the outcome (score: 0–1)* *2. Follow-up being long enough for outcomes to occur (score: 0–1)* *3. Adequacy of follow-up of cohorts (score: 0–1)*		
	NOS QA for Case-Control Studies (Max score: 4) *1. Case definition adequacy (score: 0–1)* *2. Representativeness of the case (score: 0–1)* *3. Selection of controls (score: 0–2)* *4. Definition of controls*	NOS QA for Case-Control Studies (Max score: 2) • *Comparability of cases and controls on the basis of the design or analysis (score: 0–2)*	NOS QA for Case-Control Studies (Max score: 3) *1. Assessment of exposure (score: 0–1)* *2. Same method ascertainment for cases and controls (score: 0–1)* *3. non-Response rate (score: 0–1)*		
A Deeb 2017 (Prospective observational study; assessed by NO QA for cohort studies)	1. B; Somewhat representative (1 score) 2. NA 3. B; Structured review (1 score) 4. B; No	B; Study controls for insulin regimen (1 score)	1. C; Self report 2. A; Yes (1 score) 3. A; Complete follow (1 score)	**5**: • *S: 2* • *C: 1* • *O: 2*	**Fair**
B Afandi 2017 (Prospective observational study; assessed by NO QA for cohort studies)	1. B; Somewhat representative (1 score) 2. NA 3. A; Secure records (1 score) 4. B; No	B; Study controls for HbA1c levels (1 score)	1. B; Record linkage (1 score) 2. A; Yes (1 score) 3. D; No statement	**5**: • *S: 2* • *C: 1* • *O: 2*	**Fair**
A Deeb 2016 (Prospective observational study; assessed by NO QA for cohort studies)	1. B; Somewhat representative (1 score) 2. NA 3.B; Structured review (1 score) 4. B; No	B; Study controls for reduction of insulin dosage (1 score)	1. C; Self report 2. A; Yes (1 score) 3. B; Unlikely to introduce bias (1 score)	**5**: • *S: 2* • *C: 1* • *O: 2*	**Fair**
AE Al-Agha 2017 (Prospective single arm pilot study; assessed by NO QA for cohort studies)	1. B; Somewhat representative (1 score) 2. NA 3. A; Secure records (1 score) 4. B; No	B; Study controls for insulin regimen (1 score)	1. B; Record linkage (1 score) 2. A; Yes (1 score) 3. B; Unlikely to introduce bias (1 score)	**6**: • *S: 2* • *C: 1* • *O: 3*	**Fair**
NS Elbarbary 2014 (Prospective observational study; assessed by NO QA for cohort studies)	1. B; Somewhat representative (1 score) 2. NA 3. A; Secure records (1 score) 4. A; Yes (1 score)	C; Cohorts are not controlled for confounders	1. B; Record linkage (1 score) 2. A; Yes (1 score) 3. B; Unlikely to introduce bias (1 score)	**6**: • *S: 3* • *C: 0* • *O: 3*	**Poor**
F Alawadi 2020 (Prospective single-armed interventional study without a control group; assessed by NO QA for cohort studies)	1. B; Somewhat representative (1 score) 2. NA 3. A; Secure records (1 score) 4. A; Yes (1 score)	B; Study controls for fasting status -before and after Ramadan- (1 score)	1. B; Record linkage (1 score) 2. A; Yes (1 score) 3. B; Unlikely to introduce bias (1 score)	**7**: • *S: 3* • *C: 1* • *O: 3*	**Good**
T Muammar 2022 (Retrospective cohort study; assessed by NO QA for cohort studies)	1. B; Somewhat representative (1 score) 2. NA 3.B; Structured review (1 score) 4. B; No	B; Study controls for insulin regimen (1 score)	1. B; Record linkage (1 score) 2. A; Yes (1 score) 3. B; Unlikely to introduce bias (1 score)	**6**: • *S: 2* • *C: 1* • *O: 3*	**Fair**

Table 2 (continued)

Reference (Study Design)	Selection	Comparability	Outcome (Cohort) / Exposure (Case-Control)	Total Score	Quality
W Kaplan 2015 (Prospective observational study; assessed by NO QA for cohort studies)	1. B; Somewhat representative (1 score) 2. NA 3. A; Secure records (1 score) 4. B; No	C; Cohorts are not controlled for confounders	1. B; Record linkage (1 score) 2. A; Yes (1 score) 3. B; Unlikely to introduce bias (1 score)	**5**: • *S: 2* • *C: 0* • *O: 3*	**Poor**
Sh Abdelghaffar 2022 (Case-control study; assessed by NO QA for case-control studies)	1. A/B; Yes (1 score) 2. A; Consecutive representative (1 score) 3. B; Hospital controls 4. A; No history of diseases/endpoint (1 score)	A; Study controls for fasting status (1 score)	1. D; Written self-report /medical history 2. A; Same method for cases and controls (1 score) 3. A; Same rate for both groups (1 score)	**6**: • *S: 3* • *C: 1* • *E: 2*	**Good**

Note This table presents the quality assessment of the included studies, evaluated using the Newcastle-Ottawa Scale Quality Assessment (NOS QA) scale for cohort and case-control studies. The assessment criteria are divided into three main categories: Selection and Comparability, both present in the NOS QA scale for both study designs, and also the Outcome - for cohort study design - or the Exposure – for case-control study design. Each study is evaluated and scored based on the specified criteria, leading to a total score and also a final determination of the study's quality as either "Good", "Fair", or "Poor". Abbreviations and short forms: C: Comparability domain; E: Exposure Domain; HbA1c: Hemoglobin A1c; NA: Not Applicable; NOS QA: Newcastle-Ottawa Scale Quality Assessment; O: Outcome domain; S: Selection domain

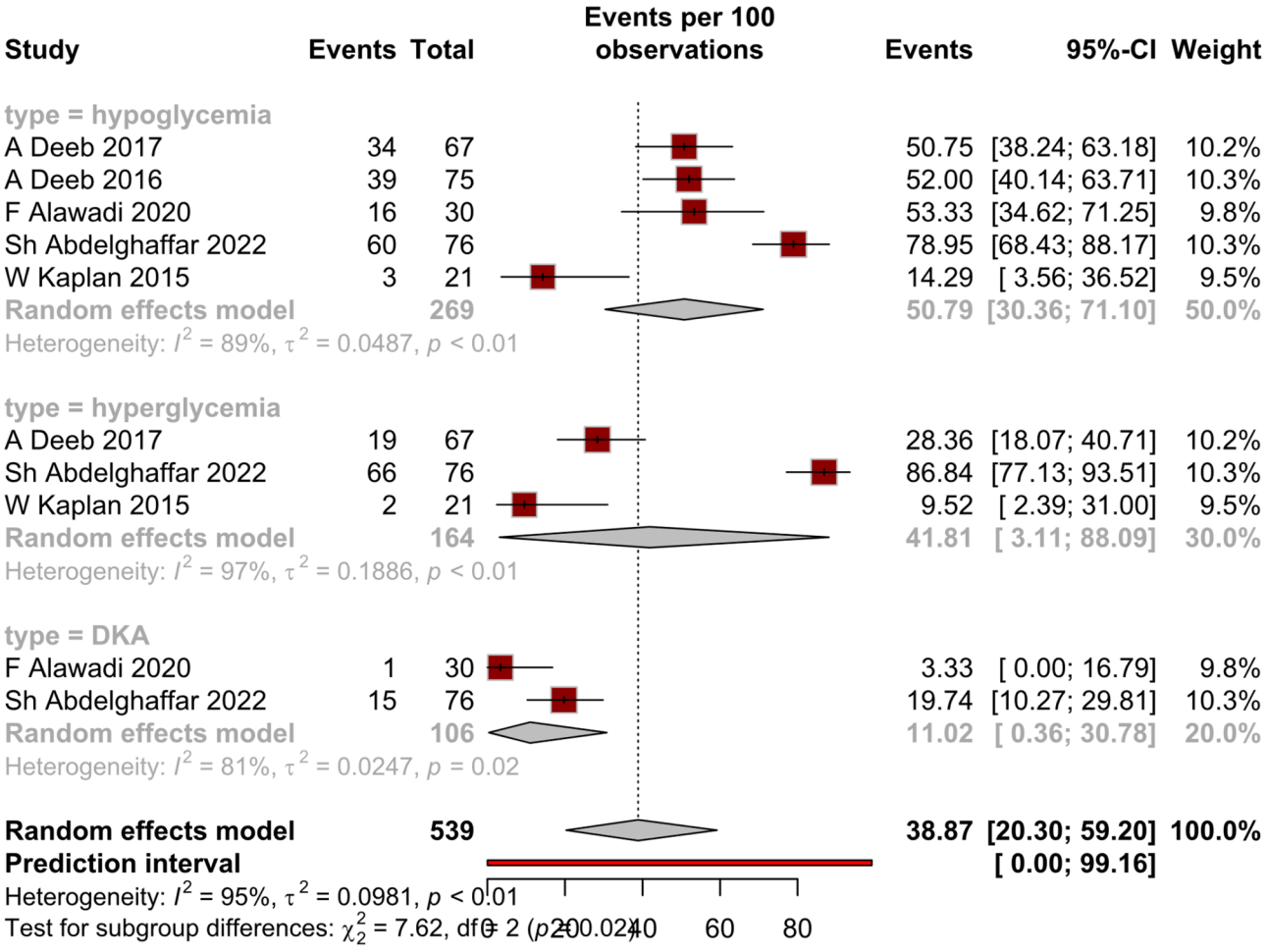

Fig. 2 Result of meta-analysis for Acute complications

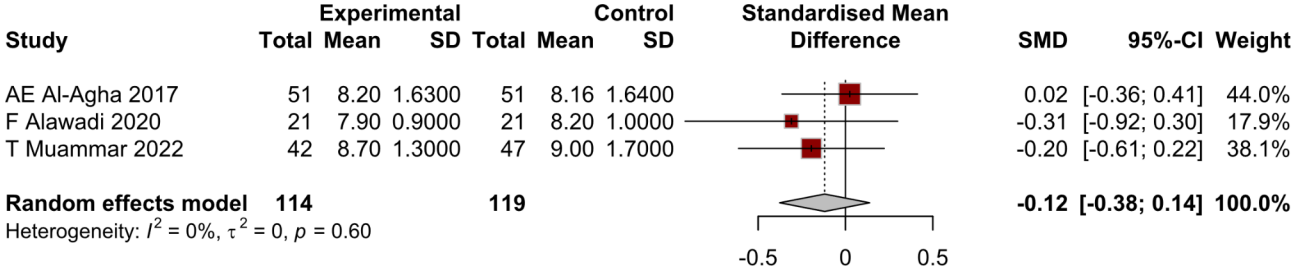

Fig. 3 Results of meta-analysis for changes of HbA1C

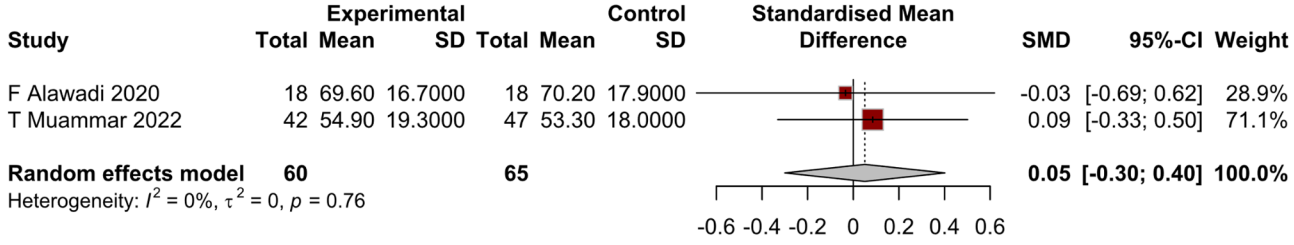

Fig. 4 Results of meta-analysis for changes of weight

experienced hypoglycemic and hyperglycemic events, although the severe fluctuations in the blood glucose level were obvious. It is worth mentioning that none of the subjects experienced severe hypoglycemia [8].

An observational case-control research conducted by Abdelghaffar et al. illustrated that hyperglycemia (incidence rate:86.8%) was the most prevalent side effect of fasting among teenage T1DM patients, followed by hypoglycemia (78.9%). It is worth mentioning that the occurrence rate of hypoglycemia was only slightly higher in the fasting group compared to the control group [9]. Meanwhile, Deeb et al. monitored 65 patients (10–18 years old) for 3 consecutive months (including Ramadan) and reported that 52% of the participants had at least 1 episode of symptomatic hypoglycemia during the fasting days whereas only 29% of them experienced hyperglycemia [10].

Nevertheless, some studies have not reported statistically considerable alterations in the frequency and duration of hyperglycemic and hypoglycemic events during the fasting period in Ramadan. Alawadi et al. monitored 30 T1DM patients' blood sugar levels during Ramadan continuously and demonstrated that 66.7% of individuals encountered hypoglycemia in Ramadan compared to 79% before Ramadan [11].

Due to the blood glucose fluctuations during fasting, T1DM patients who are willing to fast should be advised to check their blood glucose repeatedly [10].

Fasting and diabetic ketoacidosis (DKA) in adolescent T1DM patients

Abdelghaffar et al. illustrated that 19.7% of the fasting group developed DKA and dehydration compared to none in the non-fasting control group [9]. Among 37 subjects assessed by Deeb et al., one of them experienced DKA during the fasting period. The same patient had experienced another episode of DKA 9 months before Ramadan, Due to that, fasting was probably not the only contributing factor of DKA in this patient [10]. One case of DKA among 22 subjects was also reported by Alawadi et al. which occurred as a result of missing insulin injection [11].

Impact of fasting on HbA1c level in adolescent T1DM patients

Several studies have indicated that fasting does not make a noticeable difference in the HbA1c level [10, 12–14]. It was indicated by Alawadi et al. that the average HbA1c level changed from 8.23 before Ramadan to 7.89% after Ramadan [11]. A 2022 research by Muammar et al. did not show a drastic change in the mean blood sugar levels and the average HbA1c levels after fasting during Ramadan [13].

Fasting and weight change in adolescent T1DM patients

The average weight of the subjects followed by Alawadi et al. reduced from 70.2 pre-Ramadan to 69.6 post-Ramadan which was not statistically significant [11]. Muammar et al. also reported that patients did not experience a considerable change in weight after Ramadan fasting regardless of their insulin regimen [13]. Fasting has deteriorated patients' lipid indexes probably because most of them did not follow their physicians' dietary suggestions [9].

Impact of blood glucose monitoring on fasting's complications

Our review revealed that the average level of blood glucose before the fasting period plays a key role in determining fasting outcomes for young individuals suffering from T1DM. Kaplan et al. have compared the frequency of hyperglycemia and hypoglycemia episodes between 7 T1DM patients with a mean HbA1c level of 7.5(SD:0.4) and 14 patients with a mean HbA1c level of 9.1(SD:0.9) who fasted during Ramadan in 2016. It was reported that a higher mean HbA1c level contributed to more frequent episodes of hyperglycemia and hypoglycemia. Due to that, it was concluded that modifying the average blood glucose level before Ramadan fasting would alleviate the possible side effects [15]. However, It was further revealed by Muammar et al. that HbAA1c may not effectively reflect the effects of fasting on individuals in comparison with continuous glucose monitoring (CGM) and flash glucose monitoring (FGM) [13].

Experts suggest young individuals regularly and carefully monitor their blood glucose levels while fasting to minimize fluctuations [10, 12, 13, 15]. Al-Agha et al. revealed that utilizing glucose monitoring sensors (FGM) in young T1DM patients can minimize critical hypoglycemic events and diabetic ketoacidosis (DKA) [12]. Moreover, adolescent individuals are recommended to interrupt their fast in case hypoglycemia or hyperglycemia occurs. However, young people may refuse to break their fast. Therefore, they are more susceptible to adverse effects [10].

Some studies have revealed that fasting is considered safe for T1DM patients with proper glycemic control [9, 11]. Alawadi et al. suggested that selected patients with type 1 diabetes who do not have significant diabetes-related complications may be able to fast safely during Ramadan with appropriate care including glucose monitoring and educational tools [11].

Study limitations

The findings of this systematic review and meta-analysis highlight the potential consequences of fasting for young T1DM patients and the impact of blood glucose monitoring and variable insulin regimens on the outcomes. While some studies report adverse effects such as hyperglycemia, hypoglycemia, and DKA, others suggest that fasting may be safe with proper glycemic control and monitoring. Several studies suggest that pre-Ramadan glycemic indexes, blood glucose level monitoring, and patient education have an important role in determining the outcomes of fasting for adolescent T1DM patients. Further research should focus on addressing the limitations identified in the existing literature and defining a guideline on blood glucose monitoring and insulin dosage adjustments.

Conclusion

The findings of this systematic review and meta-analysis highlight the potential consequences of fasting for young T1DM patients. While some studies report adverse effects such as hyperglycemia, hypoglycemia, and DKA, others suggest that fasting may be safe with proper glycemic control and monitoring. Hypoglycemia was the most prevalent reported complication of fasting for adolescent T1DM patients in our review, followed by hyperglycemia. Diabetic Ketoacidosis (DKA) was also noted as a possible complication however, the incidence rate was lower compared to hypoglycemia and hyperglycemia. The impact of fasting on HbA1c levels and weight was also assessed however, the effect was not remarkable.

Several studies suggest that the pre-Ramadan glycemic indexes, blood glucose level monitoring and patient education might have an important role in determining the outcomes of fasting for adolescent T1DM patients. However, the evidence regarding this issue remains inconclusive and requires further investigation. Further research should focus on addressing the limitations identified in the existing literature and defining a guideline on blood glucose monitoring and insulin dosage adjustments.

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Author contributions

OS, AS: Conceptualization, Project Administration, Data curation, Writing-Original Draft, Writing – Review & Editing, Visualization. A.H, F.N, F.E, DA: Validation, Resources, Methodology, Software, Formal analysis, Writing – Original Draft. MA, MB, ABM: Writing- Original Draft, Writing – Review & Editing.

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Data availability

All data has been presented in the manuscript.

Declarations

Ethical statement

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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