

Fasting Ramadan in Yemeni Patients with Type 1 and Type 2 Diabetes: A Comparative Study on the Ability to Fast in 2 Consecutive years

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Background: Fasting is obligatory for all healthy adult Muslims in the month of Ramadan, one of Islam's five pillars. Over 50 million diabetics fast annually, emphasizing the necessity for specialized care.

Aim: The study focused on the ability of diabetic patients in Yemen too fast for two consecutive years during Ramadan.

Methodology: A total of 573 Patients (343 females and 230 males, including 19 adolescents aged 12–19 years) participated in the study. The patients answered a questionnaire regarding how they fasted in 2022 and after fasting Ramadan in 2023 they were contacted to ask how they had fasted and reasons for breaking their fast. The patients' medications were adjusted according to the Diabetes and Ramadan guidelines (DAR). Statistical analysis was used for ANOVA and chi-square tests to investigate correlations and differences. Frequencies and percentages were used to describe qualitative data. Binary logistic regression analysis was used to calculate odds ratio and 95% confidence intervals.

Results: The percentage of patients that fasted all of Ramadan was 84% and among those that broke their fast, hyperglycemia and hypoglycemia were the primary reasons for this. We found that there were significant associations between breaking fasting patterns and age ($p = 0.023$), type 1 diabetes ($p = 0.041$), insulin use ($p = 0.017$), and those that had a history of breaking their fast in a previous year ($p < 0.001$). The levels of HbA1c, duration of diabetes, body mass index (BMI), and level of education were not significantly related to developing hypoglycemia.

Conclusion: The study shows different factors affecting fasting Ramadan in diabetic patients in Yemen over 2 years. It emphasizes the need for personalized care plans, focused educational initiatives for teenagers and adults with diabetes, and ongoing initiatives to improve the health of Yemeni people with diabetes for fasting during Ramadan.

Keywords: Ramadan fasting, diabetic patients, glycemic control, hypoglycemia prevalence, fasting behavior, diabetes care

Introduction

Ramadan, the ninth lunar month in the Islamic calendar, holds significant importance for Muslims worldwide, as it is a period of obligatory fasting for all adult Muslims in good health. This practice, one of the five pillars of Islam, is observed for approximately 30 days, with the exact duration varying due to the lunar calendar's 355-day cycle.^{1,2} As a result, the timing of Ramadan shifts annually, sometimes coinciding with extreme weather conditions.³

Fasting during Ramadan can be particularly challenging for individuals with diabetes, who may experience fluctuations in blood sugar levels. Despite this, many diabetic patients choose to fast, with an estimated 112 million individuals with diabetes observing this practice annually.⁴ Those with type 1 diabetes and those with type 2 diabetes on insulin are especially vulnerable to experiencing hypo- or hyperglycemia during fasting.⁵

Global organizations working on this issue in 2017 included the International Diabetes Federation and the Diabetes and Ramadan (DAR) International Alliance developed guidelines to assist physicians in adjusting medication regimens and identifying high risk patients who should avoid fasting.^{2,6} With these guidelines, doctors and nurses can better advise

and assist their Ramadan patients.⁷ Studies have shown that a significant proportion of patients with type 2 diabetes (94%) fasted for at least 15 days during Ramadan.^{8,9}

In Yemen, we conducted a study on patients with diabetes to determine their ability to fast during Ramadan. The aim was to ascertain the ratio of patients who adhered to fasting and the count of those who had to discontinue their fasting regimen due to hypo/hyperglycemia or other causes in 2022. Some of these patients had their medication doses modified by physicians or themselves, while others maintained their regular medication regimen without any adjustments. After observing the fasting period of Ramadan in 2023, the patients were contacted regarding their ability to fast. Notably, all patients had their medication regimens modified during Ramadan, adhering to the instructions outlined by the DAR.⁶

Materials and Methods

Study Design

This was a comparative study done over 2 years in 3 Diabetes clinics. These clinics were located in two tertiary centers (university of science and technology hospital and Ibn Sina hospital) and a specialized private endocrinology clinic all of them are located in Sana'a Yemen.

Study Population

A total of 573 patients, among them 343 females and 230 males, including 19 adolescents aged 12–19 years (18 of them had type 1DM and one of them had type 2 diabetes),

Ethical Considerations

To participate in the trial, each patient signed an informed consent form including a parent or legal guardian of patients under 18 years of age.¹⁰ The University of Science and Technology Hospital's ethical review committee accepted the project. The Helsinki Declaration was followed throughout the study.¹¹

Inclusion Criteria

All patients that were at an age 12 or older with type 1 or type 2 diabetes that had been diagnosed at least one year prior to their visit were asked to participate in the study. Patients were considered to have type 1 DM on the basis of their past history if they were referred from other clinics or on what was documented in their files from previous visits.

Exclusion Criteria

Patients that had diabetes for less than one year, and pregnant women with type 1 or type 2 or gestational diabetes were excluded from the study. During the clinic visits, the patients underwent capillary glucose check by a glucometer, blood pressure, BMI, HbA1c, and creatinine measurements. The BMI was categorized to Underweight (BMI<18.5); Normal (BMI 18.5–24.9); Overweight (BMI 25–29.9); Obesity (BMI≥30).¹²

Data Collection

The patients came to the clinics to care for their diabetes in the three months leading up to Ramadan 1444 hijri (2023). Every participant in the trial had a minimum duration of one year of diabetes before the start of the study.

The patients were requested to complete a questionnaire about their fasting experience during the previous year's Ramadan, namely in the 1443 hijri (2022) period (Table 1). They were asked to indicate whether they were capable of fasting for the whole month or whether they had to interrupt their fast, along with providing the reasons for not being able to fast. The patients were also queried regarding their approach to managing hypoglycemia, including if they modified their medications and, if so, whether this was done under the guidance of a physician or independently. The patients received advice on fasting, and the drugs were modified by the DAR guidelines or as deemed suitable by the physician.² The patients were instructed to discontinue fasting during hypoglycemia. The patients were requested to consent to be contacted after Ramadan to inquire whether they could observe fasting and, if not, the rationale behind discontinuing the fast.

Table 1 The Study Tool for the Collection of Patient Data

Variable	N	%
Fasting Ramadan in the past		
Yes	553	96.5
No	20	3.5
Cause of not fasting		
Comorbid condition	8	40.0
Advised by Doctor	5	25.0
Not allowed by parents or family	1	5.0
High or low blood sugars	6	30.0
Type of medication		
Mixed insulin	99	17.3
Basal bolus	13	2.3
Mixed + regular insulin	27	4.7
Mixed + OHA	58	10.1
Reg + NPH	6	1.0
Mixed + basal	6	1.0
OHA including sulfonylurea	265	46.2
OHA without sulfonylurea	88	15.4
Other	7	1.2
Basal and OHA	4	0.7
An episode of hypoglycemia < 70 mg/dl while fasting		
Yes	131	22.9
No	442	77.1
Time of hypoglycemia		
Dawn to noon	20	15.3
Noon till asr(afternoon)	36	27.5
Asr till maghrib (sunset)	70	53.4
After breaking fast	5	3.8
Treatment of hypoglycemia		
No treatment continued fast	68	51.9
Broke fast	54	41.2
Needed medical help	6	4.6
Needed assistance at home	3	2.3
Monitoring during Ramadan		
No monitoring	165	28.8
Only if symptomatic or occasional	308	53.8
1/day	57	9.9
2–3 times/day	41	7.2
>3 times/day	2	0.3
How many days did you break your fast last Ramadan other than menstruation		
No		84.3
1–10	62	10.8
11–20	11	1.9
21–30	17	3.0
Hyperglycemia during Ramadan > 300 mg/dl		
Yes	231	40.3
No	342	59.7
Management of Hyperglycemia		
Managed at home	129	55.8
Visited Doctor	6	2.6
Went to hospital	1	0.4
Nothing done	95	41.1

(Continued)

Table 1 (Continued).

Variable	N	%
Planning to fast this year		
Yes	563	98.3
No	10	1.7
Adjustment of dose of insulin or medications last year during Ramadan		
Yes	160	27.9
No	413	72.1
If medicine adjustment		
On your own	33	20.6
The advice of Dr.	125	78.1
The advice of someone with no medical background	2	1.3
Receiving any education in the past regarding managing diabetes during Ramadan		
Yes	217	37.9
No	356	62.1
If yes, type of education		
Lecture	7	3.2
By doctor in person	169	77.9
Brochure	21	9.7
Online	20	9.2
Did you come to this visit to get better control of diabetes before Ramadan?		
Yes	71	12.4
No	502	87.6
Before last Ramadan, who followed you for your diabetes?		
Endocrinologist	277	48.3
Internist	99	17.3
Pediatrician	1	0.2
No regular follow-ups with different doctors each time	196	34.2
How many days did you break your fasting this year?		
No	404	83.1
1–10	53	10.9
11–20	6	1.20
21–30	23	4.7
Missing	87	
Reasons for not fasting		
Comorbid condition	29	35.4
Advised by Doctor	1	1.2
High or low blood sugars	52	63.4

Abbreviations: Reg, regular insulin; OHA, oral hypoglycemic agents; NPH, neutral protamine Hagedorn insulin.

After Ramadan, out of the 573 patients that had answered the questionnaire during their office visit before Ramadan 2023 only 489 patients answered the phone for follow-up after completing fasting Ramadan, but 87 individuals did not, possibly due to inadequate coverage in some remote regions and a small number of patients providing the incorrect number. We made three attempts to contact the patients who did not answer the phone. The timeline of the study can be seen in [Figure 1](#).

Statistical Analysis

To tabulate and analyze the data, the statistical program IBM SPSS V.26 was used. Graphical methods (histogram and Q-Q plot) and statistical tests (Kolmogorov–Smirnov and Shapiro–Wilk tests) were used to test the normality of continuous variables which are normally distributed in this study. Mean and standard deviation were used to present the quantitative variables, and the differences were examined by the Student's *t*-test.

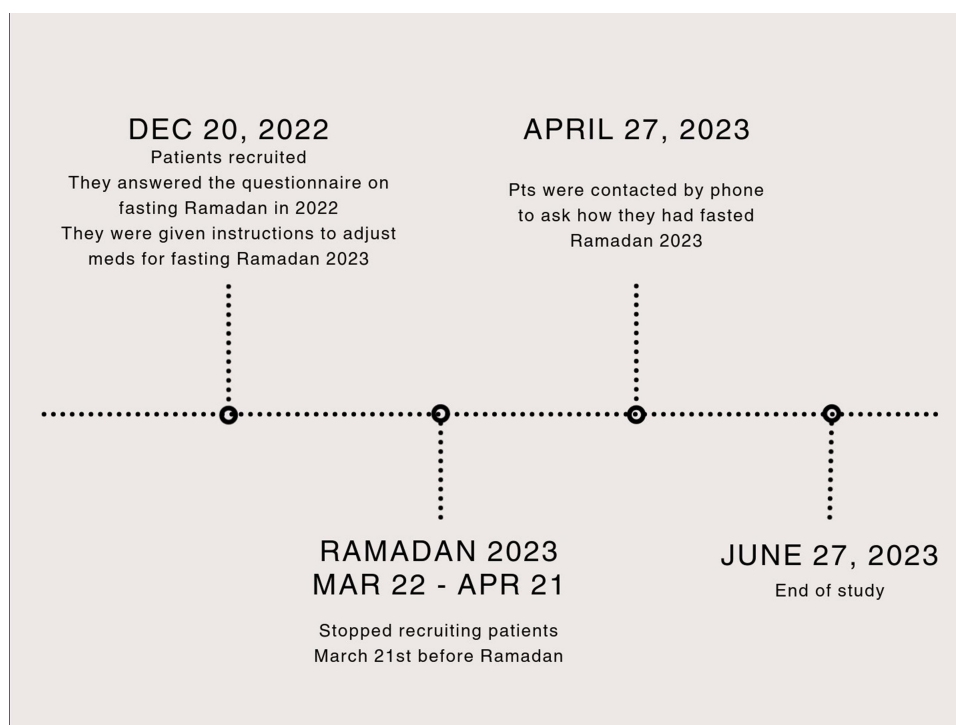


Figure 1 Timeline of the study.

Frequencies and percentages were used to describe the qualitative data, and the χ^2 were used to assess the associations and binary logistic regression analysis was used to calculate odds ratios and the corresponding 95% Confidence Intervals (CIs) for outcomes in relation to the independent variables. Variables with p-value less than 0.2 were included in the multiple logistic regression model to calculate the adjusted odds ratio in relation to the outcomes. Statistical significance was determined by a p-value lower than 0.05.

Results

The study involved a cohort of 573 individuals who actively participated in the research. They were asked to answer a questionnaire (Table 1).

Most participants (59.9%) were female, with 40.1% male. The age distribution is vast, with a large share of people aged 50–59 (29.1%) and ≥ 60 (32.6%). Illiteracy was the largest category (49.7%), followed by higher education (18.5%). A large percentage (36.5%) was overweight, whereas 34.0% normal weight and 25.8% were obese, while only 3.7% were under weight. The demographic and clinical factors analysis yielded interesting findings among patients diagnosed with Type 1 and Type 2 diabetes mellitus (DM). There was no statistically significant variation in the distribution of gender between patients with Type 1 and Type 2 DM ($p = 0.428$). Nevertheless, the study revealed a substantial association ($p < 0.001$) between body mass indexes (BMI). Patients with Type 1 and Type 2 diabetes exhibit a variety of BMI patterns. Just 2.7% of patients only with type 1 diabetes were obese, while the prevalence of type 2 diabetes was significantly higher in overweight patients (93.3%) and obese patients (97.3%) compared to the general population ($p < 0.001$) of the study, the mean BMI was $26.9 (\pm 5.2)$.

Most had normal systolic and diastolic blood pressure, with 75.4% having SBP below 140 mmHg and 83.8% below 90. About 29.8% of individuals have hypertension (SBP ≥ 140 and DBP ≥ 90). Most of the patients had high random capillary glucose levels during their office visit that was above 200 mg/dl in 55.1%. Furthermore, only (6.0%) patients show >1.2 mg/dL creatinine level. The HbA1c levels were measured in all patients at their office visit before Ramadan 2023. It was found that there was no statistically significant difference in hypoglycemia between patients with HbA1c levels below 7 (24.3%), between 7 and 8.9 (24.9%), and equal to or exceeding 9 (21.2%), the mean HbA1c was $9.2\% (\pm$

2.5) with the p value 0.620. Type 2 diabetes accounts for 89.2% of cases, while diabetes duration is evenly distributed. These data give a complete picture of the participating patients' health, establishing the groundwork for additional analysis and interpretation (Table 2).

Table 2 General Features of The participants

Variable	Mean±SD	N	%
Gender			
Male		230	40.1
Female		343	59.9
Age (year)	50.8±14.9		
<20		19	3.3
20–29		39	6.8
30–39		59	10.3
40–49		102	17.8
50–59		167	29.1
≥60		187	32.6
Educational level			
Illiterate		285	49.7
Can read and write		13	2.3
Basic education		103	18.0
High school		66	11.5
Higher education university		106	18.5
BMI (Kg/m ²)	26.9±5.2		
Underweight (BMI<18.5)		21	3.7
Normal (BMI 18.5–24.9)		195	34.0
Overweight (BMI 25–29, 9)		209	36.5
Obesity (BMI≥30).		148	25.8
Systolic BP (mmHg)	123.5±23.2		
≥140		141	24.6
<140		432	75.4
Diastolic BP (mmHg)	77.8±11.3		
≥90		93	16.2
<90		480	83.8
Hypertension SBP ≥140 and DBP ≥90			
Yes		171	29.8
No		402	70.2
RBS (mg/dl)	234.7±110.4		
<140		111	19.4
140–200		146	25.5
>200		316	55.1
Missing			
Creatinine mg/dL	0.8±0.4		
>1.2		33	6.0
≤1.2		521	94.0
Missing		19	
HbA1c (%)	9.2±2.5		
<7		107	19.0
7–8.9		193	34.2
≥9		264	46.8
Missing		9	

(Continued)

Table 2 (Continued).

Variable	Mean±SD	N	%
Type of Diabetes			
Type 1 DM		62	10.8
Type 2 DM		511	89.2
Duration of DM	9.4±6.3		
1-<5		149	26.0
5-<10		171	29.8
10-<15		126	22.0
15 and above		127	22.2

Abbreviation: DM, diabetes mellitus.

Factors Influencing the Breaking of Fasting Patterns Among the Teenagers

There were 19 diabetic teenagers 18 patients with type 1 diabetes mellitus and only 1 with type 2 diabetes mellitus in the study, and their diabetes mellitus (DM) durations varied. Last Ramadan, 52.6% of adolescent patients did not break their fast and 47.4% did. Among the teenagers, 70.6% did not break their fast during the current year and among those who did not fast cite family constraints, medical advice, and blood sugar issues as their main causes with only 21.1% breaking their fast more than 15 days. Regarding prescriptions, the majority used mixed insulin (26.3%), mixed with regular insulin (21.1%), and basal-bolus regimen (36.8%), respectively. The main explanation given by all participants who did not fast was either high or low blood sugar. Our findings highlight the significance of providing tailored medical guidance and blood sugar control tactics to diabetic teenagers throughout Ramadan, especially those who are using mixed insulin regimens (Table 3).

Table 3 Characteristics of Adolescents with Diabetes (n=19)

Variable	N	%
Duration of DM (year)		
1-<5	10	52.6
5-<10	7	36.8
10-<15	1	5.3
≥15	1	5.3
How many days did you break your fast last Ramadan other than menstruation		
Fast	9	47.4
1-5	4	21.1
6-10	2	10.5
11-15	0	0.0
16-20	1	5.3
>20	3	15.8
Fasting Ramadan in the past		
Yes	16	84.2
No	3	15.8
Cause of not fasting		
Advised by doctor	1	33.3
Not allowed by parents or family	1	33.3
High or low blood sugars	1	33.3

(Continued)

Table 3 (Continued).

Variable	N	%
How many days did you break the fast this year?		
Fast	12	70.6
1–5	1	5.9
6–10	0	0.0
11–15	1	5.9
16–20	1	5.9
>20	2	11.8
Reasons for not fasting		
High or low blood sugars	5	100.0
Type of medication		
Mixed insulin	5	26.3
Basal bolus	7	36.8
Mixed + regular insulin	4	21.1
Reg + NPH	1	5.3
Other	1	5.3
Basal insulin +OHA	1	5.3

Predictors of Fasting Adherence During Ramadan

The analysis of fasting practices over the most recent Ramadan in 2022 revealed noteworthy connections between various demographic and clinical factors. It is observed that a small portion of females (13.4%) broke their fast in comparison to males (19.1%). However, this disparity did not achieve statistical significance ($p = 0.065$). A significant association ($p < 0.001$) exists between age and fasting performance. Breaking fast was least common among those aged 30–39 (6.8%) and most among those aged ≥ 60 (12.0%), excluding teenagers. Education had little effect on fasting ($p = 0.273$). The prevalence of breaking the fast was significantly greater in patients with type 1 DM (45.2%) compared to patients with type 2 DM (12.1%), indicating a significant connection ($p < 0.001$). The fasting behavior of people was significantly influenced by the kind of medication ($p < 0.001$). Those taking mixed insulin (31.3%) and mixed insulin with regular insulin (37.0%) had higher rates of breaking fasting. Whereas those on oral agents with or without sulfonylureas were the least likely to break their fast ($p < 0.02$ OR 0.24) this can be seen in [Table 4](#).

Table 4 Breaking Fasting Last Ramadan Among Some Variables in 2022

Variable	Yes		No		p-value	OR	95% CI
	N	%	N	%			
Gender							
Male	44	19.1	186	80.9	0.065	1.53	0.97, 2.40
Female	46	13.4	297	86.6			
Age (year)	46.6±19.0		51.6±13.8		0.019		
<20	10	52.6	9	47.4	<0.001	6.05	2.26, 16.19
20–29	15	38.5	24	61.5	0.002	3.41	1.60, 7.26
30–39	4	6.8	55	93.2	0.096	0.40	0.13, 1.18
40–49	12	11.8	90	88.2	0.385	0.73	0.35, 1.49
50–59	20	12.0	147	88.0	0.338	0.74	0.40, 1.37
≥ 60	29	15.5	158	84.5	Ref		

(Continued)

Table 4 (Continued).

Variable	Yes		No		p-value	OR	95% CI
	N	%	N	%			
Educational level							
Illiterate	36	12.6	249	87.4	Ref		
Can read and write	2	15.4	11	84.6	0.771	1.26	0.27, 5.91
Basic education	18	17.5	85	82.5	0.225	1.46	0.79, 2.71
High school	15	22.7	51	77.3	0.039	2.03	1.04, 3.99
Higher education university	19	17.9	87	82.1	0.183	1.51	0.82, 2.77
Type of Diabetes							
Type 1 DM	28	45.2	34	54.8	<0.001	5.96	3.39, 10.51
Type 2 DM	62	12.1	449	87.9			
Duration of DM (year)	10.2±6.4		9.2±6.3		0.158		
1-<5	21	14.1	128	85.9	Ref		
5-<10	22	12.9	149	87.1	0.748	0.90	0.47, 1.71
10-<15	20	15.9	106	84.1	0.680	1.15	0.59, 2.23
≥15	27	21.3	100	78.7	0.120	1.65	0.88, 3.08
Type of medication							
Mixed insulin	31	31.3	68	68.7	0.628	1.25	0.50, 3.13
Mixed+(regular insulin, OHA or Basal)	23	25.3	68	74.7	0.880	0.93	0.36, 2.37
OHA with/without sulfonylurea	28	7.9	325	92.1	0.002	0.24	0.10, 0.58
Others	8	26.7	22	73.3	Ref		
Breaking fast this year							
Yes	35	42.7	47	57.3	<0.001	6.09	3.56, 10.43
No	44	10.9	360	89.1			

Predicting Fasting Adherence: Insights from Previous Ramadan Experiences

Remarkable findings emerged from an analysis of people's reasons for having to break their fasts during the current and prior Ramadan. This year, 83.2% of those who had to break their fast did so regularly, compared to 16.9% who did so sporadically (16.9% of the time) in the last year. The significant finding was that 81.3% of individuals had to break their fast in both years ($p < 0.001$) showing a high level of consistency in their fasting behavior (Table 5). The results of this study highlight the necessity of providing focused interventions and assistance to people who have previously broken their fast during Ramadan to enhance their subsequent fasting experiences.

Analyzing breaking fasting patterns during Ramadan in 2023 revealed significant associations with various demographic and clinical variables. Age demonstrated a significant association ($p < 0.001$), with individuals aged 30–39 having the lowest percentage of breaking their fast (12.5%), and those aged 20–29 having the highest (50.0%).

Table 5 Number of People Who Had to Break Their Fast Both Years During Ramadan

Breaking Fast Ramadan 2023	Breaking Fast in Ramadan 2022					
	Yes		No		Total	
	N	%	N	%	N	%
Yes	35	7.2	47	9.7	82	16.9
No	44	9.1	360	74.1	404	83.2

Notes: The figure shows the percentage of breaking fast in both years (highlighted area) = $7.2+74.1= 81.3\%$.

Educational levels did not significantly impact breaking fasting ($p = 0.141$). Patients with type 1 diabetes exhibited a higher tendency to break their fast (42.0%) compared to patients with type 2 diabetes (14.0%), revealing a significant association ($p < 0.001$). The type of medication also significantly influenced breaking fasting behavior ($p < 0.001$), with individuals on mixed insulin (26.3%) and mixed with regular insulin (46.2%) demonstrating higher rates of breaking their fast. These findings underscore the importance of considering demographic and diabetes-related factors when assessing fasting behavior during Ramadan in 2023 (Table 6).

The HbA1c levels were measured in all patients at their office visit before Ramadan 2023. It was found that there was no statistically significant difference in hypoglycemia between patients with HbA1c levels below 7 (24.3%), between 7 and 8.9 (24.9%), and equal to or exceeding 9 (21.2%) with the p value 0.620.

According to Multiple logistic regression analysis (Table 7) to calculate the adjusted odds ratio, male patients were more likely to break their fast in Ramadan 2022 than females (p value 0.024, AOR 1.75). Patients aged 30–39 years were less likely to break their fast in the Ramadan 2022 (p value 0.041, AOR 0.32). However, patients aged 20–29 years were more likely to break their fast in Ramadan 2023 (p -value 0.07 AOR 3.13).

Table 6 Breaking Fasting Ramadan Among Some Variables in 2023

Variable	Yes		No		p-value	OR	95% CI
	N	%	N	%			
Gender							
Male	38	19.1	161	80.9	0.277	1.30	0.81, 2.10
Female	44	15.3	243	84.7			
Age (year)	45.5±17.1		51.8±14.1		0.002		
<20	5	29.4	12	70.6	0.139	2.36	0.76, 7.32
20–29	16	50.0	16	50.0	<0.001	5.65	2.48, 12.87
30–39	6	12.5	42	87.5	0.664	0.81	0.31, 2.12
40–49	15	16.3	77	83.7	0.790	1.10	0.54, 2.24
50–59	17	11.8	127	88.2	0.417	0.76	0.39, 1.48
≥60	23	15.0	130	85.0	Ref		
Educational level							
Illiterate	30	12.6	208	87.4	Ref		
Can read and write	1	11.1	8	88.9	0.894	0.87	0.10, 7.18
Basic education	17	20.0	68	80.0	0.100	1.73	0.90, 3.37
High school	12	21.4	44	78.6	0.093	1.89	0.90, 3.98
Higher education university	22	22.4	76	77.6	0.025	2.01	1.09, 3.69
Type of Diabetes							
Type 1 DM	21	42.0	29	58.0	<0.001	4.45	2.39, 8.30
Type 2 DM	61	14.0	375	86.0			
Duration of DM (year)	9.3±5.9		9.2±6.5		0.907		
1-<5	22	16.7	110	83.3	Ref		
5-<10	21	14.2	127	85.8	0.566	0.83	0.43, 1.58
10-<15	21	20.8	80	79.2	0.422	1.31	0.68, 2.55
≥15	18	17.1	87	82.9	0.923	1.03	0.52, 2.05
Type of medication							
Mixed insulin	21	26.3	59	73.8	0.694	0.83	0.33, 2.10
Mixed+(regular insulin, OHA or Basal)	23	29.1	56	70.9	0.928	0.96	0.38, 2.40
OHA with/without sulfonylurea	29	9.8	268	90.2	0.002	0.25	0.11, 0.60
Others	9	30.0	21	70.0	Ref		
Breaking fasting last Ramadan 2022							
Yes	35	44.3	44	55.7	<0.001	6.09	3.56, 10.43
No	47	11.5	360	88.5			

Table 7 Multiple Logistic Regression of Factors Associated with Breaking Fasting 2022 and Ramadan 2023

Variable	p-value	AOR	95% C.I
Breaking fasting Ramadan 2022			
Gender	0.024	1.75	1.08, 2.85
Age (30–39 y)	0.041	0.32	0.11, 0.95
Type of Diabetes	<0.001	3.21	1.7, 6.06
OHA with/without sulfonylurea	<0.001	0.30	0.17, 0.52
Breaking fasting Ramadan 2023			
Age (20–29 y)	0.007	3.13	1.37, 7.16
OHA with/without sulfonylurea	0.005	0.46	0.26, 0.79
Breaking fasting last Ramadan	<0.001	4.41	2.49, 7.82

Abbreviation: OHA, oral hypoglycemic agents.

Those with type 1 diabetes were more likely to break their fast Ramadan 2022, and those on OHA were less likely to break their fast in 2022 and 2023 (p-values <0.001 and 0.005, AORs 0.30 and 0.46, respectively), and those with a history of breaking their fast in the previous year were more likely to break their fast again (p-value <0.001, AOR 4.41).

Discussion

Fasting during Ramadan is a unique challenge for individuals with diabetes mellitus since it might impact blood sugar levels. Our study in Yemen was designed to examine how people with diabetes fasted and changed their medications and what happened to them in Ramadan 2022 and 2023. The study's conclusions indicate that a sizable percentage of people with diabetes (96.5%) had fasted during Ramadan. This observation is consistent with the worldwide pattern documented in the CREED study.⁹ About 94% of people with type 2 diabetes in that study reported fasting for at least 15 days during Ramadan in various nations. The fact that many patients with diabetes fast highlights the significance of meeting their unique requirements during this religious practice.

Significantly, our findings demonstrate that a substantial proportion of individuals with diabetes encountered hypoglycemia when fasting, as seen by 22.9% reporting instances of blood glucose levels falling below 70 mg/dL. The prevalence mentioned aligns with the results of a global investigation, which documented a hypoglycemia occurrence rate of 21.4% in one study during Ramadan and 23% in another study.^{13,14} The occurrence of hypoglycemia occurred mainly in the afternoon in our patients 53.4% and 80.9% between noon and sunset, in another study which was done on adolescents showed that the majority of hypoglycemia almost 70% occurred between 10 am and 7 pm.¹⁵ Studies have shown that the incidence of hypoglycemia is higher during Ramadan than in other months 0.14 episodes vs 0.03 in other months. It is advised by experts to decrease the dose of insulin, this is usually emphasized on decreasing the basal insulin by 30–40% and take it after iftar and the sahoor dose of fast acting insulin should also be reduced by 25–50%, if the patient is on mixed insulin then the sahoor dose needs to be decreased by 25–50%.^{2,6} The results regarding the adolescents with diabetes who broke their fast due to hypo or hyperglycemia in 2022 were 52.6% and those breaking their fast for more than 20 days in Ramadan was 15.8%. This improved in 2023 to 70.6% who were able to fast Ramadan completely and 11.8% who had to break their fast >20 days. This is a much higher rate of breaking their fast when compared to another study done on 50 children and adolescents with type 1 diabetes on the insulin pump or basal bolus regimen in which 7.8% only had to break their fast during Ramadan due to hypoglycemia.¹⁶ Another study done on adolescents with type 1 DM also on basal bolus or insulin pumps showed that 79.9% were able to fast the whole month of Ramadan, the percentage of patients that broke their fast were 20.1% out of these 29.1% were due to hypoglycemia.¹⁷ This highlights the challenges faced by the adolescent population who are not on a basal bolus regimen or insulin pumps. Although 31.7% of the patients in our study were on insulin, only 7.5% of all of our patients checked their blood sugars twice or more daily, 28.8% did not monitor their blood sugars at all, and 53.8% checked their blood sugars only when they were symptomatic. This makes it difficult to adjust the medication and insulin doses accordingly. The DAR

guidelines 2017 recommend that high-risk patients check their blood sugars up to seven times a day.² Even though patients were urged to check their blood sugar more frequently, many of our patients were unable to do so primarily because it was expensive and most of them did not have health insurance. It is recommended that patients who experience hypoglycemia (blood glucose level less than 70 mg/dl) break their fast.² However, out of the 131 patients in our group who developed hypoglycemia, 51.2% broke their fast, while the remaining patients continued to fast until sunset. Just 4.6% of individuals who experienced hypoglycemia needed medical attention, and 2.3% needed help at home. It was stressed to the patients at their clinic visit that they should break their fast if they experience hypoglycemia and that it is dangerous to continue fasting when their blood sugar is low.

Healthcare practitioners must prioritize educating patients on accurately identifying and efficiently managing hypoglycemia. Preventing adverse outcomes requires teaching and coaching about appropriate responses to hypoglycemic episodes. About 40.3% of our patients had hyperglycemia, defined as blood sugar levels higher than 300 mg/dL. Much of the population was able to control their hyperglycemia at home, indicating that better self-management techniques and a greater understanding of when to seek medical assistance are needed. A study reported that during Ramadan, 45.1% of those who took part experienced hyperglycemia.⁸ For most individuals, maintaining their health at home was an option.

The Pre-Ramadan assessment should include a risk stratification and an individualized management plan. DAR risk stratification suggested that certain factors in diabetic patients cause them to be very high risk, and they should be advised not to fast, some of these risk factors are severe hypoglycemia within 3 months before Ramadan; diabetic ketoacidosis within 3 months of Ramadan; history of recurrent hypoglycemia and hypoglycemic unawareness; acute illness; chronic dialysis.^{2,6} The implementation of personalized treatment plans that consider the particular type of diabetes and prescribed medications, alongside offering guidance on fasting during the sacred month of Ramadan, is of the utmost importance. In Yemen, where the majority of people use mixed insulin, regular insulin with NPH insulin, and regular insulin with mixed insulin (total 52.7%), all of which have been associated with an increased risk of hypoglycemia. In 2001, it was found in another study that 78% of patients with type 1 diabetes were treated with only 2 injections/day and 9% of the patients required hospitalization for hypoglycemia during Ramadan.¹⁸ An examination of fasting patterns in 2022 and 2023 revealed a consistent trend among those who broke their fast the previous year. Therefore, targeted interventions and support are necessary for individuals who have a history of having to break their fast to improve their subsequent fasting experiences. Hypoglycemia may not be reliably predicted by HbA1c alone, given that observed fluctuations in HbA1c levels among individuals experiencing fasting-induced hypoglycemia are not statistically significant. In one study, it showed that having a higher HbA1c before Ramadan among diabetic children may protect them against hypoglycemia.¹⁹ In another study, they found that among children having a lower HbA1c before Ramadan was associated with less hypoglycemia.¹⁷ A large number of our patients 46.8% had an HbA1c $\geq 9\%$ mean HbA1c 9.2 (SD 2.5), this is slightly better than to a study done in 2020 which showed that 58.4% of the diabetic patients presenting to an endocrinology clinic had an HbA1c $\geq 9\%$.²⁰ Many of the patients presenting to our clinic stop their medications or replace them with cheaper medications (metformin, glibenclamide) that they can afford also the majority of our patients do not come for regular follow-up as most of them do not have medical insurance.²⁰

It is critical to conduct a comprehensive assessment of the unique characteristics of each person in order to effectively manage blood glucose levels during the sacred month of Ramadan. The DAR guidelines advise adjusting medications during Ramadan to help patients fast.¹³ We followed these guidelines when advising our patients on how to adjust their medications during Ramadan. Our main obstacle was the patients that were on mixed insulin or on regular insulin and mixed insulin, the majority of the patients although being advised to switch to basal bolus regimen or even change to mixed insulin analogues were unable to because of the cost, 33% of our patients were on mixed insulin either alone or in addition to regular insulin or oral hypoglycemic agents which is known to be associated with an increased risk of hypoglycemia.^{6,21} Among our patients on mixed insulin alone after adjustment of their doses according to Dar guidelines, 73.8% were able to fast Ramadan without breaking their fast, those that were on mixed insulin and regular insulin. About 53.8% were able to fast the whole month. The EPIDIAR study showed that 1 in 4 patients on OHA and 1 in 3 patients on insulin changed their doses during Ramadan either up or down.¹⁸ In our study 27.9% of the patients adjusted, their dose of insulin or OHA during Ramadan, 20.6% of them on their own and 78.1% by the advice of a doctor. In our study, the majority of patients on OHA without sulfonylureas were able to fast (93.2% in 2022 and 88.2% in 2023). Patients on

Metformin, DPP-4 inhibitors, SGLT-2 inhibitors and thiazolidinediones usually do not need any change in their medications during Ramadan due to the low risk of hypoglycemia.^{2,6,22}

Conclusion

This study sheds light on the challenges faced by individuals with diabetes who observe fasting during Ramadan. This study tracks Yemeni individuals diagnosed with type 1 and type 2 diabetes over 2 years and the challenges they faced while trying to observe their fast during the holy month. Hypoglycemia occurred in many diabetic patients, especially in those with type 1 DM, patients with type 2 DM on mixed insulin, adolescents and older patients. The continued pattern of fasting behavior over the years emphasizes the need for focused interventions for people with a history of breaking fast. This accentuates the need for individualized medical guidance for those with a history of hypoglycemia.

Due to the unavailability of diabetic educators in Yemen, this puts a further burden on the physician to discuss with the patients how to manage their diabetes during Ramadan. The study emphasized the significance of individualized care strategies by finding links between breaking fasting patterns and drug regimens and demographic characteristics.

Ethics Approval and Informed Consent

The ethics committee at the University of Science and Technology Hospital approved the study. Written informed consent was obtained from all study participants including a parent or legal guardian of patients under 18 years of age.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

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