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Differential effects of gender and patient background diversity on the changes in metabolic and biophysical profiles in people with type-2 diabetes from different ethnicities who fast during Ramadan (H1439); a prospective study from Qatar

Zeinab Dabbous [a,*], *Mohammed Bashir* [a], *Abdel-Naser Elzouki* [a], *Mustafa Sid Ahmed* [a], *Seleena Farouk* [a], *Mohamed Hassanien* [b], *Rayaz A. Malik* [c], *Abdul Badie Abou Samra* [a], *Tarik Elhadd* [a], *for the PROFAST Study Group*

[a] *Department of Medicine & Qatar Metabolic Institute, Hamad Medical Corporation, Doha, Qatar*
[b] *Dubai Hospital, Dubai, United Arab Emirates*
[c] *Weill Cornell Medicine-Qatar, Doha, Qatar*

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ABSTRACT

Objective: The '**PRO**spective Study of dose adjustment of multiple anti-diabetic therapy for Type-2 diabetic patients **FAST**ing the Month of Ramadan aimed to assess the biophysical and metabolic effects of fasting during Ramadan, including HbA1c, weight, blood pressure and lipid profile.

Study design methods: We performed a prospective study of people with Type-2 diabetes who were on ≥3 drugs for lowering glucose before and after Ramadan of H1438 (May-June 2017) in Hamad Medical Corporation, Qatar. We enrolled 228 participants, of whom 181 completed the study and were included in the analysis.

Results: There were 115 (63.5%) men and 66 (36.5%) women, mean age 53.6 ± 9.7 years and mean diabetes duration of 10 ± 6 years. Both HBA1c [7.8% (62 mmol/mol) vs. 7.6% (60 mmol/mol); p = 0.004]; and diastolic BP (75.7 ± 8.55 vs. 68.8 ± 23.1 mmHg, P = 0.001) improved significantly after Ramadan while there was an increase in total cholesterol (3.94 ± 0.89 mmol/l vs 4.11 ± 1.02 mmol/l; p = 0.008) and triglycerides (1.55 ± 0.72 mmol/l vs 1.71 ± 0.9 mmol/l; p = 0.012). Subgroup analysis showed that patients on sulphonylurea, South Asians and males had a significant reduction in both HBA1c and weight.

Conclusion: Patients with Type 2 diabetes who fast during Ramadan show an improvement in glycaemic control and diastolic blood pressure, but a worsening of total cholesterol and triglycerides, particularly those of South Asian origin and men.

* Corresponding author at: Qatar Metabolic Institute, Hamad Medical Corporation, Doha, Qatar.
E-mail address: zdabbous@hamad.qa (Z. Dabbous).

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1. Introduction & background

Muslims all over the world abstain from eating and drinking from dawn till sunset during Ramadan. Many studies have focused on the harmful impact of Ramadan in people with Type 2 diabetes, particularly in relation to hyperglycaemia and hypoglycaemia [1]. Accordingly, several international professional bodies have developed guidelines to enable safe fasting and have endorsed the view that many patients with diabetes should not fast [2–4]. Some studies have shown an improvement in glycaemic control [5–8] whilst others have shown deterioration [6,9–11]. An observational study of 1301 patients with diabetes in Qatar, showed an improvement in blood glucose, HbA1c, total cholesterol, low-density and high-density lipoprotein cholesterol, triglycerides, and systolic and diastolic blood pressures during Ramadan [8]. In a study of 40 participants with T2DM from Egypt who fasted during Ramadan there was an improvement in glycaemic control, lipid profile and reduced oxidative stress [5]. In a study of 88 participants with T2DM in Iran who fasted during Ramadan there was a significant increase in fasting blood glucose (FBG) and HbA1c [9]. Whilst in a study from Algeria, 60 obese women with T2DM showed a significant improvement in fasting blood glucose and HbA1c, but a deterioration in the lipid profile [11].

Data on the metabolic and biophysical benefits of people with T2DM who fast during the holy month of Ramadan are limited or conflicting. Furthermore, most studies have involved patients who were either on a single or maximum of two therapeutic agents. A change in the biochemical and biophysical profile of diabetic patients taking three or more drugs has hitherto not been studied. 'The '**PRO**spective Study of dose adjustment of multiple anti-diabetic therapy for Type-2 diabetic patients **FAST**ing the Month of Ramadan' (PROFAST Ramadan Study), aimed to assess the biophysical and metabolic effects of fasting during Ramadan. We assessed the change in HbA1c, weight, blood pressure and lipid profile during Ramadan.

2. Patients & methods

Ethical approval for the study was granted from the Institutional Review Board of Hamad Medical Corporation, Doha, Qatar, (reference number **16437/16**) and from each of the local hospitals. People with T2DM were recruited from six diabetes and internal medicine clinics in HMC, Doha, Qatar. Inclusion criteria were: (1) People with T2DM (clinically diagnosed according to WHO criteria for at least 1 year prior to entry into the study); (2) stable treatment for the 6 months prior to enrollment in the study; (3) on $\geq$3 drugs for lowering glucose; (4) HbA1c $\leq$ 85 mmol/mol (9.9%); (5) eGFR > 30 ml/min; (5) Age 18–79 years. Exclusion criteria were: (1) History of recurrent hypoglycaemia or hypoglycaemia unawareness; (2) Admission with more than 2 episodes of diabetic ketoacidosis (DKA) or hyperosmolar non-ketotic coma (HONC) in the preceding year, or an episode of DKA within the preceding 3 months prior to Ramadan; (3) Active coronary artery disease, congestive cardiac failure, or those with advanced comorbidities and/or advanced diabetes complications, who were considered by their clinicians not suitable for the study; (4) Cancer.

Dietary advice, and life style modifications were made according to the latest recommendations by the Diabetes and Ramadan- International Diabetes Federation (DAR-IDF) and American Diabetes Association (ADA) guidelines [1,12]. The patients anti-diabetic medications were adjusted according to the PROFAST Ramadan Study protocol [13]**.** The dose of sulphonylureas was reduced by 50% and the dose of metformin was reduced to 1 g/day, if on >2 g in all patients during Ramadan. The dose of basal insulin was reduced by 25% and taken at Iftar (meal taken when the fast is broken in the early evening). For twice daily premixed insulin the first dose was taken at *Iftar* and the second dose was reduced by 25%–50% and taken at Sohoor (the meal before commencing the fast). Flexibility was given to those on basal bolus, basal plus or more complex insulin regimens based on individual circumstances as well as HbA1c and self-monitoring of home blood glucose. The dose of pioglitazone, dipeptidyl peptidase 4 inhibitors (DPP-4i), sodium-glucose co-transporter-2 inhibitors (SGLT-2i) or glucagon-like peptide-1 analogues (GLP1-RA) were not altered. Participants were consented and enrolled 4–8 weeks before Ramadan (Visit A), when they received standard counseling, dietary and lifestyle advice and dose adjustment This advice was reinforced during Ramadan via a telephone call by the attending physician after the first 10 days of Ramadan. The timing was agreed upon between the physician and the patient during visit A and the patient was given a mobile number to call in case he/she had any queries or emergency. Visit B, took place 4–8 weeks after Ramadan, when data were collected on episodes of hypoglycaemia (whether symptomatic or measured), number of days fasted and any visit to the Emergency Department (ED). Participants were classified into 4 groups: Group A on a sulphonylyurea (SU); Group B on insulin; Group C on both insulin and a SU and Group D if on neither insulin or SU.

2.1. *Statistical analysis*

Categorical data were reported as number (percentages) while numerical data were reported as mean ± SD. Descriptive statistics were performed to analyze frequencies of the study variables. A paired student *t*-test was used to explore changes in the variables before and after Ramadan. P values of less than 0.05 were considered statistically significant. Statistical analysis was performed using STATA 15 soft-ware (College Station, TX: Stata Corp LP).

3. Results

We enrolled 228 participants, 181 of whom completed the study and were included in the analysis. Table 1 shows the baseline characteristics of the study population. There were 115 males (63.5%) and 66 females (36.5%) with a mean age of 53.5 ± 9.7 years, mean weight of 83.3 ± 14.5 kg, mean dia-

Table 1 – Baseline Characteristics. Data is expressed as mean ± standard deviation and percentages.

	Total (181)			
Mean age	53.5 ± 9.8 Years			
Gender (%)	Males	Females		
	115 (63.5%)	66 (36.5%)		
Ethnicity (%)	Qatari	Arab	Asian	
	51 (28.2%)	74 (40.9%)	56 (30.9%)	
Mean duration of diabetes	10.6 ± 6.5 Years			
Mean weight	83.3 ± 14.5 kg			
Mean HBA1C	7.8 ± 1.0%			
Groups	A	B	C	D
	97(53.6%)	55(30.4%)	17(9.4%)	12(6.6%)
Number of medications	3 Medications	≥4 Medications		
	101 (56.4%)	78 (43.6%)		

betes duration of 10.6 ± 6.5 years, and mean HBA1C of 7.8 ± 1.0%. The majority of the study group were Middle Eastern/Arab [74 (40.9%)]. Group A (SU+) had 97 patients (53.6%), Group B (insulin+) had 55 patients (30.4%), group C (Insulin and SU) had 17 patients (9.4%) and group D (neither insulin or SU) had 12 patients (6.6%). The mean number of days fasted by the participants was 28 days.

Table 2 shows the cardiometabolic changes over the month of Ramadan. HbA1c (62 mmol/mol (7.8%) to 60 mmol/mol (7.6%), $P = 0.004$) and diastolic blood pressure (75.7 ± 8.55 to 68.8 ± 23.1 mmHg, $P = 0.001$) decreased significantly while there was no change in systolic BP (132.4 ± 17.6 to 130.6 ± 16.5 mmHg, $P = 0.16$) and body weight (85.9 ± 15.8 to 85.7 ± 16.2 kg, $P = 0.25$). Total cholesterol (3.94 ± 0.89 to 4.11 ± 1.02 mmol/l, $P = 0.008$) and triglycerides (1.55 ± 0.72 to 1.71 ± 0.9 mmol/l, $P = 0.012$) increased significantly, but there was no change in HDL-cholesterol (1.02 ± 0.29 to 1.03 ± 0.27 mmol/l, $P = 0.977$) or LDL cholesterol (2.2 ± 0.72 to 2.25 ± 0.82 mmol/l, $P = 0.343$).

3.1. *Effect of medication*

Table 3 compares the cardiometabolic changes pre-and post-Ramadan. HBA1c was significantly reduced only in group A (60 mmol/mol (7.6%±1.0) vs 57 mmol/mol (7.4 ± 1.0%); p = 0.009). Weight was significantly reduced in groups A (85.0 ± 15.8 kg vs 84.6 ± 15.9 kg p = 0.047) and B (87.8 ± 16.1 kg vs 87.2 ± 15.9 p = 0.047). Total cholesterol was increased in group C (3.9 ± 0.8 mmol/l vs 4.5 ± 1.3 mmol/l p = 0.05), while triglycerides was increased in group A (1.5 ± 0.8 mmol/l vs 1.8 ± 1.1 mmol/l p = 0.014). Systolic BP was significantly reduced in group D (135.1 ± 16.9 mmHg vs. 127.1 ± 13.6 mmHg p = 0.03).

3.2. *Effect of ethnic background*

The South Asian group demonstrated a significant reduction in HbA1c [63 mmol/l mol (7.9 ± 1.1% vs 57 mmol/mol (7.4 ± 0.9%) $p < 0.001$] and weight (79.0 ± 13.4 kg vs 78.0 ± 12.8 $p < 0.001$), but worsening of triglycerides (1.5 ± 0.7 mmol/l vs 1.8 ± 1.1 mmol/l p = 0.038) (Table 4). The Qatari group showed a deterioration of total cholesterol (3.9 ± 0.8 mmol/l vs 4.2 ± 1.0 mmol/l p < 0.003) and in LDL cholesterol (2.0 ± 0.5 mmol/l vs 2.2 ± 0.7 p < 0.012).

3.3. *Gender*

Men showed a significant reduction in weight (87.9 ± 16.9 vs 87.3 ± 16.9 p < 0.001), HbA1c [63 mmol/l (7.9 ± 1.1%) vs 60 mmol/l (7.6 ± 1.1%) p = 0.005] and systolic BP (134 ± 16.7 mmHg vs 129 ± 15.9 mmHg p = 0.002) with an increase in total cholesterol (3.8 ± 0.8 mmol/l vs 4.0 ± 1.0 mmol/l p = 0.02) and triglycerides (1.5 ± 0.7 vs 1.7 ± 0.8 P = 0.016) (Table 5).

3.4. *Emergency department visits*

Six participants attended the ED during Ramadan for presentations unrelated to fasting and diabetes.

Table 2 – Change in biophysical and metabolic parameters during Ramadan.

	Pre Ramadan	Post Ramadan	P value
HbA1c mmol/mol (%)	62 (7.82 ± 1.1)	60 (7.61 ± 1.0)	0.004
Weight (Kg)	85.94 ± 15.88	85.79 ± 16.23	0.25
SBP (mmHg)	132.48 ± 17.67	130.63 ± 16.5	0.16
DBP (mmHg)	75.7 ± 8.55	68.86 ± 23.1	0.001
Total Cholesterol (mmol/l)	3.94 ± 0.89	4.11 ± 1.02	0.008
Triglycerides (mmol/l)	1.55 ± 0.72	1.71 ± 0.9	0.012
HDL (mmol/l)	1.02 ± 0.29	1.03 ± 0.27	0.977
LDL (mmol/l)	2.20 ± 0.72	2.25 ± 0.82	0.343

HbA1c: glycosylated haemoglobin; SBP: systolic blood pressure; DBP: diastolic blood pressure; HDL: high density lipoprotein; LDL: low density lipoprotein.

Table 3 – Changes in HbA1c, Weight, SBP, DBP, Total cholesterol, Triglycerides, HDL and LDL by Group of medications.

	Group A (SU)			Group B (Insulin)			Group C (SU + Insulin)			Group D (none)		
	Pre Ramadan	Post Ramadan	P value	Pre Ramadan	Post Ramadan	P value	Pre Ramadan	Post Ramadan	P value	Pre Ramadan	Post Ramadan	P value
HbA1c mmol/mol (%)	60 (7.6 ± 1.0)	57 (7.4 ± 1.0)	0.009	63 (7.9 ± 1.1)	62 (7.8 ± 0.9)	0.244	63 (7.9 ± 1.1)	61 (7.7 ± 1.2)	0.214	67 (8.3 ± 1.3)	65 (8.1 ± 1.3)	0.352
Weight (kg)	85.0 ± 15.8	84.6 ± 15.9	0.047	87.8 ± 16.1	87.2 ± 15.9	0.047	89.8 ± 19.1	91.0 ± 20.3	0.144	88.4 ± 19.3	87.2 ± 16.3	0.421
SBP (mmHg)	130.8 ± 16.2	130.6 ± 15.4	0.926	135.5 ± 18.7	132.6 ± 17.5	0.279	130.1 ± 17.1	128.5 ± 18.1	0.665	135.1 ± 16.9	127.1 ± 13.6	0.033
DBP (mmHg)	77.3 ± 8.3	77.0 ± 7.9	0.747	75.1 ± 7.7	75.3 ± 7.6	0.835	71.2 ± 9.2	69.0 ± 8.8	0.284	76.9 ± 7.4	77.2 ± 6.2	0.859
TC (mmol/l)	4.0 ± 0.9	4.1 ± 1.0	0.202	3.8 ± 0.7	3.9 ± 0.9	0.189	3.9 ± 0.8	4.5 ± 1.3	0.05	4.0 ± 1.0	4.2 ± 1.3	0.405
Triglyceride (mmol/l)	1.5 ± 0.8	1.8 ± 1.1	0.014	1.5 ± 0.5	1.6 ± 0.7	0.07	1.5 ± 0.6	1.3 ± 0.5	0.104	1.4 ± 0.5	1.3 ± 0.5	0.509
HDL (mmol/l)	1.0 ± 0.3	1.0 ± 0.3	0.914	1.0 ± 0.2	0.9 ± 0.2	0.460	1.2 ± 0.5	1.2 ± 0.4	0.686	1.0 ± 0.1	1.0 ± 0.2	0.343
LDL (mmol/l)	2.2 ± 0.8	2.2 ± 0.8	0.946	2.2 ± 0.6	2.2 ± 0.8	0.448	2.1 ± 0.6	2.4 ± 0.7	0.228	2.3 ± 0.9	2.5 ± 1.2	0.484

SU: sulphonylurea; HbA1c: glycosylated haemoglobin; SBP: systolic blood pressure; DBP: diastolic blood pressure; TC: Total cholesterol; HDL: high density lipoprotein; LDL: low density lipoprotein.

Table 4 – Changes in HbA1c, Weight, SBP, DBP, Total cholesterol, Triglycerides, HDL and LDL by patient background group.

	Arab			South Asian			Qatari		
	Pre Ramadan	Post Ramadan	P value	Pre Ramadan	Post Ramadan	P value	Pre Ramadan	Post Ramadan	P value
HbA1c mmol/mol (%)	62 (7.8 ± 1.0)	61 (7.7 ± 1.1)	0.459	63 (7.9 ± 1.1)	57 (7.4 ± 0.9)	0.001	61 (7.7 ± 0.9)	60 (7.6 ± 1.0)	0.377
Weight (kg)	92.9 ± 16.5	92.6 ± 16.4	0.480	79.0 ± 13.4	78.0 ± 12.8	0.001	85.3 ± 15.9	85.1 ± 16.0	0.592
SBP (mmHg)	132.2 ± 17.9	128.9 ± 14.7	0.123	132.7 ± 15.9	129.4 ± 16.1	0.122	132.0 ± 19.5	134.8 ± 18.8	0.282
DBP (mmHg)	74.9 ± 8.7	74.9 ± 7.9	0.978	78.6 ± 7.8	77.0 ± 8.9	0.106	74.1 ± 7.62	75.1 ± 7.0	0.440
Cholesterol (mmol/l)	4.0 ± 0.9	4.1 ± 1.0	0.089	3.89 ± 0.9	3.89 ± 0.9	0.988	3.9 ± 0.8	4.2 ± 1.0	0.003
Triglycerides (mmol/l)	1.5 ± 0.	1.6 ± 0.6	0.384	1.5 ± 0.7	1.8 ± 1.1	0.038	1.6 ± 0.6	1.7 ± 0.9	0.283
HDL (mmol/l)	1.0 ± 0.3	1.0 ± 0.3	0.813	0.9 ± 0.3	0.9 ± 0.2	0.738	1.0 ± 0.3	1.1 ± 0.3	0.482
LDL (mmol/l)	2.3 ± 0.8	2.4 ± 0.9	0.496	2.2 ± 0.7	2.0 ± 0.8	0.109	2.0 ± 0.5	2.2 ± 0.7	0.012

HbA1c: glycosylated haemoglobin; SBP: systolic blood pressure; DBP: diastolic blood pressure; HDL: high density lipoprotein; LDL: low density lipoprotein.

Table 5 – Changes in HbA1c, Weight, SBP, DBP, Total cholesterol, Triglycerides, HDL and LDL by Gender.

	Male			Females		
	Pre Ramadan	Post Ramadan	P value	Pre Ramadan	Post Ramadan	P value
HbA1c mmol/mol (%)	63 (7.9 ± 1.1)	60 (7.6 ± 1.1)	0.005	61 (7.7 ± 1.0)	60 (7.6 ± 0.9)	0.054
Weight (kg)	87.9 ± 16.9	87.3 ± 16.9	0.0014	82.6 ± 14.8	82.3 ± 14.7	0.209
SBP (mmHg)	134 ± 16.7	129 ± 15.9	0.002	128 ± 18.9	132 ± 17.3	0.904
DBP (mmHg)	77.0 ± 7.9	76.5 ± 8.3	0.521	73.9 ± 8.6	74.0 ± 7.3	0.993
Cholesterol (mmol/l)	3.8 ± 0.8	4.0 ± 1.0	0.022	4.1 ± 0.8	4.2 ± 0.9	0.216
Triglycerides (mmol/l)	1.5 ± 0.7	1.7 ± 0.8	0.016	1.5 ± 0.8	1.6 ± 1.0	0.366
HDL (mmol/l)	0.9 ± 0.3	0.9 ± 0.2	0.600	1.1 ± 0.2	1.1 ± 0.2	0.254
LDL (mmol/l)	2.2 ± 0.7	2.2 ± 0.7	0.621	2.2 ± 0.7	2.3 ± 0.8	0.393

HbA1c: glycosylated haemoglobin; SBP: systolic blood pressure; DBP: diastolic blood pressure; HDL: high density lipoprotein; LDL: low density lipoprotein.

4. Discussion

Fasting during the month of Ramadan has been shown to have beneficial effects on insulin sensitivity in healthy young men [14]. However, in people with T2DM there are conflicting data on the change in biochemical and biophysical variables [11,15–17]. Most studies have included small numbers of participants and assessed limited variables. The PROFAST Ramadan study was performed in a relatively large number of participants with T2DM treated with a complex drug regimen (3 or more agents). In our cohort of patients that included people from different nationalities and ethnic backgrounds, we have shown that in the overall study group there was an improvement in HbA1c and diastolic blood pressure, but a worsening of the total cholesterol and triglycerides, which appears to be influenced by the patients' background. The beneficial effect on weight, glycaemic control and diastolic blood pressure and worsening of triglycerides was confined to South Asians. The favourable effects were not seen in the Qatari's or other Arabs. Furthermore, the Qatari's showed a worsening of the total cholesterol and LDL cholesterol, whilst the other Arabs showed neither an improvement nor worsening of their biophysical or biochemical variables.

The diversity of our population in Qatar allowed us to compare the effect of nationality background, and ethnicity on biophysical and biochemical markers in our study groups. Differing cultural and dietary habits are likely to have played a major role in the differences observed in our study. The South Asian participants demonstrated the greatest improvement in glycaemic control and weight, likely due to the fact that they are mostly manual workers who undertake greater physical exercise during Ramadan. A study of 29 South East Asians with T2DM fasting during Ramadan also showed a comparable improvement in HbA1c [18].

Studies examining the effect of Ramadan on body weight, serum lipid profile and blood pressure have shown conflicting results. We have shown no change in weight or systolic blood pressure with a significant increase in the total cholesterol and triglycerides, but no change in HDL- and LDL- cholesterol. A systemic review has shown a significant deterioration in the lipid profile of participants with diabetes but no change in participants without diabetes [10]. In a study from Tunisia of 38 participants with T2DM who fasted during Ramadan, there was a decrease in weight and HDL cholesterol and an increase in LDL cholesterol, but no change in blood pressure [16]. In our cohort, whilst weight did not change overall, those on sulphonylureas or a combination of insulin and sulphonylureas showed a decrease in weight, which may be attributed to the reduction in the dosage of these medications prior to Ramadan. A study from Turkey of 52 patients with T2DM treated with diet or sulphonylureas did not show a significant change in weight during Ramadan [17]. In a study of 39 overweight participants with T2DM treated with oral hypoglycaemic agents (OHA), there was also no change in body weight, with an increase in total cholesterol but no change in triglycerides [15]. In a study from Singapore, participants who fasted during Ramadan increased their proportion of fat intake, which may have contributed to a lack of change in weight [18]. A study from Tehran in 57 participants with T2DM showed an increase in Body mass index (BMI) in women, but a decrease in both BMI and waist-hip ratio in men, with no change in blood pressure, fasting blood glucose and serum fructosamine [19].

Our study also showed some gender influence on the studied variables. Ramadan fasting in males resulted in a reduction in weight, systolic blood pressure and HbA1c, but an increased in total cholesterol and triglycerides. On the other hand, females showed only a trend for an improvement in HbA1c, and neutral effects on the other measures. Some of the differential effects in the South Asians may primarily be driven by gender, as they were mainly males (85%) and conversely, this may also have influenced outcomes in Qatari group as 70% were females and they are less likely to be physically active compared to males. The distribution of medications, primarily insulin and sulphonylureas was not skewed in any of the three groups. The South Asian group had only 17 subjects on SU and therefore, differences in medication is unlikely to have influenced the observed changes in this group.

Focused education has been shown to improve lipids and glycaemic control in people with T2DM who fast during Ramadan [20]. A prospective study comparing 40 participants without diabetes to 40 participants with diabetes who fasted during the month of Ramadan reported a significant 23% improvement in fasting blood sugar in participants with diabetes, with no change in the non-diabetic group [5]. A study

from Singapore showed that the mean HbA1c improved from 74 mmol/mol (8.9%) to 70 mmol/mol (8.6%) during Ramadan [6].

Both a strength and a limitation of our study is the complex combinations of antidiabetic medications used and the multi-national, multiethnic population studied. The relatively small number of the subgroups may have biased some of the results, which is not an avoidable limitation. Further, as some of these differences could be affected by the BMI, it would have been better to have the BMI of the subjects. We have data on weight, but we do not have data on patients heights to calculate BMI. Another limitation could be the timing of assessments, which were within 8 weeks before and after Ramadan and may have impacted on the change in glycaemic control and the lipid profile. It may have also been better to use fructosamine rather than HbA1c as it would better reflect short term change in glycaemic control. We also have no details on the dietary habits and caloric intake before and after Ramadan and we have not assessed the effect of social class.

5. Conclusion

Our study has shown that fasting during Ramadan is associated with an improvement in glycaemic control and diastolic blood pressure but a deterioration in the total cholesterol and triglyceride levels, which were most prominent in South Asians and in men.

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Conflict of interest

None declared.

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REFERENCES

[1] Hassanein M, Al-Arouj M, Hamdy O, Bebakar WMW, Jabbar A, et al. Diabetes and Ramadan: practical guidelines. Diabet Res Clin Pract 2017;126:303–16.

[2] Salti I, Benard E, Detournay B, Bianchi-Biscay M, Le Brigand C, et al. A population-based study of diabetes and its characteristics during the fasting month of Ramadan in 13 countries: results of the epidemiology of diabetes and Ramadan 1422/2001 (EPIDIAR) study. Diabet Care 2004;27:2306–11.

[3] Ali S, Davies MJ, Brady EM, Gray LJ, Khunti K, et al. Guidelines for managing diabetes in Ramadan. Diabet Med 2016;33:1315–29.

[4] Al-Arouj M, Assaad-Khalil S, Buse J, Fahdil I, Fahmy M, et al. Recommendations for management of diabetes during Ramadan: update 2010. Diabet Care 2010;33:1895–902.

[5] Al-Shafei AI. Ramadan fasting ameliorates oxidative stress and improves glycemic control and lipid profile in diabetic patients. Eur J Nutr 2014;53:1475–81.

[6] Siaw MY, Chew DE, Dalan R, Abdul Shakoor SA, Othman N, et al. Evaluating the effect of Ramadan fasting on Muslim patients with diabetes in relation to use of medication and lifestyle patterns: a prospective study. Int J Endocrinol 2014;2014:308546.

[7] M'guil M, Ragala MA, El Guessabi L, Fellat S, Chraibi A, et al. Is Ramadan fasting safe in type 2 diabetic patients in view of the lack of significant effect of fasting on clinical and biochemical parameters, blood pressure, and glycemic control? Clin Exp Hypertens 2008;30:339–57.

[8] Bener A, Yousafzai MT. Effect of Ramadan fasting on diabetes mellitus: a population-based study in Qatar. J Egypt Public Health Assoc 2014;89:47–52.

[9] Norouzy A, Mohajeri SM, Shakeri S, Yari F, Sabery M, et al. Effect of Ramadan fasting on glycemic control in patients with type 2 diabetes. J Endocrinol Invest 2012;35:766–71.

[10] Salim I, Al Suwaidi J, Ghadban W, Alkilani H, Salam AM. Impact of religious Ramadan fasting on cardiovascular disease: a systematic review of the literature. Curr Med Res Opin 2013;29:343–54.

[11] Khaled BM, Bendahmane M, Belbraouet S. Ramadan fasting induces modifications of certain serum components in obese women with type 2 diabetes. Saudi Med J 2006;27:23–6.

[12] Marathe PH, Gao HX, Close KL. American diabetes association standards of medical care in diabetes 2017. J Diabet 2017;9:320–4.

[13] Elhadd T, Dabbous Z, Bashir M, Elzouki A, Ghadban W, et al. Incidence of hypoglycaemia in patients with type-2 diabetes taking multiple glucose lowering therapies during Ramadan: the PROFAST Ramadan study. J Diabet Metab Disord 2018.

[14] Gnanou JV, Caszo BA, Khalil KM, Abdullah SL, Knight VF, et al. Effects of Ramadan fasting on glucose homeostasis and adiponectin levels in healthy adult males. J Diabet Metab Disord 2015;14:55.

[15] Laajam MA. Ramadan fasting and non-insulin-dependent diabetes: effect on metabolic control. East Afr Med J 1990;67:732–6.

[16] Bouguerra R, Jabrane J, Maatki C, Ben Salem L, Hamzaoui J, et al. Ramadan fasting in type 2 diabetes mellitus. Ann Endocrinol (Paris) 2006;67:54–9.

[17] Sari R, Balci MK, Akbas SH, Avci B. The effects of diet, sulfonylurea, and Repaglinide therapy on clinical and metabolic parameters in type 2 diabetic patients during Ramadan. Endocr Res 2004;30:169–77.

[18] Yeoh EC, Zainudin SB, Loh WN, Chua CL, Fun S, et al. Fasting during Ramadan and associated changes in glycaemia, caloric intake and body composition with gender differences in Singapore. Ann Acad Med Singapore 2015;44:202–6.

[19] Yarahmadi S, Larijani B, Bastanhagh MH, Pajouhi M, Baradar Jalili R, et al. Metabolic and clinical effects of Ramadan fasting in patients with type II diabetes. J Coll Phys Surg Pak 2003;13:329–32.

[20] Tourkmani AM, Abdelhay O, Alkhashan HI, Alaboud AF, Bakhit A, et al. Impact of an integrated care program on glycemic control and cardiovascular risk factors in patients with type 2 diabetes in Saudi Arabia: an interventional parallel-group controlled study. BMC Fam Pract 2018;19:1.