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Original Article

# Biochemical, Physiological and Body Composition Changes in Patients with Type 2 Diabetes during Ramadan Fasting

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## Abstract

**Context:** During the month of Ramadan, healthy Muslims must fast from dawn until sunset. However, religious rulings dispense the sick from this duty. During the fast, diabetic patients, are predisposed because of their disease, to an increased risk of hypoglycemia, loss of diabetes control, dehydration especially in summer and thromboembolic complications. **Objectives:** In order to better categorize the indications for the fasting of the month of Ramadan by people with type 2 diabetes mellitus (T2DM), we studied the effects of fasting on clinical; and biological parameters, dietary behavior, and physical activity. **Subjects and Methods:** We conducted an observational, descriptive, comparative study of patients with T2DM and 16 age- and sex-matched controls. **Results:** The average age of patients was 52 ± 4 years, and the mean duration of diabetes was 7 ± 4 years. The fasting did not seem to affect the anthropometric parameters and the glycemic control. For the lipid profile, fasting significantly increased high-density lipoprotein-cholesterol ($P$ = 0.004), total cholesterol ($P$ = 0.001) and triglycerides ($P$ = 0.04). Dietary intake decreased from 54% before Ramadan to 47% in Ramadan ($P$ = 0.001), and the intake of lipids increased from 27% to 37% during Ramadan ($P$ = 0.001), in particular, the intake of polyunsaturated fatty acids, which doubled between the two periods ($P$ = 0.009). Physical activity also showed a significant increase in patients and controls combined, essentially represented by the prayer of Tarawih. **Conclusions:** The Ramadan fast is well tolerated by T2DM patients, treated by diet or oral antidiabetic medications. They can stay free from serious complications, through regular medical support and self-monitoring. However, it is necessary for patients allowed to fast by their physician, to ensure a proper nutrition and obtain diabetes education.

**Keywords:** Diabetes, fasting, tolerance

## Introduction

The month of Ramadan, the 9th month of the Islamic lunar calendar, is a holy month in the Muslim religion. During this period, Muslims must fast from dawn until sunset. The Holy Qur'an specifically exempts people with a medical reason from observing the fast, especially if this can have negative consequences on their health.[1] During the fasting, diabetic patients, because of their pathology, are exposed to an increased risk of hypoglycemia, loss of diabetes control, dehydration (especially in summer) and thromboembolic complications. Also, there are disturbances of chronobiology due to a change in the daily rhythm, marked by frequent disturbances in sleep, and a nocturnal diet. Because of all this, it is recommended for patients with T2DM who are uncontrolled, unstable, or have diabetes-related complications to avoid fasting.[1,2] Some patients proceed with fasting despite their physician's disagreement and the presence of a religious exemption.[1] We aimed to study the consequences of fasting and changes in eating habits on certain clinical and biological parameters in a group of diabetic patients compared to a control group and to derive some recommendations based on the results obtained.

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## Subjects and Methods

### Study design

We conducted an observational, descriptive and comparative study. We included 31 subjects divided into two groups: group 1 composed of 15 patients with T2DM, recruited from patients attending the National Institute of Nutrition in

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Tunis and group 2 of age- and sex-matched 16 non-diabetic controls from the staff of the National Institute of Nutrition or their family circle. The exclusion criteria were type 1 diabetes (T1DM), pregnant and lactating women and those with very poorly controlled T2DM or on insulin and patients with diabetic complications (proliferative retinopathy and nephropathy) or poorly controlled hypertension. All of them decided to fast the month of Ramadan 1431 Hijri year, which coincided with the period from August 20, 2009, to September 21, 2009, with an average duration of fasting of 15 hours/day. The study was approved by the IRB of the Tunis Medical School, and all subjects consented to participation in the study.

### Outcome measures

Patients were evaluated over three different periods: T1 of 20 to 30 days before the beginning of the month of Ramadan, T2; the second period, during the month of Ramadan, and T3 the third period (T3): 20 to 30 days after the end of the month of Ramadan. During each visit, the body weight was recorded, and blood samples were collected for fasting blood sugar, serum lipids, serum creatinine, uric acid, and C-peptide. They also undertook a food survey, using the 24-hour recall method, and the Lucie Randorn's food composition table. The results of which were processed using the Bilnut software and a determination of the percentage of fat mass (FM) and lean mass (LM) using an impedance meter. Blood samples for glycated hemoglobin (HbA1c) analysis were taken during visit 1 and visit 3. Hypoglycemic events and other complications of fasting, if any, were recorded in visit 2. The data for each patient was entered in a case report form at the initial visit and in the subsequent follow-up visits. Baseline data included demographic variables, diabetic history, any concomitant illness and drug therapy. The aim of the pre-Ramadan visit (Visit 1) was to assess the physical well-being of the patients, assess their diabetic control and educate them in adjusting their diet and timing of medication during the month of Ramadan. They were advised to break their fast as soon as any complication was noted or in the case of blood glucose ≤60 mg/dl or ≥300 mg/dl. A glucometer and strips were provided to the patients and the controls. However, they were instructed to carry on with their usual living habits and physical activity.

### Statistical analysis

The various parameters were entered using the SPSS software SPSS Statistics for Windows, Version 17.0. (SPSS 43 Inc Chicago, USA) and expressed on the average ± standard deviation. We used analysis of variance (ANOVA) and nonparametric tests Kruskal-Wallis for the comparison of quantitative values and the Chi-square test for comparison of the percentages.

## Results

### Clinical Observations

There were 15 diabetic patients (6 males and 9 females) mean age 52.0 ± 4.9 (Range 46-65) years and 16 control (7 males and 9 females) with the mean age of 50.8 ± 4.9 (range 44-59) years. The mean duration of diabetes was 7.1 ± 5.0 years with extremes of 2 and 20 years. Diabetic patients observed an average of 29.4 ± 1.6 days of fasting versus 28.0 ± 3.2 days of fasting for controls ($P$ = not significant [NS]). One patient developed hypoglycemia at 60 mg/dl, which occurred before the usual break of fasting. This patient received 2 Metformin tablets and 2 tablets of Glibenclamide. A second patient developed hypoglycemia at 50 mg/dl at about 11 am. This patient received 2 tablets of Metformin and one tablet of Gliclazide. These two patients contacted us by telephone, and the dose of sulfonureas was reduced in these patients and reiterated the importance of the *Suhour* (pre-dawn) meal.

### Body composition and metabolic changes

We observed little change in weight and body mass index (BMI) during Ramadan. However, these two parameters increased significantly between T2 and T3 (respectively: $P$ = 0.002, $P$ = 0.001) [Table 1]. Fasting blood glucose increased from 156 ± 53 mg/dl to 171 ± 61 mg/dl between T1 and T2, but this variation was not statistically significant. Glycemic equilibrium before and after Ramadan was comparable in our patients with respective HbA1c levels of 8.0 ± 1.9% to T1 and 8.1 ± 1.8% to T3 ($P$ = NS). The level of C-peptide increased non-significantly in T2 and then decreased statistically significantly in T3 ($P$ = 0.038) to regain its initial value. We found that total cholesterol increased statistically significantly in T2 ($P$ = 0.001) and then returned to the initial value in T3 ($P$ = 0.01). The mean triglyceride level increased from 1.4 ± 0.9 mmol/l in T1 to 1.7 ± 1.0 mmol/l in T2. This variation was statistically significant ($P$ = 0.04). High-density lipoprotein (HDL)-cholesterol also increased between T1 and T2 ($P$ = 0.057) then returned to initial values at T3 ($P$ = 0.004). At the same time, the LDL-cholesterol level remained stable over the three periods ($P$ = NS) [Table 2].

### Nutritional and physiological changes

Total caloric intake before Ramadan was 2249 ± 385 Kcal/day. It increased in T2, but not significantly, to 2731 ± 711 KCal/day. As for the quantitative nutritional intake, we found a significant decrease in carbohydrate intake ($P$ = 0.01) and a significant increase in lipid intake ($P$ = 0.001) during Ramadan. After Ramadan, total caloric, carbohydrate ($P$ = 0.002) and lipid ($P$ = 0.001) intake regained their initial values. Protein intake remained stable in all the three periods. The ratio of animal proteins to vegetable proteins (PA/PV) increased from 0.87 ± 0.40 to 1.17 ± 0.90 during Ramadan (P = NS). Lipid and dietary fiber intake are reported in Table 3. Intakes of calcium, iron, folate, potassium, phosphorus, magnesium, zinc, vitamins B1, E, and C, remained stable throughout the three periods. Sodium intake remained stable during the period T1 and T2 and then increased significantly after Ramadan ($P$ = 0.04). We found that water intake remained stable over the three periods (T1: 1412 ± 345 ml/day; T2: 1577 ± 387 ml/day; $P$ = NS). Physical activity increased during Ramadan but not significantly [Table 4]. Comparing the evolution of anthropometric parameters during Ramadan

**Table 1: Evolution of anthropometric parameters**

| Parameters | Periods | | |
|---|---|---|---|
| | T1 | T2 | T3 |
| Weight (kg) | 77±10.5 | 76.1±9.8[a] | 77.8±9.9[b] |
| BMI (kg\m²) | 28.7±2.4 | 28.6±2.7[a] | 29.4±3.06[b] |
| WC (cm) | 98.7±3.8 | 99±4.2 | 99.9±3.9 |
| LM (%) | 28.9±8.1 | 27±5.5 | 25.6±4.3 |
| FM (%) | 36.1±10.8 | 35.7±11.2 | 37.9±10.2 |

[a]Significant difference between T2 and T3, [b]Significant difference between T1 and T3. BMI: Body mass index, WC: Waist circumference, LM: Lean mass, FM: Fatty mass.

**Table 2: Evolution of lipid parameters**

| Parameters | Periods | | |
|---|---|---|---|
| | T1 | T2 | T3 |
| Total cholesterol (mmol/l) | 4.56±0.79[a] | 5.08±0.82[b] | 4.76±0.94 |
| Triglycerides (mmol/l) | 1.4±0.88[a] | 1.69±1.01 | 1.39±0.68 |
| HDL-Cholesterol (mmol/l) | 1.14±0.25 | 1.25±0.28[b] | 1.08±0.19 |
| Calculated LDL-Cholesterol (g/l) | 1.1±0.3 | 1.1±0.34 | 1.17±0.28 |

[a]Significant difference between T1 and T2, [b]Significant difference between T2 and T3

**Table 3: Lipid and dietary fiber intake**

| Intake | Periods | | |
|---|---|---|---|
| | T1 | T2 | T3 |
| SFA (TEI%) | 7.82±2.32 | 9.81±2.71[b] | 7.57±2.1 |
| MUFA (TEI%) | 11.82±3.38 | 11.03±6.27 | 13.1±6.32 |
| PUFA (TEI%) | 8.22±5.33[a] | 16.11±6.48[b] | 9.31±5.29 |
| Cholesterol (mg/d) | 228.8±199.5 | 255.2±130.03[b] | 148.9±83.7 |
| Fiber (g/d) | 19.05±5.6 | 17.59±9.97 | 20.72±9.59 |

[a]Significant difference between T1 and T2, [b]Significant difference between T2 and T3. TEI: Total energy intake, SFA: Saturated fatty acid, MUFA: Mono-unsaturated fatty acid, PUFA: Polyunsaturated fatty acid

**Table 4: Evolution of physical activity in the diabetes subgroup only**

| Period | Level of physical activity | | |
|---|---|---|---|
| | Low (<20 min/d) | Moderate [20-60 min/d] | Intense (>60 min/d) |
| T1 | 53.3% | 33.3% | 13.3% |
| T2 | 26.7% | 33.3% | 40% |

between the two groups (T2-T1/T1), we note that weight and BMI decreased in both groups, more in the control group, but these variations were comparable and not significant between the two groups [Table 5]. Although fasting blood glucose and HbA1C levels were significantly higher in diabetic versus pre-Ramadan controls ($P < 0.001$), these two parameters changed similarly during Ramadan in both groups ($P$ = NS). Before Ramadan, the different lipid parameters were comparable between the two groups. While during Ramadan, triglyceride levels increased in diabetic patients by 40% versus 7.7% in controls and this difference was statistically significant ($P = 0.02$). During Ramadan, diabetic patients increased total their caloric intake by 481.7 KCal while controls decreased it by 404 Kcal ($P = 0.003$). Diabetic patients, increased their intake of saturated fatty acids during the month of Ramadan more than controls ($P = 0.04$). Before Ramadan, iron, and potassium were significantly higher in the control group than in the diabetic group ($P = 0.02$, $P = 0.02$, respectively). During Ramadan, patients with diabetes increased their iron intake by 22.8 ± 47%, conversely, controls decreased it by 7.8 ± 31%. This variation was statistically significant ($P = 0.04$).

## Discussion

Despite the relaxation provided by the religion based on the dispensation granted by the Holy Quran to anyone who is sick or vulnerable to fasting, some diabetic patients insist on fasting in the month of Ramadan. Weight, BMI, waist circumference and body fat percentage did not change significantly before and during fasting in diabetic patients. This could be explained by an increased physical activity in our diabetic patients (P = NS) represented by the Tarawih prayer. However, in T3, there was a significant increase in weight and BMI explained by the consumption of traditional sweets and confectionery during the Eid celebrations and a laxity in following the dietetic rules after a month of self-control. Several studies did not find any significant difference in weight, BMI, and body fat percentage before and during Ramadan.[3,4] Indeed, in 2003 Bouguerra *et al*.[5] surveyed 25 well-controlled patients with T2DM treated with diet or oral antidiabetic agents. Weight and body mass index (BMI) remained stable during fasting and 3 weeks after completion of fasting. Conversely, Khaled and Belbraouet[6] in a study of 276 obese type 2 diabetic women, found a significant decrease in weight ($P < 0.01$), while the waist circumference remained stable. Thus these two different studies found contrasting results with regards to the effect of fasting on weight and BMI; this was likely because of the population studied and the period during which the fasting took place.

In our study, the glycemic control of diabetic patients did not undergo any significant changes during fasting. Moreover, fasting glucose before and during Ramadan was comparable between diabetic patients and controls, despite the increase in total calorie intake in diabetic patients (p: NS) and decrease in the control group (P = NS). Numerous studies[3,7,8] have been carried out to evaluate the impact of fasting on the glycemic control of diabetic patients. In the Jabrane study, fasting glucose, fructosamine and mean HbA1C did not change during fasting, as did daily energy intake.[9]

Unlike all other previous studies, Usyal *et al*.[10] T2DM patients reported a significant rise in HbA1C of 7.3 ± 1.6% to 7.6 ± 1.7% ($P = 0.006$) during Ramadan, with a rapid return to normal values 3 weeks after the end of the month of fasting, with weight and BMI remaining stable. We also found a significant increase in the mean peptide C level, reflecting

**Table 5: Comparison of body mass index and waist circumference changes before and during Ramadan between diabetics and controls**

| Parameters | Groups | T1 | *P* (T1) | T2 | (T2-T1)/T1 | *P* (T2-T1/T1)) |
|---|---|---|---|---|---|---|
| Weight (kg) | T2DM | 77±10.5 | NS | 76.1±9.8 | -1±2.1 | NS |
| | Controls | 77.8±10.7 | | 76.6±10.9 | -1.5±2 | |
| BMI (kg/m²) | T2DM | 28.7±2.4 | NS | 28.6±2.7 | -0.27±3.9 | |
| | Controls | 28.3±4 | | 27.9±4.1 | -1.27±2 | |
| WC (cm) | T2DM | 98.7±3.8 | NS | 99±4.2 | 0.3±1.9 | 0.03 |
| | Controls | 99.6±9.2 | | 97.6±9.2 | - 2.03±3.5 | |

P (T1): Difference between T2DM patients and controls before Ramadan, P (T2–T1)/T1: Variation of the difference between T2DM patients and controls between T2 and T1

a hypersecretion of insulin during the month of Ramadan. This is likely secondary to the increase in caloric intake. This secretion regained its initial value after Eid. Similarly, Kassab *et al.* found a significant increase in the insulin level which was explained by the increase in energy intake in 44 women.[6]

In the present study, fasting was well tolerated. We did not find any major finding of hyperglycemia, ketoacidosis, thromboembolic or cardiovascular events, or severe hypoglycemic events requiring hospitalization in our patients. Only two patients presented with hypoglycemic episodes along with adrenergic signs: one followed the skipping the Suhour meal, and the other followed intense physical activity during the fast. Similarly, Khaled and Belbraouet[6] reported in the 276 type 2 diabetic women studied, two cases of hypoglycemia in two patients with biguanides and glimepiride: one following the leap of the Suhour meal, other due to intense physical activity. The EPIDIAR study[2] was conducted among 12,243 patients, 79% of whom had T2DM from 13 Muslim countries, showed that 4% of those with T2DM had at least one severe hypoglycemic episode during the year preceding Ramadan and 2% during Ramadan. Thus, the frequency of severe hypoglycemia in T2DM was significantly greater during Ramadan ($P < 0.0001$). In this study, T2DM patients were 7.5 times more likely to have hypoglycemia and 5 times more likely to have hyperglycemia (requiring hospitalization) during Ramadan.

Total cholesterol, triglycerides, and HDL-cholesterol levels increased significantly during Ramadan only to revert to their initial values after Eid which marks the end of the month of fasting. The level of LDL cholesterol remained stable. This is explained by the significant increase in dietary intake of lipids and saturated fatty acids. The increase in HDL-cholesterol is explained by many authors [11-13], by the reduction in the number of meals during Ramadan. Similarly, Lamine *et al*.[14] found a significant increase in total cholesterol and HDL cholesterol about an increase in mono and poly-unsaturated lipid intake.

Total calorie intake in the diabetes group increased during Ramadan albeit not significantly. In our study, we observed a decrease in carbohydrate intake ($P = 0.01$) and an increase in lipid intake ($P = 0.001$), especially saturated fatty acids ($P = 0.006$) and polyunsaturated fatty acids ($P = 0.009$). This can be explained by the increased consumption of fried food during Ramadan. There was no significant change in protein intake, while the PA / PV ratio increased from 0.87 to 1.17 during Ramadan indicating a high consumption of meat and animal products during this month. Our results are comparable to previous reports.[15,16] On the other hand, Beltaifa *et al*.[15] found an overconsumption of lipids and proteins accompanied by a decrease in the carbohydrate intake. Khaled and Belbraouet found a significant decrease in total energy intake with increased intake of lipids, saturated fatty acids, polyunsaturated fatty acids, and cholesterol, decreased carbohydrate and dietary fiber intake as well as an increased intake of proteins.[6]

## Conclusions

Based on this study along with a review of the pertinent literature, fasting by patients with T2DM seems to be well supported by regular medical monitoring and self-monitoring. Fasting does not seem to have any effect on anthropometric parameters, blood pressure profile and glycemic control. It does, significantly, elevate the HDL cholesterol, total cholesterol, and triglycerides, but that is a transient change. Our study needs to be expanded to include more patients so that we can draw more conclusions. Finally, it is appropriate to make some recommendations with regards to fasting in people with diabetes. Any diabetic patient who wishes to fast should consult his or her physician beforehand. Patients with diabetes who are allowed to fast by their physician should observe a regular capillary blood glucose monitoring throughout the fasting period. Patients should immediately stop fasting if blood glucose is less than 70 mg/dl or if it exceeds 300 mg/dl. The Suhour must be taken as late as possible, should be balanced, and include low glycemic index carbohydrates. It is recommended to drink lots of liquids (sugar-free) especially when it is hot. Moderate physical activity is strongly recommended after breaking the fast, such as that the Tarawih prayers which are a suitable example of physical activity.

### Author's contribution

All authors contributed to the planning, conduct and data anlyses of the study. They drafted, revised and approved the final version of the manuscript.

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Nil.

## Conflicts of interest

There are no conflicts of interest.

## Compliance with ethical principles

The study was approved by the IRB of Tunis Medical School and was conducted in accordance to the ethical principles. All participants provided informed verbal consent.

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