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Full Length Research Paper

Ramadan fasting influences on food intake consumption, sleep schedule, body weight and some plasma parameters in healthy fasting volunteers

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This study examines the changes in the lifestyle that accompanied Ramadan fasting. For this purpose, we followed the questionnaire programming meals, food consumption and sleep rhythm. We also followed changes in plasma biological parameters. The results show that daily energy consumption was not changed and neither was the body weight. Nevertheless, a decrease in fat mass was detected. Concerning plasma, we found a decrease in blood glucose from the 7th day of fasting. This effect was found also at the 21st day, accompanied by a reduction in insulin levels. Our results on plasma lipids showed a decrease in triglycerides with total cholesterol level unchanged. Furthermore, we noted an increased HDL-C against a decreased LDL-C fraction. Taken together, these results suggest that fasting may induce beneficial effects in blood lipid concentrations.

Key words: Ramadan fasting, food intake consumption, sleep schedule, body weight, plasma parameters, healthy fasting volunteers.

INTRODUCTION

Ramadan is the 9th month of the lunar calendar. During this month, Muslims particularly refrain from eating and drinking from sunrise to sunset. Several dietary surveys conducted on this subject have shown during this month that food choices undergo very significant variations (Gharbi et al., 2003; El Ati et al., 1995). Further, the nocturnal timing of meals was accompanied with enormous changes in the rhythms of sleep/wake and rest/ activity (Bahammam, 2005; Haouari et al., 2008). Indeed, many authors have noticed that body weight, glucose homeostasis and plasma lipid could be influen-ced by the inverted food intake timing, which characterizes this month of intermittent fasting (Nomani et al. 1989; Nomani et al., 1992; Iraki et al., 1997).

However, over the past two decades, a multitude of controversy emerged concerning both the nature and the intensity of variations induced by diurnal fasting. To avoid heterogeneity that may interfere with the effects, we selected a population of young healthy males, with a comparable daily physical activity. The purpose of this study was to assess how Ramadan could induce changes on both body weight and different tissues masses, on the one hand, and on some plasma parameters, on the other hand. Furthermore, the modifications on food intake consumption and sleep schedule were also investigated.

MATERIALS AND METHODS

Population volunteers

38 male students from the Health Science School of Tunis were randomly selected as volunteers for this work. None of them took any medication either before or during the study, and they were all free from any disease. The main characteristics of this population of volunteers are summarized in the Table 1. During the study days, all meals were quantitatively and qualitatively standardized, with active help of Al-Rabta university restaurant nutritionists. 38

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Table 1. Characteristics of the study population.

Number	Average age (years) (M ± SEM)*	Average weight (kg) (M ± SEM)*	BMI (kg/m^2) (M ± SEM)*
38	20.8 ± 1.0; [18 - 23]	70.0 ± 0.7	23.33 ± 0.28

*M, Mean; *SEM, standard error of the mean

volunteers, we performed a detailed investigation both during control period and during this month of fasting, for three non-consecutive days. Each survey programming included sleep schedule, meals timing and the amount of food consumed. Our survey data are provided directly by the volunteers in response to questions asked by the dietetician. The food consumption was then converted into calories and nutrients using appropriate software (Nutrisoft-Bilnut – Program, Version 2.0.1, 2000).

Measurement of body weight and determination of different tissue masses

The variables measured by impedance-meter "TBF-401 A" (Tanita Corporation, Tokyo, Japan) were muscular mass, fat mass and body water. Kinetic of eventual changes in body weight and the different tissue masses were followed by performing the three measurements in the 7th (D7), 15th (D15) and 27th (D27) days of fasting and compared to the control period values before Ramadan (D_0).

Determination of plasma levels

Blood sampling

To evaluate the effect of Ramadan in plasma, blood sample was collected from the 38 volunteers, at about 08:00 am (local time) before Ramadan (D_0) and at 05:00 pm for (D_7) and (D_{21}) of Ramadan (before the end of fasting). This work was undertaken in autumn (October, 2005). It is important to note that for each day of our study, the average duration of the fast was about 12 h and maximum ambient temperature ranged from 15 to 22°C. In addition, a study of possible changes in the values of cortisol plasma was performed using two blood samples to evaluate its daily variability. Taking into account our previous results (Haouari et al., 2007), we collected two samples at 8:00 h and at 20:00 h to determine the respective values of the peak and trough in the circadian pattern of this hormone. With these two values, we estimated for the three days of our study the variability of the cortisol rhythm, which was expressed in percentage of minimum-value.

Variability (%) = (Peak-value – trough-value) × 100 / trough-value

Analytical techniques

The glucose values were determined using the enzymatic Kit (glucose oxidase Beckman reagent Kit, Beckman SYNCHRON CX7 analyzer). As for the plasma values of triglycerides (TG) and total cholesterol (TC), they were analyzed by the enzymatic method (Hycel test kit, Hycel Inc., Houston, TX, USA). For high-density lipoprotein cholesterol (HDL-C), selective precipitation technique (Randox-Kit, Ireland) was used. Concerning, the low-density lipoprotein cholesterol (LDL-C) fraction, it was estimated by calculation using the Friedewald formula;

LDL-C (mmol/L) = (CT) - HDL-C - TG / 2.2

For cortisol and insulin plasma concentrations, they were determined by radio-immunoassay kits (CEA, France).

Statistical analysis

All results were expressed as mean ± SD or SEM as indicated in the Tables. Comparison of means was made using a paired Student's *t*-test. As for comparisons of percentages, they were performed through Chi-square. For both tests used, a difference is considered significant if p<0.05. Statistical analyses were conducted using GraphPad InStat v.3.0a for Macintosh (GraphPad Soft-ware, San Diego, CA, USA).

RESULTS

Influence of Ramadan fasting on sleep schedule and food intake rhythms

Total energy intake and its distribution in carbohydrate, fat and protein calories

Our results demonstrate that average total caloric intake during Ramadan among our volunteers, was slightly decreased, but the variation was statistically significant (Table 2). However, analysis of Ramadan food consumption showed a significant decrease in carbohydrate intake (12.1%, P < 0.001). Such decrease was concomitant with an increase consumption of both fats (+20.4%, P<0.001) and protein, especially those of animal origin. Indeed, we noticed a significant increase of 34.6% (p <0.001) in the ratio of animal proteins/vegetal proteins (AP/VP) (Table 2).

Impact of Ramadan on timing of meals and sleep patterns

Our results show that the daily number of meals was significantly reduced (p<0.001) during Ramadan, with up to three meals a day for most volunteers (Table 3). In contrast, before Ramadan, at least four meals were consumed by the majority of volunteers. We found that the frequency of regularity in the timing of meals, which are strictly nocturnal, was increased significantly (p<0.001). Furthermore, our data show that bedtime of our volunteers was significantly delayed during Ramadan (p<0.01), inducing a decrease in sleep duration (p<0.01) (Table 3).

Influence of fasting on body weight and tissue masses

Measurements of body weight carried in our volunteers did not show significant changes, except for a slight decrease detected at D_{27} towards the end of the month (Table 4). However, our results reveal that the fat mass

Table 2. Variations in total energy intake and their distributions in carbohydrate, fat and protein calories during Ramadan, compared to the control period.

Period	Total energy intake (TEI) (kcal/day)	Carbohydrate calories (% TEI)	Fat calories (% TEI)	Protein calories	
				(% TEI)	AP / VP
Before Ramadan	2313 ± 109	57.7 ± 0.5	29.4 ± 0.4	13.0 ± 0.15	1.01 ± 0.03
During Ramadan	2293 ± 105^{NS}	50.7 ± 0.6***	35.4 ± 0.5***	14.0 ± 0.10^{NS}	1.36 ± 0.03***

Data were collected by investigation in a population of 38 healthy young male volunteers. Values are expressed as mean ± SD. *** p < 0.001 between Ramadan and the control period, before Ramadan. AP / VP, animal proteins/vegetal proteins.

Table 3. Timing of daily meals and sleep during Ramadan, compared to the control period.

Rhythms explored		Period					
		Before Ramadan (C)				During Ramadan (R)	
Food intake rhythm	Number of daily meals	≤ 2	3	≥ 4	P	≤ 2	3
	Percentage (%) of volunteers	3.4	41.6	55.1	###	30.3	68.7
Sleep rhythm	Bedtime (hh : min)	23:08 ± 00:11			**	00:05 ± 00:13	
	Variability of Bedtime (hh : min)	01:10 ± 00:12			NS	01:00 ± 00:08	
	Sleep duration (hh : min)	07:24 ± 00:09			**	06:43 ± 00:11	

Data were collected by survey in a population of 38 young healthy male volunteers both during Ramadan "R" and outside this month, as control period "C". Values are expressed as mean ± SD. ** p < 0.01 between Ramadan and control period, before Ramadan; # # # between the percentages of volunteers for each case respectively; NS (not significant) between the period of Ramadan and the control period before Ramadan.

was unchanged at D_7, and decreased significantly from D_{15} (11.9%, p<0.05). Such influence of diurnal fasting was also found at D_{27}, with a percentage of 9.9%; p<0.05. As for muscular and water masses, these remained statistically unaffected in the different periods of our study (Table 4).

Influence of Ramadan fasting on biological plasma parameters levels

Ramadan and glucose homeostasis

Our results show that the values of fasting blood glucose, determined on days D_7 and D_{21} of Ramadan were reduced compared to that of the control period D_0 (Table 5). Such decrease in blood glucose was detected since D_7, with a percentage of variation of 4.5% (p<0.05). At D_{21}, this consequence of strictly nocturnal food intake was amplified to 7.9% (p<0.01). Similarly, insulin levels showed a significant decrease (p<0.05) by 30.4% of fasting values at D_7. This influence increased at D_{21} reaching 57.3% (p<0.001). In addition, the comparative study between the values at both stages of fasting (D_7 and D_{21}), showed a significant difference (p<0.001). Con-cerning plasma cortisol variability, morning value mea-sured at 08:00 h showed a significant decrease in the peak, both at D_7 (-9.6%, p<0.05) than at evening (-14.4%, p<0.05). As for nocturnal value measured at 20:00 h, a significant increase was observed at D_7 (14.7%, p <0.05). This increase was accentuated in D_{21} (28.8%, p<0.05), with a significant difference between D_7 and D_{21} (p<0.01). These influences of fasting on both values of morning peak and nocturnal trough led to a growing loss of variability of plasma cortisol. The latter was reduced from the control value of 278 to 198% (p<0.001) and 151% (p<0.001), respectively, for D_7 and D_{21} (Table 5).

Ramadan and plasma lipid levels

Our results show that the values of fasting plasma triglycerides fell significantly at both D_7 (25.9%, p <0.001) and D_{21} (20.0%, p <0.01). For values of total cholesterol, we found a remarkable stability in which no significant difference was detected (Table 6). Nevertheless, a slight decrease was detected on D_{21}. Regarding HDL-C plasma, our data showed a significant increase from D_7 (26.7%, p <0.01) and persisted in D_{21} (20%, p <0.01). In contrast, LDL-C fraction underwent a significant decline at D_7 8.9% (p <0.05), then reduced at D21 to a percentage of 5.9% (Table 6).

DISCUSSION

Our data showed no significant effects of the Ramadan fasting on the average body weight of our volunteers, except a slight decrease. This lack of a significant effect on body weight, both at the beginning and towards the end of Ramadan, agrees with observations made by Beltaifa et al. (2002) and Akanji et al. (2000). But among older heterogenic population however, many authors were able to detect a drop in body weight (Adlouni et al.,

Table 4. Influence of Ramadan fasting on body weight values and tissue masses.

Parameter	Days of fasting	Body weight (Kg)	Body fat (Kg)	Muscular weight (kg)	Body water (kg)
Body weight and tissue masses variations (n= 38)	D_0	70.0 ± 0.7	10.1 ± 0.28	59.6 ± 0.46	43.6 ± 0.5
	D_7	69.9 ± 0.6	10.4 ± 0.30	59.3 ± 0.42	43.4 ± 0.4
	D_{15}	69.0 ± 0.5	8.9 ± 0.27*	59.5 ± 0.41	43.3 ± 1.0
	D_{27}	68.7 ± 0.6	9.1 ± 0.33*	58.9 ± 0.48	42.9 ± 0.7

Measurements were performed in a population of 38 young healthy male volunteers in the 7th "D_7", 15th "D_{15}" and 27th" D_{27}" days of Ramadan and one week before Ramadan, as a control day "D_0 ". Data are expressed as averages ± SD. *p < 0.05 between the three days of fasting D_7, D_{15} and D_{27}, compared to the control day D_0.

Table 5. Influence of Ramadan on plasma glucose, insulin and cortisol values.

Plasma parameter		Day of fast		
		D_0	D_7	D_{21}
Glucose (mmol/L)		4.94 ± 0.11	4.71 ± 0.16*	4.55 ± 0.39**
Insulin (mU/L)		32.6 ± 3.9	22.7 ± 0.76*	13.9 ± 0.88***###
Cortisol (nmol/L)	Average of morning values (Peak)	1574.5 ± 131.0	1423.1 ± 33.9	1347.3 ± 95.1
	Average of evening values (Hollow)	417. 0 ± 29.2	478.2 ± 26.5*	536.9 ± 12.4* ##
	Variability (%)	278	198***	151***

The study was conducted in a population of young boys healthy volunteers (n = 38) in the 7th "D_7" and 21st "D_{21}" days of Ramadan and a week before Ramadan, as a control day "D0". Data are expressed as averages ± SD. *p < 0.05, ** p < 0.01, *** p <0.001 between the two days of fasting by D_7 and D_{21}, compared to control day (D_0). ## p < 0.01, ### p < 0.001 between the two days of fasting D_7 and D_{21}

Table 6. Influence of Ramadan fasting on plasma triglycerides values "TG", total cholesterol "ChT", HDL cholesterol "HDL-C" and LDL cholesterol "LDL-C".

Day of fasting	Plasma parameter				Atherogenicity Index
	TG (mmol/L)	Total cholesterol (mmol /L)	HDL-c (mmol/L)	LDL-c(mmol /L)	
D_0	0.97 ± 0.03	4.16 ± 0.10	1.16 ± 0.05	2.61 ± 0,10	3.59 ± 0.11
D_7	0.72 ± 0.02***	4.19 ± 0.23	1.47 ± 0.10**	2.38 ± 0.11*	2.85 ± 0.16**
D_{21}	0.78 ± 0.03**	4.11 ± 0.18	1.39 ± 0.08**	2.45 ± 0,10	2.95 ± 0.14**

The study was conducted in a population of young male healthy volunteers (n = 38) in the 7th "D_7" and the 21st "D_{21}" days of Ramadan and a week before Ramadan, as a control day "D_0". Data are expressed as averages ± SD. * p < 0.05, ** p < 0.01, *** p <0.001 between the two days of fasting "D_7" and "D_{21}", compared to control day D_0.

1997; Karaağaoğlu and Yücecan, 2000; Ramadan et al., 1999). Such a change detected by Sweileh et al. (1992) towards the end of Ramadan, has been associated with a loss of body fat. However, our results reveal a significant decrease of fat mass, both in the middle and towards the end of the month of fasting, without statistical changes in body muscular and water masses. This influence of Ramadan could be attributed to a diurnal mobilization of reserves, following the strictly nocturnal meals timing.

Regarding the impact of Ramadan on the lifestyle of fasting, we observed significant changes, including a reduction in the number of meals. This reduction had no impact on daily energy intake which remained quantitatively unchanged. This finding supports the stability of body weight, which is consistent with numerous studies performed in different populations (Maislos et al., 1998; Ziaee et al., 2006). However, we found that during the Ramadan, meal times were very regular in the majority of our volunteers. However, the regularity in the timing of strictly nocturnal meals could increase the synchronization between the rhythm of food intake, on one hand and those of other related endogenous functions. This suggestion could explain the variations observed at the beginning of Ramadan at the different variables studied. Moreover, our previous observations concerning the influences of the fast at some endogenous functions support the hypothesis of the desynchronization. Indeed, we noticed that in Ramadan, strictly nocturnal meals induced very significant variation in circadian rhythms of many biological variables, such as serum liver enzymes (Haouari-Oukerro et al., 1994), urinary sodium and potassium values (Haouari et al., 2000). It was the same in rats, when we showed that the inversed food intake affects significantly, not only, the rate of insulin secretion but also of its biosynthesis (Haouari-Oukerro et al., 1994).

Furthermore, our data showed that the sleep rhythm of young students was significantly delayed with a reduction in sleep duration. However, the rhythm of sleep had a great importance in the stability of endogenous functions rhythms Reinberg (2003). Taking into account our current results, it is important to note that these changes in both styles of sleep and food intake had no significant effects on the circadian rhythm of cortisol (Bogdan et al., 2001; Haouari et al., 2008) and bio-markers of endogenous periodicity (Mormont et al., 2002). Hence, the changes induced by the Ramadan lifestyle among our volunteers population had no effect on endogenous spontaneous “biological-clock”.

Differences between cortisol mean values before (D_0) and after Ramadan (D_{21}) confirm the results of cortisol obtained by Bogdan et al. (2001) before (D_0) and after Ramadan (D_{23}). Concerning the declines in blood glucose and triglycerides, particularly at D_7, they support the hypothesis of the existence of a period necessary to adapt the general metabolism, following the inversion of the food intake schedule. Similarly remarkable drop in the values of insulin, demonstrated that accentuation at D_7 and at D_{21}, was consistent with the establishment of a central endogenous functions adaptation. Such an adaptation, with the new timing of meals would be for diurnal mobilization of fat reserves. This hypothesis finds support on the one hand by the decrease in fat mass and on the other hand by the increase in the values of triglycerides between J_7 and J_{21}. The values of total cholesterol show a remarkable stability, especially at the beginning of the month, despite the increased frequency of consumption of animal products (Gharbi et al., 2003). This lack of variation is in perfect agreement with the findings of several studies (Maislos et al., 1998; Ziaee et al., 2006). As for HDL-C, our results show that it significantly increased from day 7 and this variation persisted until day 21. Such an effect of fasting is particularly supported by the observations of Qujeq et al. (2002) on the 15th day of Ramadan, and those of Adlouni et al. (1997) to the end of the month. Moreover, the value of plasma LDL-C fraction showed a decrease from J_7 and J_{21}, which fades slightly. These variations suggest that Ramadan is capable of reducing the index of atherogenicity in fasters. Therefore, this model of intermittent fasting, characterized by strictly nocturnal food intake, could provide an opportunity to reduce the risk of cardio-vascular disease by increasing the fraction of "good" cholesterol HDL-C against a decrease in "bad" cholesterol LDL-C.

In conclusion, all of our results suggest that strictly nocturnal food intake can cause, before adaptation, some significant changes in the studied biological variables. Indeed, the observed changes during the first week could be attributed to the desynchronization between the rhythm of Ramadan and food bio-periodicity endogenous. As for the attenuation in the amplitudes of the detected variations between the beginning and the end of the month, this supports the hypothesis of adaptation of these functions, each characterized by a spontaneous circadian rhythm. This adjustment will result in better mobilization of reserves and adjustment responses of our body to reverse the rate of food intake. Besides, all variations induced by the diurnal fasting remain in biologic norm limits. In addition, it is important to note that some of the consequences of these, especially food intake rhythm, are beneficial, particularly the improvement in the assessment of plasma lipid levels.

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