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Effects of Ramadan Fasting on Body Weight and the Biochemical and Haematological Parameters of the Blood

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ABSTRACT. The Effects of Ramadan fasting on body weight as well as on the different biochemical and haematological parameters of the blood were studied on 74 healthy male and female Jordanian adults ranging in age from 20 to 48 years. Venous blood samples were tested which were taken during the pre-Ramadan week, 1st, 2nd and 4th weeks of Ramadan, as well as during the post-Ramadan week. Of the studied parameters, body weight, glucose, uric acid, total cholesterol, HDL - cholesterol, LDL - cholesterol, total protein, albumin, iron, calcium, total bilirubin, free bilirubin, alkaline phosphatase and its intestinal isoenzyme, RBC count and PCV were found to decrease significantly ($p < 0.05$) during the fasting weeks of Ramadan. Whereas the MCH and MCHC of the haematological parameters were found to increase significantly ($p < 0.05$) due to the decreased RBC count and PCV. However, the following parameters; triglycerides, phosphate, urea, creatinine, conjugated bilirubin, alanine transaminase, aspartate transaminase, bone and liver isoenzymes of alkaline phosphatase, Hb, MCV, WBC count and ESR did not change significantly. It was concluded that Ramadan fasting could induce weight loss through restriction of energy intake with consequent relative hydration of the blood causing changes in biochemical and haematological parameters of the blood. Although these changes were within normal reference ranges and within the 95% confidence limits of pre-Ramadan values and appear to be reversible but they require attention by physicians practising in Muslim communities and countries, as they could be misleading in diagnosis and monitoring of the disease.

Muslim style fasting in Ramadan differs from ordinary fasting and water deprivation in that it is intermittent and diurnal. While fasting all the day from sunrise to

sunsite, one can consume food and drink without restriction during the hours of darkness. The time of Ramadan observance falls 11 days earlier on the A.D. calender each year. Therefore fasting hours (daytime length) and weather conditions of the fasting month each year could vary with the geographical site and the season.

The physiological significance of Ramadan fasting is poorly understood. Reports in the literature concerning the effects of Ramadan fasting on body weight and the biochemical and haematological parameters of the blood are very few and show conflicting results. Some of these reports showed statistically significant effects (Gumaa *et al.* 1978, Scott 1981, Fedail *et al.* 1982, El-Hazmi *et al.* 1987, Sulaiman *et al.* 1988, Nomani *et al.* 1990, Sulimani 1991), whereas other reports did not show statistically significant effects (Mustafa *et al.* 1978, Yegin *et al.* 1983, Shoukry 1986, Suliman and Khatib 1988).

Environmental factors however could interfere with the study results, these may include hot, cold, humide and dry weather conditions affecting the hydration state of the body during the fasting hours. The effect of these environmental factors will be dependent on the geographical site and the season at which the study is performed.

The present study therefore aimed to investigate the effects of Ramadan fasting on body weight and the biochemical and haematological parameters of the blood under moderate environmental conditions that prevailed during Ramadan month of 1997, which coincided with January and February.

Subjects and Methods

The study was made on 74 healthy adult volunteers, 60 male and 14 females, ranging in age from 20 - 48 years. Fourty three of the volunteers (34 males and 9 females) were studied for the body weight and the biochemical and haematological parameters. The other 31 volunteers (26 males and 5 females) were studied for the isoenzymes of alkaline phosphatase (ALK P).

Venous blood from the anticubital vein was taken during the week preceding the month of Ramadan and then at the 1st, 2nd and 4th weeks of Ramadan, as well as during the week of post-Ramadan. All the blood samples were taken at noon time (*i.e.* at 12.00 to 1.00 h.), body weight was also measured at the same time using the same weighing balance.

The blood samples (15ml) for the biochemical parameters were allowed to clot and the serum was separated within one hour of sampling. The serum samples were then kept frozen until after Ramadan for two weeks after which they were analyzed for the biochemical parameters using BM / Hitachi 704 autoanalyzer and Boehringer Mannheim reagent kits for automated analysis (Boehringer Mannheim House, Bell Lane, Lewes, East Sussex, BN7 ILG, England).

For isoenzyme assays of ALKP a manual two point procedure was used as described by Tietz (1976) and modified by Alvi *et al.* (1987). In this method Boehringer Mannheim reagent kit was used containing 4-aminonitrophenyle phosphate (4.0 mol / L) as substrate, 2-amino - 2-methyl propanol (0.93 mol / L) as buffer and MgCl (1.0 mmol / L) as activator. The serum activity of bone ALK P was measured after heating the serum at 56 °C for 15 min and the serum activity of intestinal ALK P was measured after inhibiting this isoenzyme with L-phenylalanine (5.0 mmol / L) and substracting the residual activity from the activity of total ALK P. The serum activity of liver ALK P was calculated by substracting the activity of bone ALK P from the residual activity obtained after inactivation with L-phenylalanine (Tietz 1976, Henry 1984, Alvi *et al.* 1987).

The blood samples (5 ml) for the haematological parameters were drawn into EDTA tubes (0.1 w/v). Whole blood measurements of the haematological parameters were performed within two hours of sampling. Red blood cell count (RBC), haemoglobin concentration (Hb), erythrocyte mean cell volume (MCV) and white blood cell count (WBC) were measured using a Clay Adams Ultra-Logic 800 Haematology Analyzer (Clay Adams, Persipany, NJ, USA). Packed cell volume (PCV) was measured by centrifugation of blood capillaries for four minutes using an MSE microhaematocrit centrifuge type 346 (MSE scientific instruments, manor royal, crawley, sussex RH 10 2QQ, England). Erythrocyte mean cell haemoglobin (MCH) was calculated from Hb and RBC values and erythrocyte mean cell haemoglobin concentration (MCHC) was calculated from Hb and PCV values. Erythrocyte sedimentation rate (ESR) for one hour was measured by the westergren method (Henry 1984).

Data are presented as means and standard deviations (SD). Statistical significance was determined using one - way analysis of variance followed by student's t - test for paired samples. Differences were considered significant when $p < 0.05$.

Results

Table 1 shows the changes in body weight and the biochemical parameters observed during the Ramadan month. When the results were compared with the pre-Ramadan values, there was a significant decrease in body weight at the 2nd and 4th weeks of fasting and also at the post-Ramadan week. There was also a significant decrease in uric acid, total cholesterol, HDL - cholesterol, LDL - cholesterol, total protein, albumin, iron, calcium, total bilirubin, free bilirubin and ALK P at the 1st, 2nd, and 4th weeks of fasting or at either one of them. When the results of glucose, and triglycerides were compared with the 1st week of fasting values, glucose showed a significant decrease at the 2nd and 4th weeks of fasting, whereas triglycerides did not show a significant change. There were no significant changes in regard to phosphate, urea, creatinine, conjugated bilirubin, alanine transaminase (ALT) and aspartate transaminase (AST), when compared with the pre-Ramadan values.

Further investigation was carried out for the observed changes in total ALK P activity, by measuring the activities of the isoenzymes of ALK P.

Table 2. shows the changes in serum activities of total ALK P and its isoenzymes of liver, bone and intestinal origins observed during the Ramadan month. When the results were compared with the pre-Ramadan values, there was a significant decrease in total and intestinal ALK P at the 2nd and 4th weeks of fasting. Whereas the liver and bone ALK P isoenzymes did not show a significant change.

Table 3. shows the changes in the haematological parameters observed during the Ramadan month. When the results were compared with the pre-Ramadan values, there was a significant decrease in RBC count and PCV values at the 2nd and 4th weeks of fasting. Whereas MCH and MCHC values showed a significant increase at the 2nd and 4th weeks of fasting and also at the post-Ramadan week. There were no significant changes in regard to Hb, MCV, WBC and ESR values.

Table 1. The means and the standard deviations (SD) of the body weight and the serum concentrations of measured biochemical paramters.

Measured Parameter	Units	Number of Subjects**	Ramadan				
			Pre	1st wk.	2nd wk.	4th wk.	Post
			Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Body weight	Kg	43	72.0 (12.6)	–	71.1* (12.9)	70.8* (13.0)	71.1* (12.9)
Glucose	mmol/L	40	5.40 (2.21)	5.12 (0.51)	4.86+ (0.55)	4.73+ (0.50)	5.11 (1.28)
Uric acid	mmol/L	30	0.29 (0.10)	0.26* (0.10)	0.26* (0.09)	0.25* (0.09)	0.28 (0.10)
Total cholesterol	mmol/L	31	4.98 (1.11)	4.75 (1.11)	4.67 (1.23)	4.27* (1.01)	4.55* (1.14)
HDL-cholesterol	mmol/L	30	1.30 (0.33)	1.11* (0.22)	1.09* (0.25)	1.07* (0.19)	1.22 (0.28)
LDL-cholesterol	mmol/L	30	3.13 (0.63)	2.92 (0.74)	2.69* (0.90)	2.64* (0.62)	2.87 (0.82)
Triglycerides	mmol/L	37	1.35 (0.68)	0.97 (0.44)	0.83 (0.36)	0.82 (0.33)	1.35 (0.87)
Total protein	g/L	33	83.1 (11.4)	71.1* (5.8)	70.8* (6.1)	73.3* (7.6)	75.5* (6.0)
Albumin	g/L	31	54.4 (4.6)	50.8* (2.8)	49.7* (2.6)	50.3* (2.6)	51.3* (2.7)
Iron	µmol/L	22	19.23 (5.75)	–	15.35* (5.25)	14.21* (4.56)	19.63 (5.55)
Calcium	mmol/L	31	2.67 (0.30)	2.50* (0.19)	2.50* (0.16)	2.58 (0.14)	2.69 (0.19)
Phosphate	mmol/L	33	1.12 (0.18)	1.10 (0.17)	1.10 (0.12)	1.09 (0.15)	1.16 (0.22)
Urea	mmol/L	40	2.58 (0.74)	2.43 (0.64)	2.40 (0.80)	2.37 (0.76)	2.56 (0.66)
Creatinine	µmol/L	40	92.3 (17.2)	95.6 (16.8)	94.6 (13.4)	93.0 (16.5)	95.6 (15.7)
Total bilirubin	µmol/L	33	20.0 (9.0)	–	15.1* (6.7)	14.2* (5.7)	21.0 (9.9)
Free bilirubin	µmol/L	33	16.0 (8.6)	–	11.9* (5.7)	11.3* (5.8)	16.3 (9.7)
Conjugated bilirubin	µmol/L	33	4.1 (3.3)	–	3.4 (3.1)	3.1 (2.4)	4.1 (3.2)
ALT (SGPT)	U/L	25	9.0 (4.4)	–	8.3 (4.1)	8.2 (3.9)	8.9 (5.4)
AST (SGOT)	U/L	28	18.5 (5.3)	–	17.7 (6.0)	17.8 (6.5)	18.3 (6.6)
ALK P.	U/L	28	157.4 (41.3)	–	138.4* (44.8)	134.3* (36.8)	155.1 (42.1)

* $p < 0.05$ – compared with the pre-Ramadan value. + $p < 0.05$ – compared with the 1st wk. value.
** Represent the number of volunteers who were able to give all the required samples for a given test.

Table 2. The means and the standard deviations (SD) of the serum activities of alkaline phosphatase (ALK P) and its isoenzymes of liver, bone and intestinal origins.

Measured Parameter	Units	Number of Subjects**	Ramadan			
			Pre	2nd wk.	4th wk.	Post
			Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Total ALK P.	U/L	27	78.6 (18.1)	72.1* (15.2)	71.9* (14.2)	76.5 (15.8)
Liver ALK P.	U/L	31	48.2 (17.2)	48.5 (15.5)	49.9 (13.5)	49.3 (15.2)
Bone ALK P.	U/L	31	19.2 (4.5)	18.3 (3.4)	18.7 (4.7)	19.8 (5.1)
Intestinal ALK P.	U/L	31	9.7 (5.8)	5.9* (4.6)	5.4* (3.8)	6.8* (5.0)

* $p < 0.05$ – compared with the pre-Ramadan value.

** Represent the number of volunteers who were able to give all the required samples for a given test.

Table 3. The means and the standard deviations (SD) of the measured haematological parameters

Measured Parameter	Units	Number of Subjects**	Ramadan			
			Pre	2nd wk.	4th wk.	Post
			Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
RBC	$x10^{12}/L$	42	4.96 (0.39)	4.80* (0.43)	4.80* (0.41)	5.08 (0.44)
PCV	%	42	47.12 (3.72)	44.95* (3.22)	44.58* (2.97)	44.63 (3.57)
Hb	g/dL	42	14.80 (1.43)	14.90 (1.03)	14.75 (1.03)	15.70 (1.60)
MCV	fl	42	94.00 (5.30)	93.80 (7.95)	93.20 (5.89)	93.4 (5.17)
MCH	pg	42	29.80 (2.26)	30.97* (2.69)	30.80* (2.26)	30.98* (2.44)
MCHC	g/dL	42	31.50 (2.48)	32.90* (1.60)	33.10* (1.32)	34.99* (1.89)
WBC	$x10^9/L$	42	6.30 (1.14)	6.27 (1.22)	6.20 (1.13)	6.70 (1.13)
ESR	mm/hr	22	13.1 (13.1)	12.5 (11.1)	12.2 (8.9)	11.4 (12.3)

* $p < 0.05$ – compared with the pre-Ramadan value.

** Represent the number of volunteers who were able to give all the required samples for a given test.

Discussion

The present finding of an average weight loss of 1.2 kg (*i.e.* 1.7%) at the 4th week of fasting (Table 1) coincides with the findings of other reports (Husain *et al.* 1987, Suliman and Khatib 1988, Takruri 1989) in which the loss of weight ranged from 1.2% to 3.5% and the percentage of loss being greater in overweight persons.

The loss of weight and the decrease in serum uric acid levels accompanied by a gradual decrease in serum glucose could be explained as a result of energy intake restriction induced by fasting. These results are in accordance with the findings of Nicholls and Scott (1972) who induced weight loss through restriction of energy intake and found a significant decrease in serum uric acid level which was not accompanied by an increased excretion of urate in the urine. These authors proposed that their findings could be partly due to the relative hydration associated with weight loss and to a decreased rate of purine synthesis when energy intake is restricted. Similar results were obtained by others (Yegin *et al.* 1983). In contrast, other workers (Nomani *et al.* 1990) have noted an increase in serum uric acid level with Ramadan fasting and weight loss. These authors explained their results by concluding that serum uric acid level could increase as body weight status changes from normal to underweight or overweight and decrease as body weight status changes to normal from overweight or underweight. The mean body weight of their subjects was 66.2 kg compared to the mean of 72.0 kg of the present study.

The decrease in serum cholesterol which was in parallel to the decrease in serum uric acid could be explained by the likely interaction between the pathways of lipid and purine metabolism (Schoenfeld and Goldberger 1963, Berkowitz 1964, Gumaa *et al.* 1978, Allen and Adena 1985). The decrease in HDL - cholesterol could also be due to the reduced physical activity which is known to be significant in Muslims fasting the month of Ramadan. However, some investigators (Shoukry 1986) also observed a significant decrease in plasma apoproteins of C-II and C-III at the end of Ramadan fasting which are known to be the major proteins in the VLDL lipoproteins which could also explain the decrease in serum cholesterol.

The present study showed a significant decrease in serum total protein and albumin throughout the fasting weeks of Ramadan which persisted even at the post-Ramadan week (Table 1). The decrease in both total protein and albumim could be due to the relative hydration induced by weight loss (Nicolls and Scott 1972). The decrease in serum total protein was also observed by Scott (1981) in a similar study

performed on saudi nationals.

The decrease in serum iron from the pre-Ramadan value of 19.23 μmol/L to 15.35 and 14.21 μmol/L at the 2nd and 4th weeks of fasting respectively (Table 1) could be explained by a possible decrease in the iron binding protein transferrin. In fact, in a similar study by El-Hazmi *et al.* (1987) there was a decrease in serum iron and total iron - binding capacity which supports the transferrin as being the cause for the decreased serum iron. The decrease in serum iron could also be due however to the altered circadian rhythm induced by the change in meal frequency and sleep - activity cycles associated with the fasting month of Ramadan (Husain *et al.* 1987). The significant decrease in serum calcium could be attributed to the decreased concentrations of serum total protein and albumin. Similar result was also obtained by Scott (1981). There were no significant changes in the serum level of phosphate, urea and creatinine (Table 1). Similar results were also obtained by others (Scott 1981, Yegin *et al.* 1983). The present study also showed a significant decrease in total and free bilirubin (Table 1), which could be due to the decreased serum albumin. Whereas no change was observed in conjugated bilirubin. The significant decrease during the fasting weeks of Ramadan in serum activities of total ALK P was in line with the observations of others (Scott 1981, El-Hazmi *et al.* 1987). As the serum activity of total ALK P includes isoenzymes originated from the liver, bone and intestine, it was of interest to clarify which isoenzyme was responsible for the reduction in total activity of ALK P. As shown in Table 2, total and intestinal ALK P activities were significantly decreased, whereas the liver and bone ALK P activities did not show a significant change. The decrease in intestinal ALK P activity at the 4th week of Ramadan was about 56% compared to the pre-Ramadan value. This large change would not manifest itself as much at the total activity level of ALK P because of the low proportion of intestinal isoenzyme within the total ALK P activity in normal subjects. The decrease in intestinal ALK P could be due to decreased intestinal secretion associated with the fast, as the intestinal component of serum ALK P was found to be influenced by diet due to its entrance into the blood of all individuals by way of the thoracic lymph after meals (Langman *et al.* 1966, Moss 1982).

The haematological results of the present study (Table 3) showed a significant decrease in RBC count and PCV values and also a significant increase in MCH and MCHC. There were no significant change in Hb, MCV, WBC and ESR values. The decrease in RBC count and PCV values could be explained by a decreased rate of erythrocyte production presumably a consequent to the decreased rate of metabolic activity, as a result of energy intake restriction. In fact, Husain *et al.* (1987) observed a decrease in oxygen consumption and carbon dioxide elimination and a decrease in

resting cardiac frequency in subjects fasting the month of Ramadan. These authors also found that the time spent in religious activity was extended for all subjects during the month of Ramadan and consequently concluded that increased religious dedication could lead to an altered mental state that tends to lower the metabolic rate and cardiac frequency. The possibility of the increased rate of erythrocyte destruction as a cause for the reduced RBC count is excluded as the total bilirubin did not show an increase and also as others (Al-Hadramy *et al.* 1990) found no change in red cell survival during Ramadan fasting, using ^{51}Cr.

The increase in MCH and MCHC values could be due to the decreased RBC count and PCV, as these indices were calculated from the Hb, RBC and PCV. A decrease in RBC count and an increase in MCH and MCHC were also obtained by Scott (1981) in a study similar to the present one.

All the haematological results observed in the present study during Ramadan fasting (Table 3) have returned to the pre-Ramadan levels at the post-Ramadan week, except the calculated indices of MCH and MCHC which stayed high reflecting the change in Hb at the post-Ramadan week. All the biochemical results observed in the present study during Ramadan fasting (Table 1 and 2) showed either complete or partial returning to the pre-Ramadan levels at the post-Ramadan week.

Conclusion

Ramadan fasting could induce change in biochemical and haematological parameters of the blood ranging from 3.2% such as in RBC count to 29% such as in total bilirubin. Although these changes do not appear to be pathological or even sometimes beneficial as they show tendency towards decreasing levels and reversible, but they require attention by physicians practicing in Muslim communities and countries, especially in patients with different disease states or other potentially vulnerable groups, further studies are therefore needed to show the effects of Ramadan fasting in disease states.

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تأثير صيام رمضان على وزن الجسم وعلى الفحوصات الكيميائية الحيوية والدموية للدم

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لقد درس تأثير صيام رمضان على وزن الجسم وعلى الفحوصات الكيميائية الحيوية والدموية عند ٧٤ صائماً من الجنسين يتراوح أعمارهم من ٢٠-٤٨ سنة . أخذت عينات من الدم الوريدي للصائمين وفحصت في الأسبوع قبل رمضان وفي الأسبوع الأول والثاني والرابع خلال رمضان إضافة إلى الأسبوع الأول بعد شهر رمضان .

من الفحوصات المدروسة ، وزن الجسم ، الجلوكوز ، حامض البولة ، الكوليسترول الكلي ، الكوليسترول عالي الكثافة ، الكوليسترول خفيف الكثافة ، البروتين الكلي ، الألبومين ، الحديد ، الكالسيوم ، البيليروبين الكلي ، البيليروبين الحر ، الفوسفاتاز القلوية ، الكلوية والمعوية ، عدد الكريات الحمراء وحجم الخلايا الدموية المرصوصة ، كل هذه القياسات تتناقص خلال صيام رمضان بشكل اعتباري احصائياً .

بينما كمية وتركيزخضاب الدم في داخل الكرية الحمراء تتزايد خلال صيام رمضان بشكل اعتباري احصائيا وذلك بسبب التناقص الملحوظ في عدد الكريات الحمراء وحجم الخلايا الدموية المرصوصة . من ناحية أخرى فان

القياسات التالية لا تتأثر بفعل الصيام وهي الغليسريدات الثلاثية ، الفوسفات ، البولة ، كرياتينين ، البيليروبين المربوط ، غلوتامات بيروفات ناقلة الأمين غلوتامات اوكسالات ناقلة الامين ، الفوسفاتاز القلوية من الكبد والعظم ، تركيز خضاب الدم الكلي ، حجم الكرية الحمراء الوسطى ، عدد الكريات البيضاء ودرجة ترسيب الكريات الحمراء .

خلص البحث إلى أن صيام رمضان ربما يؤدي إلى نقصان وزن الجسم لدى الصائمين من خلال تقنين الطاقة المتناولة مؤدياً بالنتيجة إلى زيادة الماء في الدم ومسبباً في تغيرات معتبرة في القياسات الكيميائية والدموية للصائمين والتي تبدو بأنها تغيرات مؤقته ولكنها تحتاج إلى انتباه الاطباء العاملين في المجتمعات والدول المسلمة حتى لا تؤثر على التشخيص والمعالجة المرضية .