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Impact of Ramadan Fasting on Metabolism and on Serum Levels of Some Hormones among Healthy Jordanian Students

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This study design to evaluate the effect of Ramadan fasting on serum levels of some hormones among Jordanian healthy male students. The subjects of present study were 42 healthy Jordanian male students who fasted during Ramadan. Their mean age was 21±1.6 years. We evaluated some anthropometric parameters as body weight (kg), pulse rate (per min) and systolic and diastolic blood pressure (mmHg). All parameters at forth week of Ramadan were significantly lower than pre-Ramadan values. We evaluated blood glucose, triglycerides (TG), cholesterol, low-density lipoprotein LDL) and high-density lipoprotein (HDL) and Triglycerides at 1 day before, at week 1, 2 and 4 of the Ramadan month. It was found that high-density lipoprotein (HDL) cholesterol increased significantly during Ramadan, which indicated positive association with pulse rate and fat intake and negative association with systolic blood pressure and weight. The LDLc was significantly reduced at the end of fasting. A reduction in the average TC value was observed at the end of fasting but the difference was not statistically and there no significant rise in the TG and blood sugar values at the end of fasting. This study indicated that Ramadan fasting led to a decrease weight, LDLc significantly and significant not statistically reduction in the average TC value and significantly increasing in HDLc was noted during Ramadan. There was a non-significant rise in the TG and blood sugar value at the end of fasting. We measured blood hormone levels of testosterone luteinizing hormone (LH), follicle-stimulating hormone (FSH) and thyroid hormones (T3, T4) in all subjects of our study who were fasting for ≥12 h during Ramadan. Testosterone level was lower, significantly so for the second and fourth week of the month ($p<0.05$); FSH was increased, significantly for the fourth week ($p<0.05$); LH did not change significantly. There were no significant changes in T3 after Ramadan fasting. Short fasting is not probably accompanied by significant changes in thyroid hormone, but the repetitiveness of this in Ramadan fasting mild decrease in T4 level.

Key words: Ramadan fasting, cholesterol, high-density lipoprotein (HDL), low density lipoprotein (LDL), triglycerides (TG), testosterone, FSH, LH, T3, T4

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INTRODUCTION

Ramadan fasting is one of the 5 pillars of Islam and one of the most significant ibadat (worships) of Islam (Nomani, 1999). Throughout the world, millions of Muslims fast during Ramadan to fulfill this religious obligation. Because the lunar calendar determines the month of Ramadan and is about 11 days shorter than the solar year, Ramadan is not fixed to any season. The timing of daily fasting varies from country to country and with the season in which the month of Ramadan falls. Thus, depending upon the season and the geographical position of the country, the length of the fast varies from 12 to 19 h per day (Muazzam, 1991). During Ramadan, Muslims abstain from food and drink from dawn until sunset. Traditionally the practice is to eat 2 meals, 1 before dawn, suhore and 1 just after sunset, iftar. Often Muslims eat a greater variety of foods in their meals during Ramadan than in other months. As a result, the Ramadan fast provides an excellent opportunity to study the effects of various diets on the human body and can serve as an excellent research model for metabolic and behavioral studies (Hallak and Nomani, 1988). Ramadan fasting and starvation are not synonymous. Many physiological and psychological changes take place during Ramadan, most probably due to the changes in eating patterns, eating frequency and sleep patterns (Adlouni *et al*., 1997).

The effects of experimental short-term fasting on carbohydrate metabolism have been reviewed extensively. Only a few studies (Heber, 2001; Chill, 1970) have shown the effect of Ramadan fasting on serum glucose. One study showed a slight decrease in serum glucose in the first days of Ramadan.

Some studies (Hallak and Nomani, 1988; Shoukry, 1986; Fedail *et al*., 1982) have reported raised concentrations of cholesterol, which may be related to weight loss during Ramadan fasting. However, others have found no change (Maislos *et al*., 1993, 1998) or only decreased levels of cholesterol during Ramadan (Maislos *et al*., 1993, 1998; Adlouni *et al*., 1997; Azizi, 1996). Although bradycardia and hypertension may occur during prolonged fasting heart rate and blood pressure remain normal during the first few days of fasting.

The physiological effects of Ramadan fasting have been reviewed extensively, examples are, arise is serum bilirubin after 10 days of Ramadan fasting has been reported (Azizi and Siahkolah, 1998), no significant changes in serum SGOT, SGPT, protein and albumin concentrations occurred during Ramadan (Azizi and Siahkolah, 1998), urinary volume, osmolality pH, nitrogen, solute and electrolyte excretion remain normal (Cheah *et al*., 1990), changes in serum urea and creatinine are usually small and not statistically significant (Sliman and Khatib, 1988), serum uric acid increases to abnormal values (Murphy and Shipman, 1963) and fasting does not cause significant alterations in serum sodium and potassium (Azizi and Amir Rasouli, 1986).

It has shown that no significant alterations in serum concentrations of triiodothyronine (T3), thyroxine (T4), thyroid-stimulating hormone (TSH) and TSH response to intravenous injection of TRH occur in males during Ramadan (Azizi and Amir Rasouli, 1986). In women, total serum T4 and T3 may decrease in the last days of Ramadan; however, the fall is mainly due to TBG alterations, as free thyroid indices remain unchanged (Azizi *et al*., 1994; Suleiman, 1988). A small but significant increase in serum T4 in the last days of Ramadan has been reported by some authors, but not substantiated by others (Azizi *et al*., 1991; Suleman, 1988). In experimental fast lasting more than 48 h, many investigators have reported a fall in serum T4, along with a rise in serum rT3 (Borst *et al*., 1983; Spencer *et al*., 1983; Azizi, 1978) resulting from inactivation of 5'-monodeiodinase and decreased conversion of T4 to T4, TSH response to TRH has been reported to be decreased or unaltered.

Refeeding with carbohydrates but not protein or fat causes an increase in serum T3. In Islamic fasting, the length of fasting is not enough to cause any alteration in the pituitary-thyroid axis or peripheral conversion of T4. In prolonged fasting, serum testosterone and FSH may be unchanged (Suryanarayana *et al*., 1969) or decreased. (Klibanski *et al*., 1981). Serum luteinizing hormone (LH) concentration and its response to GnRH injection remains unchanged, but follicle-stimulating hormone (FSH) response to GnRH may be attenuated. Serum prolactin (PRL) is normal and its response to thyrotropin-releasing hormone (TRH) injection may remain normal or diminished (Carlson *et al*., 1977). In Islamic fasting, no alterations in serum concentrations of testosterone, FSH, LH and prolactin and prolactin response to TRH have been detected in normal males (Suryanarayana *et al*., 1969). Some observations showed no change in serum concentration of parathyroid hormone (PTH) during Ramadan. Mean serum concentrations of calcium may decrease slightly 10 day after the beginning of fasting, however, no subnormal values can be seen (Azizi *et al*., 1986).

The shift in cortical rhythm has been reported during Ramadan (Al-Hadramy 1997). In a detailed study of Ramadan fasting subjects; the nocturnal peak of melatonin was diminished and delayed; there was a shift in the onset of cortisol and testosterone secretion; the evening peak of prolactin was enhanced; FSH and GH

rhythmic patterns were affected little or not at all by the fasting and only the serum TSH rhythm was blunted (Bogdan *et al*., 2001). Apart from the religious and spiritual considerations, it is often a subject of discussion whether or not Ramadan fasting confers any harmful effects on the body so the purpose of the study was to evaluate the impact of Ramadan fasting on metabolism and on serum levels of some hormones among healthy Jordanian students not taking any medicines, not being on a diet and who fasted during Ramadan.

MATERIALS AND METHODS

This study was performed during Ramadan of October 2006 (Islamic year 1427). The subjects were 42 Jordanian healthy male students not taking any medicines and not being on a diet their mean age 21.3±1.6 years and who indicated that they were going to fast during Ramadan.

We excluded students with any acute or chronic disease or medication during the study. There were 4 stages, 1 day before Ramadan, 3 stages during Ramadan. Four blood samples were taken from each participant. The first sample (control) was taken 1 day before Ramadan the other 3 (experimental) on first week, second week and fourth week during Ramadan and Blood samples were collected from all subjects in tubes, serum separated from samples through centrifugation and assays were immediately done or the serum stored at less than or equal to -20C.

We evaluated some anthropometric parameters as body weight (kg), pulse rate (per minute) and systolic and diastolic blood pressure (mmHg).

Serum total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C) triglycerides (TG) and serum glucose of all the subjects were measured using the commercially available kits (Enzymatic colorimetric method according to Trinder method).

For determination of thyroid hormones, total (T4) and total (T3) in human serum we used Enzyme immunoassay test kit Catalog number: BC-1007 for total (T4) determination and catalog number: BC-1005 for Triiodothyronine (T3) (Biochek, Inc), direct immunoenzymatic determination of testosterone in serum or plasma (Diametra Inc), LH enzyme immunoassay tests Kit, catalog number BC-1031 (Biochek, Inc) and enzymatic immunoassay for the determination of FSH in human serum (DIMA).

Statistical evaluation: One-Way ANOVA analysis was applied for the comparison between results during Ramadan fasting and normal control before Ramadan fasting in all data. Coefficient correlation of variance was used to study the associated relations between different items of the study. Significance was concluded when the p value was <0.05.

RESULTS

The effect of Ramadan fasting on lipid profile blood, sugar, serum of T3, T4, testosterone, FSH and LH was studied on 40 healthy volunteers male student with mean age was 21.3±1.6 years. The blood parameters of the volunteers in the 1 day before, at week 1, 2 and 4 of the Ramadan month. We evaluated some anthropometrics parameters as body weight (kg), pulse rate (per min) and systolic and diastolic blood pressure (mmHg). All parameters at 4 week of Ramadan were significantly lower than pre-Ramadan values, body weight and other parameters had a trend to recoup to pre-Ramadan status; however, they were still lower than the pre-Ramadan values (Table 1).

Serum high-density lipoprotein (HDL) cholesterol increased significantly during Ramadan; in this study there was a significant reduction in LDLc. A reduction in the average TC value was observed at the end of fasting but the difference was not statistically and there no significant rise in the TG and blood sugar values at the end of fasting (Table 2).

Mean blood hormone levels are shown in (Table 3). Mean testosterone levels decreased in all 3-test samples. The decrease was significant for the samples from the second and forth weeks during Ramadan ($p<0.05$). Mean FSH levels increased during Ramadan but the increase was only significant in the sample from 20 Ramadan ($p<0.05$).

In contrast, mean LH level did not change significantly in comparison with the control sample (2 days before Ramadan). There were no significant changes in T3 after Ramadan fasting. Short fasting is not probably accompanied by significant changes in thyroid hormone, but the repetitiveness of this in Ramadan fasting mild decrease in T4 level.

Table 1: Anthropometric and other measurements of the healthy male volunteers

Measurements	1 day pre-Ramadan	First week of Ramadan	Second week of Ramadan	Forth week of Ramadan
Body weight (kg)	76.64±9.53	74.43±11.16	73.32±10.3	72.66±9.2
Pulse rate (min^{-1})	82.16±7.62	80.32±6.62	78.62±5.82	77.24±6.2
Systolic pressure (mmhg)	126.32±17.46	124.23±15.31	116.84±14.4	112.41±15
Diastolic pressure (mmHg)	84.53±12.62	82.32±8.40	76.41±9.34	76.50±10.6

Table 2: Serum glucose and serum lipids of the healthy male students pre-Ramadan and during Ramadan fasting

Measurements	1 day pre-Ramadan	First week of Ramadan	Second week of Ramadan	Forth week of Ramadan
Glucose (mg dL^{-1})	94.32±6.23	88.34±6.14	86.11±4.85	85.84±6.43
Total cholesterol (mg dL^{-1})	164.34±28.24	162.27±24.41	160.42±18.21	159.57±19.53
HDL Cholesterol (mg dL^{-1})	36.13±6.42	38.14±8.82	43.42±10.61	48.86±12.34
LDL Cholesterol (mg dL^{-1})	36.13±6.42	38.14±8.82	43.42±10.61	48.86±12.34
Triglycerides (mg dL^{-1})	148.54±54.72	146.32±62.41	145.52±43.43	139.36±52.29

Table 3: Variation in serum testosterone, follicle stimulating hormone (FSH), luteinizing hormone (LH), T4, T3 levels before and during Ramadan

Measurements	1 day pre-Ramadan	First week of Ramadan	Second week of Ramadan	Forth week of Ramadan
Testosterone (ng mL^{-1})	8.23±1.92	7.42±1.71	6.13±1.36	6.09±1.14
FSH (mIU mL^{-1})	5.86±0.94	5.98±1.03	6.42±1.23	6.72±1.05
LH (MIU mL^{-1})	6.78±1.47	6.96±0.84	7.25±1.32	7.48±1.08
TT4 (µG dL^{-1})	8.42±1.63	8.04±1.57	7.94±1.38	7.55±1.62
TT3 (ng dL^{-1})	153.54±25.21	151.62±31.84	149.72±22.54	149.48±24.37

These data show that daytime fasting; modifications in sleep schedule and psychological and social habits during Ramadan induce changes in the rhythmic pattern of a number of hormonal variables.

DISCUSSION

Results show significant reductions in body weight (mean 2.2 kg). This is consistent with many studies which reported weight loss during the month of Ramadan fasting (Athar *et al*., 1994; Hussein *et al*., 1987). In contrast to this, one study reported weight gain during Ramadan (Frost and Pirani, 1997). And still others did not find any significant change in body weight (El-Ati *et al*., 1995; Muazzam, 1991). In one study among healthy males, a significant reduction in skin fold thickness was reported during Ramadan fasting (Hallak and Nomani, 1988). A study of Tunisian women suggested that increased fat oxidation during Ramadan fasting results in an adaptive mechanism for body weight maintenance (El-Ati *et al*., 1995). Our observation of decreases in systolic and diastolic blood pressure is supported by the findings of (Athar *et al*., 1994). The body has regulatory mechanisms that activate during fasting. There is efficient utilization of fat (El-Ati *et al*., 1995). And basal metabolism slows down during fasting (Hussein *et al*., 1987). Contrary to the popular thinking, it was found that intake of a moderately.

High fat diet around 36% of the total energy improved blood cholesterol profile (El-Ati *et al*., 1995; Nomani *et al*., 1992). The normal recommended guidelines for daily fat intake is 30% or less energy (National Academy of Science, 1989). On weight basis, suggested fat intake during Ramadan is almost the same as during non-Ramadan days (Nomani 1999). Hallak and Nomani (1988) Investigated the effect of hypocaloric diet on men [1800 Kcal/day with 30% fat content] and found no significant effect on total cholesterol level.

The improved HDL cholesterol profile in this study is supported by Akanji *et al*. (2000, Aldouni *et al*. (1998) Maislos *et al*. (1998) and Rashid *et al*. (1996) noted similar increases in HDL cholesterol profiles in 2 non-Ramadan studies (Murphy and Shipman, 1963). Nonetheless, some studies have reported decreases (Hallak and Nomani, 1988). In multiple regressions analysis HDL cholesterol was positively associated with pulse rate and fat intake and negatively with weight loss and higher systolic blood pressure. Improvement in HDL cholesterol profile with higher fat intake agrees with the findings of (Nomani *et al*., 1992). The significant reduction in LDLc occurred despite the fact that tendency to consume fried foods was increased during Ramadan. Consumption of increased fried foods suggests a higher intake of fats as compared to non-Ramadan days. It appeared as if the quality and quantity of fat intake in Ramadan govern blood cholesterol level (Adlouni *et al*., 1997).

In another study suggested that feeding behavior that occurs during Ramadan beneficially affects serum apolipoprotein metabolism and may contribute to prevention of coronary heart disease (Temizhan *et al*., 1999).

Examined the relation of Fasting to coronary events and found that the number of cases with acute coronary heart disease events were significantly lower in Ramadan than before or after Ramadan.

A reduction in the average TC value was observed at the end of fasting but the difference was not statistically and the non-significant elevated serum TG may be attributed to the lipolytic effect of prolonged fasting and this was in line with study Nagra *et al*. (1998) who observed increase in serum TG level at the end of fasting. In all, changes in blood lipids seem to be variable and depend probably on the quality and quantity of food consumption and the degree of weight changes. These changes may also be related to consuming a large meal, as it has been shown that lipids increase in individuals taking one large meal every day, although, this was not confirmed in one study during fasting at Ramadan.

Present analysis founded that a slight decrease in serum glucose in Ramadan among our subjects. It has been found that a slight decrease in serum glucose occurs

in normal adults a few hours after fasting has begun. The effects of experimental short-term fasting on carbohydrate metabolism have been reviewed extensively. Only a few studies (Heber, 2001; Chill, 1970) have shown the effect of Ramadan fasting on serum glucose. One study showed a slight decrease in serum glucose in the first days of Ramadan

Followed by normalization by the 20th day and a slight rise by the 29th day (Azizi and Amir rasouli, 1986). Other studies have shown a mild (Temizhan *et al*., 2000; Scott 1981) or variation in serum glucose concentration (Khogheer *et al*., 1987; Davidson, 1979). From these studies, one may assume that during fasting days, which follow a rather large meal, taken before dawn (Sahur), the stores of glycogen, along with some degrees of gluconeogenesis, maintain serum glucose within normal limits. However, slight changes in serum glucose may occur individually according to food habits and individual differences in mechanisms involved in metabolism and energy regulation.

Studies on the effect of Ramadan fasting on blood lipids have produced variable results. Serum cholesterol may decrease in the first days of fasting (El-Hazmi *et al*., 1987) and rise to pre-fasting values (Gumaa *et al*., 1978). Some studies (Hallak and Nomani, 1988; Shoukry, 1986; Fedail *et al*., 1982) have reported raised concentrations of cholesterol, which may be related to weight loss during Ramadan fasting. However, others have found no change (Maislos *et al*., 1993, 1998) or only decreased levels of cholesterol during Ramadan (Adlouni *et al*., 1997; Azizi, 1996; Maislos *et al*., 1993, 1998). Previous studies have demonstrated that abstinence from eating and drinking during the Ramadan fast, which is accompanied by variations in the sleeping and waking pattern.

The psychological effects of fasting may bring about rhythmic changes in the secretion of most of the body's hormones (Irak *et al*., 1997; Fedail *et al*., 1982). From the findings of present study and those of other studies (Bakir *et al*., 1994; Sajid *et al*., 1991; Hosain and Ismil, 1977), it is clear that levels of sex hormones, as well as other hormones, vary in healthy males during the Islamic fasting month of Ramadan. Besides, the significant decrease in testosterone on the second and forth weeks of Ramadan (compared with before Ramadan) occurs simultaneously with significantly increases in FSH levels. This is understandable considering the negative feedback system that controls testosterone secretion, following a decrease in testosterone secretion from the testes, the secretion of gonadotrophin-releasing hormone from the hypothalamus increases and this hormone enters the anterior pituitary through the blood of the hypothalamus-pituitary portal system, thus stimulating the secretion of FSH and LH from the anterior pituitary (Bakir *et al*., 1992; Abbas and Basalamah, 1989). Studies on a great number of healthy fasting men and women have shown that all quantitative variations observed in gonadotrophin-releasing hormone and sex hormones are within the normal range and do not cause specific clinical changes (Bakir and Basalamah, 1992; Abbas *et al*., 1989). Experiments carried out on other hormones such as thyroxin, prolactin, cortisol and endorphin during fasting indicate that their variation is within the normal range (Bakir *et al*., 1992, 1994). It has been reported that despite the disturbance of biological processes of the body caused by the change in the times of eating and sleeping, the endocrine system does not change the concentration of pituitary, thyroid, parathyroid and sex hormones (Bakir *et al*., 1992; Suleiman, 1988). Islamic fasting is a unique form of abstinence recurring over a definite period of time. On the other hand, biological rhythms are factors that create physiological balance. This balance, according to many researchers, is maintained by the neuroendocrine system (Chang *et al*., 1993; Sajid *et al*., 1991). Present study showed that there were no significant changes in T3 after Ramadan fasting. Short fasting is not probably accompanied by significant changes in thyroid hormone, but the repetitiveness of this in Ramadan fasting mild decrease in T4 level. (Chan *et al*., 2003; Aziz *et al*., 1994, Suleman, 1988) observed that the fasting induced a decrease in T3 level by approximately 30% and that this is due to a reduction of leptin level which regulates the acute fasting-induced changes in the hypothalamic-pituitary-gonadal axis and in parts, changes in the hypothalamic-pituitary-thyroid axis (Chan *et al*., 2003; Spaulding *et al*., 1976) reported a reduction in T3 level after fasting in subjects receiving no-carbohydrate hypocaloric diets for tow weeks but the same subjects receiving islcaloric-containing carbohydrate showed no significant changes in T3 concentration. Furthermore, it has been shown that refeeding with carbohydrate but not protein or fat causes an increase in serum T3 (Azizi, 1978) High carbohydrate diet in Ramadan can explain non-significant T3 in all subjects. A small but significant increase in serum T4 in the last days of Ramadan has been reported by some authors (Fedail *et al*., 1982) reported an increase in serum T4 in a sample taken before the main evening meal on the first and last days of Ramadan, but some studies have shown no change in T3 and T4 levels during Ramadan fasting (Bogdan *et al*., 2001; Sajid *et al*., 1991) or of T4 between fed and fasting conditions (Bogdan *et al*., 2001). Chan *et al*. (2003) believed that T4 level remains unchanged in short fasting (once for 12-24 h) due to its longer half-life. Experimental case-control study on rats showed T4 and T3 were lower in the fasting group and this decrease was lowering in older than young rats (Kmies *et al*., 1998).

CONCLUSION

We found that the fasting Ramadan produces variations in the secretion of sex hormones and thyroid hormones among health male students; these variations are within the normal range.

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