



# The Effects of Ramadan Fasting on Electrolytes Index, Serum Osmolarity and Body Composition in Fasting and Non-Fasting Students: A Quasi-Experimental Study

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## Abstract

**Background:** Renal failure is strongly associated with serum osmolarity and changes in electrolytes and some blood metabolites. Because fasting is often associated with Ramadan, especially during the warm months of the year, there is a concern that renal function may be affected.

**Objectives:** This study aimed to observe the effect of one month of fasting on electrolytes, serum osmolarity and body composition in fasting and non-fasting students.

**Methods:** Twenty-nine healthy males (age  $21.20 \pm 1.69$  years and body mass index  $25.03 \pm 2.11$  kg/m<sup>2</sup>) were divided into two groups: fasting (n = 15) and non-fasting (n = 14). All measurements such as electrolytes index, serum osmolarity and body composition were collected before and after the fasting month. Data were analyzed with repeated measure ANOVA to compare within and between groups. The significance level was set at  $P < 0.05$ .

**Results:** Within-group variations were changed BMI, WHR, hip circumference, and waist circumference. Fasting glucose levels were significantly decreased at the end of the fasting period ( $P < 0.05$ ). Fasting urea, creatinine, uric acid, sodium, potassium, osmolarity increased significantly in the fasting group but no significant change was observed in serum albumin levels.

**Conclusions:** According to this result, fasting during Ramadan leads to an increase in osmolarity and serum electrolytes and a decrease in body composition. However, the use of healthy eating principles during Ramadan can help minimize these changes.

**Keywords:** Ramadan Fasting, Osmolarity, Body Composition

## 1. Background

The most important lunar month for Muslims in the world is Ramadan, with restrictions such as smoking, drinking liquids and eating from morning prayer to sunset prayer (1). Ramadan fasting is the part of the lunar calendar and since the lunar year is 11 days shorter than the solar year, this month is rotating throughout the solar year, therefore leading to various hours of fasting (11 to 17 hours) in different seasons (2). During the month of Ramadan, the amount and type of food changes somewhat. Part of this change may be due to people getting ready for sunrise fasting and compensating for their lack of daily food and fluids after sunset (3). During the first week of Ramadan, multiple metabolic responses are induced and adaptation occurs during the last week of Ramadan (4). During Ramadan fasting, food intake frequency, nighttime sleep, and physical activity decrease; while fatigue increases (3, 5).

Lifestyle changes during Ramadan may affect some blood components by altering serum osmolality. Limited fluid intake is one of the most important factors that may impair renal function during Ramadan fasting. However, there are contradictory results regarding the effect of fasting on electrolytes and serum osmolality. As in most studies, increases in osmolality (6, 7) and serum electrolytes (8, 9) such as sodium (10) and bicarbonate (11) have been reported during Ramadan. In this regard, Attarzadeh Hosseini et al. (12), by comparing the effect of one month of fasting and regular exercise on osmolality, serum electrolytes and body composition in active and passive men, found that fasting resulted in significant weight loss. In both groups, BMI, WHR, uric acid, potassium, creatinine and urea levels increased, but no significant change was observed in fasting glucose, sodium, phosphorus, and osmolality. Ziaee et al. (10), reported that Ramadan fasting on 80 healthy students (41 males and 39 females) lead

to a decrease of weight significantly in both sex groups. Decreased glucose and increased serum osmolality and sodium in both sexes were significant at the end of Ramadan, but potassium was significantly reduced only in men. Changes in urea and creatinine were not significant in this study. Hendawy (13) examined the effect of Ramadan fasting on renal function and found that the levels of uric acid and creatinine increased, the amount of potassium did not change significantly. Serum osmolality, calcium, phosphorus, pH and carbonate increased significantly. Dikme et al. (14) reported about fasting during Ramadan on serum osmolality in 62 diabetic patients. They were obtained glucose, blood urea nitrogen, systolic and diastolic blood pressure in study and control patients. There is a positive relationship between serum osmolality and decision making regarding levels of urea, uric acid and sodium. Morilla et al. (15) show that potassium levels increase in the afternoons and decrease in the mornings respectively. Mohammed (16) reported that blood urea and serum albumin levels were not changed significantly. However, total serum protein and serum uric acid levels were statistically lower during and after Ramadan. Contrary to the results obtained regarding the effect of fasting on serum osmolality and serum electrolytes in studies, there are controversial results regarding the effects of fasting on serum osmolality, electrolyte parameters, and body composition in studies. Fasting is often associated with hypohydration during Ramadan and especially in the hot months of the year, there is concern that renal function may be affected. Given the importance of fasting in the Muslim holy month of Ramadan, this study hoped to produce favorable results and help better understand the physiological conditions during Ramadan.

## 2. Objectives

The purpose of this study was to investigate the effects of Ramadan fasting on osmolality, serum electrolytes and body composition in fasting and non-fasting students.

## 3. Methods

### 3.1. Sample Selection

Quasi-experimental study designs, with pre and post-test pattern on two experimental and control groups (inactive male students) during the summer of Ramadan in May (May and June). The statistical population of this study was inactive male students (age range  $21.20 \pm 1.69$  years and body mass index  $25.03 \pm 2.11$  kg/m<sup>2</sup>) who were selected by available and purposeful sampling method. In the first

stage, people were introduced to the nature and manner of cooperation in conducting the research.

The health and physical questionnaire were completed by 29 volunteers and after analyzing the questionnaire, 29 individuals were selected for participation in this study. In order to observe ethical considerations while familiarizing the subjects with all stages of the research, such as laboratory evaluations, they were informed before completing the consent form that the information received would be confidential. They could also be excluded from the study if desired. Inclusion criteria include: The health of the study was based on the Health Questionnaire (17), no use of nutritional supplements, no gastrointestinal diseases, diabetes and kidney stones, no medication, no smoking, and no taking part in any training program (at least two months before participating in the training program). Subjects voluntarily participated in the study and signed a consent form based on the conditions of the study. The samples were divided into two groups: 1- fasting (n = 15) and 2- non-fasting (n = 14) groups. This manuscript was approved by the Ethical Committee in the Montazeri Technical College of Mashhad under IR.MUMS.REC.1398.42401. The following equation was used to determine sample size:

$$\begin{aligned} n &= \frac{2\sigma^2 (Z_{1-\alpha/2} + Z_{1-\beta})^2}{d^2} \\ &= \frac{2(2.5)^2(2 + 1.28)^2}{3.5^2} \\ &= 10.97 \\ &\cong 11 \end{aligned} \quad (1)$$

### 3.2. Anthropometric Indices

To assess body composition, the height of the same person was measured by stadiometer (SECA-Germany) with sensitivity of 0.1 cm. The weight was calculated by a digital scale produced by a German company (Beurer Germany, model PS06-PS07). The body mass index (BMI) was measured by weight (kg)/(height (m))<sup>2</sup> formula and waist-to-hip ratio (WHR).

### 3.3. Blood Collected

After 10 to 12 hours of fasting, they were taken to Dr. Majid Sezvar's laboratory in Mashhad between 15:00 and 16:00. For investigating the parameters of this study, 5 mL of venous blood was obtained from each subject. Fast blood sugar was determined with a glucose oxidase method using an auto-analyzer unit. For calculation of serum electrolytes, such as potassium, uric acid, sodium, creatinine and urea flame photometry method were used to determine potassium and sodium levels. Moreover, the levels of uric acid, creatinine (Jaffe kinetic method) and urea (urease method) were determined by using an auto

analyzer unit. After determination of serum sodium, urea and glucose, the serum osmolality index was calculated (Equation 2)(12).

$$\text{Serum osmolality} = (\text{Na} \times 2) + (\text{Glucose}/18) + (\text{Urea}/2.8) \quad (2)$$

### 3.4. Statistical Methods

Data were analyzed by SPSS software (version 22). After making sure that the distribution of data was normal by the Shapiro-Wilk test and variance homogeneity by Levene's test, repeated measure (ANOVA) was used to compare within and between groups. The significance level of  $P \leq 0.05$  was considered significant.

## 4. Results

The characteristics of the fasting and non-fasting subjects are shown in Table 1. Based on the results of Tables 2 and 3, the within-group changes of mean variables of weight, WHR, hip circumference, BMI, waist circumference and fasting glucose levels decreased significantly at the end of the fasting period ( $P < 0.05$ ). Urea values, creatinine, uric acid, sodium, potassium, osmolality increased significantly in the fasting group but no significant change was observed in serum albumin levels.

According to the results of Tables 2 and 3, between fasting and non-fasting groups there were no significant differences in weight, body mass index, waist circumference, and WHR. However, there was a significant difference between fasting and non-fasting groups in urea, uric acid, sodium and osmolality.

## 5. Discussion

The purpose of this study was to investigate the effects of Ramadan fasting on electrolytes, serum osmolality, and body composition in fasting as well as non-fasting students. According to the results of the present study, fasting resulted in a significant decrease in weight, BMI, waist circumference, hip circumference, and WHR. Studies have reported no change (18), decrease (19, 20) or increase (21) in body weight and BMI during Ramadan fasting. During Ramadan, fluid intake is reduced (22) and daily dehydration, depletion of glycogen-bound water reserves, and decreased extracellular water due to lower sodium intake occur (23). Therefore, dehydration may be part of the weight loss during Ramadan fasting. However, it is unclear whether there is chronic dehydration throughout the month of Ramadan (23).

Of course, this month's negative balance of water and energy is not enough to cause concern in fasting (23). The

increase in energy intake is usually due to the high energy intake after sunset (about 65% of total daily energy) and the excess energy intake through fat and protein (not carbohydrates) (24). However, in a study of increased energy intake mainly from carbohydrates, no change in body weight was observed during Ramadan (5). As the number of meals decreases, body composition may change. This has been attributed to the role of dietary patterns in metabolic activity (25), increased release of fatty acids from adipose tissue, and increased gluconeogenesis (26). Gluconeogenesis usually begins 4-6 hours after the last meal and reaches its peak by depleting the glycogen stores of the liver, and glucogenic amino acids and fatty acids are used by lipolysis to supply the energy needed. These factors contribute to weight loss and body fat mass (27). Changes in the circadian, sleeping and time-consuming cycles of meals, as well as differences in cultural and dietary habits between different ethnic groups and nations, appear to be the cause of the disparities in the results of the studies. The results showed that fasting during Ramadan led to a significant increase in urea, creatinine, uric acid, sodium, potassium, osmolality in the fasting group but no significant change was observed in serum albumin levels: although this is in line with the study of Aksungar et al. (28) and In-dral et al. (29).

Acidosis also increases blood uric acid (30). Increased uric acid had a linear relationship with the progress of fasting days (31). In one study, blood uric acid increased until day 15 and then decreased (32). This increase may be due to the physiological stress of the start of Ramadan. A slight increase in uric acid can also be due to a decrease in glomerular filtration rate and uric acid clearance (31). Of course, the state of body hydration and nutritional intake should also be considered. In healthy individuals, urine volume, osmolality, pH, nitrogen excretion and electrolytes do not change during Ramadan (33), and urea and creatinine variations are often moderate. Potassium and sodium levels are also moderate in healthy individuals (34).

Important factors that may disagree with the results of studies on volume and/or osmolality and other urinary values are geographic conditions, ambient climate, and hydration status (35). Daily creatine production depends on the body's muscle mass. Creatine-like urea is excreted by the kidneys and is therefore directly related to renal excretion. Excretion of creatinine increases slightly after meals, especially meat dishes. Serum creatine also has circadian changes. That way the lowest is 7 am and the highest is 7 pm (6). Changes in protein intake and body hydration also affect blood urea levels. Hunger and weight loss can partially increase blood urea levels (36). Because other factors besides renal function can affect serum creatinine and urea levels, the cause of the disagreement of the results of

**Table 1.** The Characteristics of Volunteers in This Study

Groups	Variations (Mean ± SD)			
	Age (year)	Height (cm)	Weight (kg)	BMI (kg/m <sup>2</sup> )
Fasting	20.40 ± 0.63	179.00 ± 6.30	79.96 ± 5.32	25.3 ± 2.33
Non fasting	22.07 ± 2.05	178.28 ± 4.33	79.45 ± 5.05	25.03 ± 1.94

**Table 2.** Changes in Body Composition in Different Groups During Ramadan

Variables	Stages		Variations		
	Post-Test (Mean ± SD)	Pre-Test (Mean ± SD)	P Value <sup>a</sup>		
			P	F	P
<b>Weight (kg)</b>				0.003	0.99
Fasting	79.96 ± 5.32	79.16 ± 5.43	0.001 <sup>c</sup>		
Non fasting	79.45 ± 5.05	79.17 ± 5.56	0.24		
<b>BMI (kg/m<sup>2</sup>)</b>				0.16	0.84
Fasting	25.03 ± 2.33	24.78 ± 2.36	0.001 <sup>c</sup>		
Non fasting	25.03 ± 1.94	24.94 ± 2.05	0.23		
<b>Waist (cm)</b>				0.164	0.14
Fasting	104.86 ± 4.18	101.86 ± 5.28	0.001 <sup>c</sup>		
Non fasting	105.00 ± 4.89	104.71 ± 4.93	0.59		
<b>Hip (cm)</b>				0.657	0.40
Fasting	96.33 ± 6.58	95.42 ± 6.14	0.002 <sup>c</sup>		
Non fasting	97.42 ± 4.27	97.14 ± 4.58	0.52		
<b>WHR (m)</b>				0.012	0.72
Fasting	1.09 ± 0.06	1.07 ± 0.07	0.008 <sup>c</sup>		
Non fasting	1.08 ± 0.76	1.08 ± 0.07	0.97		

<sup>a</sup>P value within group.<sup>b</sup>P value between group.<sup>c</sup>A significant level P < 0.05.

studies on the effects of fasting on these blood parameters may be changes in body hydration, blood sampling time, protein intake, diet, and body weight changes. Serum osmolality increases in the evening as the days of Ramadan increase. This can be due to low fluid intake and dehydration. For example, electrolyte imbalances are found in hot climates (37). In summary, considering that factors other than renal function can affect serum creatinine and urea levels, the lack of coherence in the results of studies on fasting serum osmolality may be due to the different climatic conditions, amount of perspiration and fluid intake by individuals. Water loss, dehydration and electrolyte balance disorders depend on the season in which Ramadan is located and the ambient temperature. Due to the limitations such as varied diet, different adaptation responses to physical activity, low number of subjects due to some of them withdrawing from the present study, individual dif-

ferences, and fasting time during Ramadan, Subjects' dietary habits, gender, fat status, and race may influence the interpretation of these results, so caution should be exercised more.

### 5.1. Conclusions

Based on the available evidence, it seems that fasting in Ramadan does not affect health if one follows certain health recommendations, especially adequate fluid intake and prevention of dehydration. Dehydration, can be one of the determining factors for osmolality changes and some serum electrolytes, especially during Ramadan; and osmolality amount depends on the type of food, the number of hours, fasting season, as well as the individual's physical strength. Also, fasting is effective in promoting physical health if you follow a proper diet and avoid overeating from Iftar to dawn and get enough fluids.

**Table 3.** Changes of Serum Electrolyte Values in Different Groups During Ramadan

Variables	Stages		Variations		
	Post-Test (Mean ± SD)	Pre-Test (Mean ± SD)	P-Value <sup>a</sup>		
			P	F	P
<b>FBS (mg/dL)</b>				3.23	0.39
Fasting	86.46 ± 4.74	79.93 ± 7.54	0.002 <sup>c</sup>		
Non fasting	85.14 ± 8.42	82.07 ± 5.63	0.92		
<b>Urea (mg/dL)</b>				10.27	0.04 <sup>c</sup>
Fasting	26.56 ± 4.65	32.43 ± 8.57	0.01 <sup>c</sup>		
Non fasting	27.14 ± 4.36	26.95 ± 4.72	0.84		
<b>Creatinine (mg/dL)</b>				0.27	0.80
Fasting	0.92 ± 0.07	0.99 ± 0.10	0.002 <sup>c</sup>		
Non fasting	0.97 ± 0.06	1.00 ± 0.08	0.09		
<b>Uric acid (mg/dL)</b>				0.003	0.005 <sup>c</sup>
Fasting	5.56 ± 0.39	5.94 ± 0.45	0.01 <sup>c</sup>		
Non fasting	5.36 ± 0.32	5.45 ± 0.39	0.37		
<b>Sodium (Meq/L)</b>				0.06	0.03 <sup>c</sup>
Fasting	137.40 ± 3.56	141.26 ± 3.41	0.001 <sup>c</sup>		
Non fasting	135.71 ± 4.23	138.35 ± 3.79	0.10		
<b>Potassium (Meq/L)</b>				0.79	0.47
Fasting	3.94 ± 0.51	4.28 ± 0.30	0.03 <sup>c</sup>		
Non fasting	4.19 ± 0.39	4.20 ± 0.22	0.90		
<b>Albumin (g/dL)</b>				0.003	0.22
Fasting	4.44 ± 0.32	4.28 ± 0.27	0.13		
Non fasting	4.53 ± 0.22	4.40 ± 0.24	0.06		
<b>Osmolarity (mg/dL)</b>				0.29	0.01 <sup>c</sup>
Fasting	289.08 ± 7.07	298.55 ± 8.20	0.001 <sup>c</sup>		
Non fasting	285.85 ± 9.36	290.89 ± 7.65	0.11		

<sup>a</sup>P value within group.<sup>b</sup>P value between group.<sup>c</sup>A significant level P < 0.05.

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## Footnotes

**Authors' Contribution:** Study concept and design: TD and KH; acquisition of data, analysis and interpretation of data, drafting of the manuscript: KH; critical revision of the manuscript for important intellectual content: KH; statistical analysis: KH; administrative, technical, and material support: TD; study supervision: TD and KH.

**Clinical Trial Registration Code:** IRCT20120129008863N9

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