

## Effect of Ramadan Fasting on Body Water Status Markers after a Rugby Sevens Match

Khaled Trabelsi<sup>\*1</sup>, PhD; Haithem Rebai<sup>1</sup>, PhD; Kais el-Abed<sup>1</sup>, PhD; Stephen R. Stannard<sup>2</sup>, PhD; Hamdi Khannous<sup>3</sup>, MS; Liwa Masmoudi<sup>3</sup>, MS; Zouheir Sahnoun<sup>3</sup>, MD; Ahmed Hakim<sup>3</sup>, PhD; Nicole Fellman<sup>4</sup>, PhD; Zouhair Tabka<sup>1</sup>, MD

### Authors' Affiliation:

1. Laboratory of Cardio-Circulatory, Respiratory, Metabolic and Hormonal Adaptations to the Muscular Exercise, Faculty of Medicine Ibn El Jazzar, 4002 Sousse, Tunisia
2. Institute of Food, Nutrition and Human Health, Massey University, New Zealand
3. Laboratory of Pharmacology, Faculty of Medicine, Sfax 3029, Tunisia
4. Laboratory of Sports Biology, Faculty of Medicine, University of Auvergne, Clermont-Ferrand, France; Department of Sports Medicine, CHU of Clermont-Ferrand, France

### \* Corresponding Author:

Address: 169, avenue Farhat Hached, 3000, Sfax, Tunisia

E-mail: trabelsikhale@gmail.com

Received: May 20, 2011

Accepted: Jul 03, 2011

**Key Words:** Intermittent Exercise; Dehydration; Total Body Water; Islamic Fasting

### Abstract

**Purpose:** To evaluate the effect of Ramadan fasting on body water status markers of rugby players at basal condition and following a simulation of rugby sevens match.

**Methods:** Twelve recreational rugby sevens players played three matches: one day before Ramadan (before Ramadan), at the end of the first week of Ramadan (Beg-R) and at the end of Ramadan (End-R). Before and immediately after each match, body weight was determined and blood samples were taken for the measurement of body water status markers. Total body water was measured with an impedancemeter only before matches.

**Results:** At rest, an increase in hematocrit (+4.4%,  $P=0.03$ ), hemoglobin (+3.4%,  $P=0.01$ ) and plasma osmolarity (+2.8%,  $P<0.001$ ) was noticed at End-R compared to before Ramadan. Total body water measured before Ramadan did not differ significantly from that of Ramadan. After the match, values of hematocrit and plasma osmolarity increased significantly at End-R (+1.4%,  $P=0.02$ ; +3.1%,  $P<0.001$  respectively) compared to before Ramadan. Although, hemoglobin measured after matches occurring during Ramadan did not differ from those of before Ramadan. In response to matches, the change of percentage of body water status markers did not differ during each period of the investigation.

**Conclusions:** The present results show that Ramadan fasting induces dehydration at basal conditions. Also, rugby sevens match played during Ramadan did not exacerbate the magnitude of responses to matches of blood and body water status markers.

*Asian Journal of Sports Medicine, Volume 2 (Number 3), September 2011, Pages: 186-194*

## INTRODUCTION

Ramadan is the holiest month in the Islamic calendar. During this holy month, Muslims are allowed to eat and drink only between sunset (*el moghreb*) and dawn (*el fajr*). Therefore, food

frequency<sup>[1]</sup> and quantity<sup>[2]</sup> and water intake<sup>[3]</sup> are reduced during the month of Ramadan. These changes can lead to a reduction in energy intake<sup>[3]</sup>, a loss of body weight<sup>[3-5]</sup>, and a state of dehydration<sup>[3,6]</sup>. The latter is reflected in a decrease in body weight and changes in hematological<sup>[3]</sup> and biochemical<sup>[6]</sup> para-

meters of body water status. For example, after participation in Ramadan fasting, hemoconcentration and a decrease in plasma volume become apparent [7] through increases in hematocrit and hemoglobin (indicating a decrease of 7% in plasma volume), and a concentration of plasma electrolytes [4,6]. Notwithstanding the importance of adequate hydration on physical performance [8], Muslim athletes continue to train and to compete during the holy month.

A few investigations have focused on the effect of Ramadan fasting on the body composition and body water status of Muslim athletes [3,9-12]. Hemoconcentration during the month of Ramadan has been demonstrated in elite judokas [10] and rugby players [3]. A significant reduction in body weight [3,10,13] and percentage of body fat [3,10] was also noticed. In contrast, Karli et al [14] observe no changes in body composition and in the body water status during the Ramadan month in elite power athletes.

Among these studies, only one [3] has highlighted the effect of moderate aerobic effort during the month of Ramadan on blood indicators of body water status. This research revealed that, following aerobic exercise, the values of hematocrit and hemoglobin recorded during the month of Ramadan were significantly higher than those recorded during the period of normal diet. This suggests a state of dehydration, which is amplified during the Ramadan month due to the cumulative effect of unrestored water loss.

A little attention has been paid to body water status of athletes practicing intermittent exercise [15]. Following a football match, losses of body weight vary from 1.0 to 2.5 kg [16], 2 to 2.5 kg [17] and 1.1 kg [18], and are accompanied by measureable decreases in plasma volume. Indeed, Edwards and Klark [19] demonstrated plasma volume decrements of 7.2 and 11.2 percent among recreational players and professional football players respectively after a football match. In the absence of fluid intake, Edwards et al [8] showed a higher increase of plasma osmolarity after a half time of football match and a specific football test (Yo-Yo intermittent test).

Rugby Sevens is a variant of the traditional fifteen a side rugby game. The basic rules of 'Sevens', including the size of the pitch, are the same as for an ordinary rugby match, except for a shorter match duration [20].

As there are only seven players per team, it follows that they have a potentially higher exercise loading than under the conditions of a normal game [20].

National and international rugby sevens tournaments are held throughout the year and can consequently take place during Ramadan. To our knowledge, no study has focused on the effect of a rugby sevens match, mixed exercise, on the body water status of athletes during Ramadan. Therefore, the aim of this investigation was to evaluate the effect of Ramadan fasting on the body water status of rugby players at basal condition and following a simulation of rugby sevens match.

## METHODS AND SUBJECTS

### *Participants*

Twelve healthy male recreational rugby sevens players participated in the study. All players were maintaining their regular training schedule before and during the Ramadan month (four two-hour training sessions each week). The mean and standard deviation ( $\pm$ SD) of their age, body mass (BM), and body mass index (BMI) were  $23.8 \pm 4$  years,  $86.9 \pm 16.2$  kg and  $26.6 \pm 4.1$  kg/m<sup>2</sup>, respectively. All participants had competitive experience in national tournaments for at least 5 years. None of the group was affected by chronic disease or endocrine disorders. No medical complications arose from the fasting. After receiving a complete verbal description of the protocol, risks and benefits of the study, participants provided written consent in accordance with the Declaration of Helsinki.

### *Experimental protocol*

This cross-sectional study was conducted in Sfax, Tunisia, in 2008 when Ramadan occurred between September 1st and September 30th. During this period, players participated in three simulations of rugby sevens matches: one day before the beginning of Ramadan (before Ramadan), at the end of the first week of Ramadan (Beg-R); and at the end of the fourth week of Ramadan (End-R). Before and immediately after each match, subjects underwent anthropometric

assessment and provided a fasting blood sample for the measurement of serum biochemistry and hematological parameters. In addition, a measure of total body water was conducted only before matches.

During Ramadan, training sessions began at 16.00 h. The match played before Ramadan started at 12.00 h and the matches played at Beg-R and End-R started at 16.00 h, to ensure that subjects had been without food and water for a minimum of 12 hours before each rugby sevens match. Before Ramadan, for the pre-blood sampling day, subjects were asked to take the last meal at night at about 23.00 h. A 20 minutes standardized warm-up preceded all matches.

### ***Rugby sevens match***

The basic rules of rugby sevens are the same as for an ordinary rugby match. The rugby sevens match is played in a field of the same size as the rugby union. Each team is composed of 7 players. The duration of a match is 14 min with a recovery of 1 min at mid-time.

### ***Maximal temperature and relative humidity***

The maximal temperature and relative humidity of different periods of the investigation were recorded by the meteorological department of Sfax, Tunisia.

### ***Body composition***

Body mass (BM) of each subject was measured to the nearest 100 g with a calibrated electronic scale (Tanita, TBF 300-A, Japan), with the subjects wearing only shorts.

Height (H) was measured to the nearest of 5 mm with a stadiometer. Body mass index (BMI) ( $BM/H^2$ ) was then calculated. Skinfold thickness was measured using calibrated calipers (Harpender, UK) at four standard sites: biceps, triceps, subscapular and suprailliac<sup>[21]</sup>. The percentage of body fat mass (% BFM) and lean body mass (LBM) was calculated using the methods of Durnin and Womersley.<sup>[21]</sup> Total body water (TBW) was determined using an impedancemeter (Maltron BF-906, UK) with a frequency of 50 KHz.

### ***Dietary intake analysis***

Subjects were instructed to record on data forms all food and beverages consumed during the week before

Ramadan. Subjects were also asked to record food and beverage intake three days per week during Ramadan. Dietary records were analyzed using the Bilnut program (Nutrisoft, Cerelles, France) and the food-composition tables of the National Institute of Statistics of Tunis (1978). Total water intake was defined as the fluid volume of consumed beverages plus the water content of consumed foods.

### ***Hematological measurements and serum biochemistry***

Before and after each rugby sevens match, players provided venous blood samples (~5ml) from an antecubital vein into a plain vacutainer tube in a seated position. An aliquot of blood was immediately removed and mixed with ethylene diaminetetraacetic acid (EDTA) as an anticoagulant. These blood samples were analyzed for hemoglobin (Hb) and hematocrit (Hct) using an automated analyzer (Beckman coulter, UK) according to the manufacturer's protocol. Blood volume and plasma volume changes were determined using the Dill and Costill equation<sup>[22]</sup>. The remainder of blood was allowed to clot and then was centrifuged at 1500g for 10 min at 4°C. An aliquot of the serum was used to measure serum glucose immediately after the centrifugation step; the remainder was then stored at -20°C until subsequent analysis. An automated analyzer (Beckman Coulter Cx9, UK) measured the concentrations of biochemical parameters using the appropriate reactant. Blood glucose was determined using an enzymatic colorimetric method (Biomérieux, France). Urea was determined using an enzymatic method (Biomaghreb, Tunisia). Sodium concentration was determined by potentiometry and plasma osmolarity was then calculated using the following equation:

$$\text{Plasma osmolarity (mOsm/l)} = 2 \times [\text{sodium}] (\text{mmol/l}) + [\text{urea}] (\text{mmol/l}) + [\text{glucose}] (\text{mmol/l})$$

### ***Statistical analyses***

All statistical tests were processed using STATISTICA Software (StatSoft, Paris, France). All data are expressed as mean  $\pm$  SD. A two-way ANOVA, 3 (Ramadan)  $\times$  2 (pre and post match) with repeated measures on both factors was applied. When appropriate, significant differences among means were

tested using the Scheffé's post hoc test. A paired t test was used to compare the nutritional assessment data, pre and post match values of body mass, hematocrit, hemoglobin and plasma osmolarity. A one-way ANOVA was used to compare the temperature and relative humidity data, anthropometric data, percentage change in hematocrit, hemoglobin, plasma volume, plasma osmolarity and that of body weight. When appropriate, significant differences among means were tested using the Scheffé's post hoc test. Statistical significance was set at  $P < 0.05$ .

## RESULTS

### Temperature and relative humidity (Table 1)

Compared to values at before Ramadan, maximum environmental temperatures recorded during the 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> week of Ramadan were significantly lower ( $P=0.003$ ,  $P < 0.001$  and  $P < 0.001$  respectively). In addition, we found no significant difference between the average maximum temperatures recorded during Ramadan and that of before Ramadan. In contrast, the mean relative humidity recorded during the 3<sup>rd</sup> and 4<sup>th</sup> week of Ramadan was significantly higher than before Ramadan ( $P < 0.001$ ).

### Dietary intake (Table 2)

Compared to before Ramadan, the total daily energy intake during the Ramadan month was significantly lower (-15.4%,  $P=0.04$ ), the fractional contribution of protein and fat to the daily diet was greater (+13%,  $P=0.007$  and +18.6%,  $P=0.02$  respectively), and the fractional contribution of carbohydrates to the daily diet was lower (-12.3%,  $P=0.03$ ). Total water intake (the sum of the water content of cooked foods plus ingested drinks) was significantly higher (+14.2%,  $P=0.004$ ) before than during Ramadan.

### Body composition (Table 3)

Four weeks of daily Ramadan fasting resulted in significant decreases in resting BM (-2.8%,  $P < 0.001$ ), BMI (-2.2%,  $P < 0.001$ ), and the % BFM (-6.9%,  $P < 0.001$ ). However, the TBW and the LBM remained unchanged over the whole period of the investigation.

### Hematological parameters and percentage of plasma volume changes (Table 4)

The means of the hematological measures were all within the normal reference range for the laboratory. Hct increased significantly ( $P < 0.001$ ) after different matches of the investigation. Similarly, Hb increased significantly after matches occurring before Ramadan ( $P < 0.001$ ), Beg-R ( $P=0.003$ ) and End-R ( $P < 0.001$ ).

Resting Hct measured at Beg-R and at End-R was significantly higher (+3.9%;  $P=0.04$  and +4.4%;

**Table 1:** Temperature and relative humidity [mean (SD)] before and during Ramadan month

Parameters	Temperature (°C) mean (SD)	Relative humidity (%) mean (SD)
$\bar{x}$ of two weeks before Ramadan	35.1 (1.8)	43.5 (1.2)
M0	35	41
$\bar{x}$ of the 1 <sup>st</sup> week of Ramadan	35.4 (1.3)	54.4 (7.5)
M1	30	60
$\bar{x}$ of the 2 <sup>nd</sup> week of Ramadan	31.7 (1.6)*	60.1 (6.6)
$\bar{x}$ of the 3 <sup>rd</sup> week of Ramadan	27.9 (1.6)**	72.1 (5.0)**
$\bar{x}$ of the 4 <sup>th</sup> week of Ramadan	24.7 (2.3)**	79.8 (1.8)**
M2	26	83
$\bar{x}$ of Ramadan	29.4 (4.4)	67.9 (11.6)

\* Significantly different from before Ramadan ( $P < 0.01$ ); \*\* ( $P < 0.001$ )

SD: Standard Deviation /  $\bar{x}$ : mean / M0: Match in the day before the beginning of Ramadan / M1: Match in the 7<sup>th</sup> day after the beginning of Ramadan / M2: Match in the 30<sup>th</sup> day after the beginning of Ramadan

**Table 2:** Estimated daily dietary intake [mean (SD)] before and during Ramadan month

Parameters	Before Ramadan mean (SD)	During Ramadan mean (SD)
Energy intake (Kcal/d)	3317 (688)	2806 (330)*
Proteins (g/d)	93.1 (18.5)	91.1 (11.8)
Proteins (% of energy)	11.5 (1.9)	13.0 (1.1)**
Fats (g/d)	115.5 (57.2)	111.4 (20.3)
Fats (% of energy)	30.1 (8.6)	35.7 (3.9)*
Carbohydrates (g/d)	475.3 (68.0)	359.8 (55.5)***
Carbohydrates (% of energy)	58.4 (7.9)	51.2 (3.9)*
Total water intake (L/d)	4.0 (0.5)	3.4 (0.5)**

\* Significantly from before Ramadan ( $P<0.05$ ); \*\* ( $P<0.01$ ); \*\*\* ( $P<0.001$ )

$P=0.03$  respectively), whereas resting values of Hb were significantly higher only at End-R (+3.4%,  $P=0.01$ ) compared to before Ramadan.

Compared to values at before Ramadan, Hct measured after matches occurring at Beg-R and End-R were significantly higher (+2.9%;  $P=0.04$  and +3.1%;  $P=0.02$  respectively), whereas Hb measured after matches occurring during Ramadan did not differ significantly.

Resting blood volume values decreased significantly (-4%;  $P=0.03$ ) from before Ramadan to Beg-R. However, blood volume values recorded after matches during Ramadan did not differ from those of before Ramadan. The percentage of blood volume changes in response to the match occurring before Ramadan was significantly higher compared to those of Beg-R ( $P=0.006$ ) and End-R ( $P=0.007$ ).

The percentage of plasma volume changes in response to matches remained unchanged over the whole period of the investigation.

### Plasma osmolarity (Table 4)

The mean resting values of plasma osmolarity were all within the laboratory's normal reference range. Plasma osmolarity increased significantly ( $P<0.001$ ) after different matches of the investigation.

Compared to before Ramadan, the resting values of plasma osmolarity measured at Beg-R and End-R were significantly higher (+2.3%, +2.8% respectively,  $P<0.001$ ). Similarly, the post match values of plasma osmolarity were significantly higher at Beg-R and End-R (+2.7%, +3.1% respectively,  $P<0.001$ ) compared to before Ramadan. The percentage of change in plasma osmolarity remained unchanged during all matches.

### Body weight (Table 5)

Participation in the sevens matches induced a decrease in body weight under the 3 situations ( $P<0.001$ ) and the magnitude of this weight loss during Ramadan was the same as before Ramadan.

**Table 3:** Anthropometric characteristics and total body water of subjects [mean (SD)] at three of the phases of the study

Parameters	Before Ramadan		Beginning Ramadan		End of Ramadan	
	Values mean (SD)	95% CI	Values mean (SD)	95% CI	Values mean (SD)	95% CI
Body weight (Kg)	86.9 (16.2)	77.7 – 96.1	85.1 (14.8)*	76.7 – 93.4	84.5 (14.9) <sup>‡</sup>	76.0 – 92.9
Body Mass Index (Kg.m <sup>-2</sup> )	26.6 (4.1)	24.3 – 29.0	26.1 (3.7) <sup>‡</sup>	24.0 – 28.2	26.0 (3.9) <sup>‡</sup>	23.8 – 28.2
Body fat (%)	23.3 (7.1)	19.3 – 27.3	22.3 (6.9) <sup>‡</sup>	18.4 – 26.2	21.7 (6.9) <sup>‡</sup>	17.8 – 25.6
Lean body mass (Kg)	65.7 (6.4)	62.1 – 69.3	65.3 (6.0)	61.9 – 68.7	65.3 (6.2)	61.8 – 68.8
Total body water (L)	51.3 (4.9)	48.5 – 54.1	52.8 (4.7)	50.2 – 55.4	51.5 (3.9)	49.3 – 53.7

\* Significantly different from before Ramadan ( $P<0.01$ ) / <sup>‡</sup> ( $P<0.001$ ) / CI: confidence interval

Before Ramadan: 1 day before the starting fasting / Beginning Ramadan: 7 days after starting fast / End of Ramadan: 30 days after starting fast

**Table 4:** Hematocrit, Hemoglobin, blood volume, plasma volume changes and plasma osmolarity (mean ± SD) measured before and after matches during the three phases of the study

Parameters	Before Ramadan		Beginning Ramadan		End of Ramadan	
	Values mean (SD)	95% CI	Values mean (SD)	95% CI	Values mean (SD)	95% CI
<b>Hematocrit (reference range: 40-50 %)</b>						
<b>Before M</b>	43.5 (3.3)	41.6 – 45.4	45.2 (2.2) *	44 – 46.5	45.4 (1.9) *	43.3 – 46.5
<b>After M</b>	45.0 (2.9) <sup>‡</sup>	43.4 – 46.7	46.3 (2.5) * <sup>‡</sup>	44.9 – 47.7	46.4 (2.0) * <sup>‡</sup>	45.2 – 47.5
<b>Δ (%)</b>	3.6 (2.0)	2.4 – 4.8	2.4 (1.8)	1.3 – 3.4	2.1 (1.2)	1.4 – 2.8
<b>Hemoglobin (reference range: 13-17 g/dl)</b>						
<b>Before M</b>	14.6 (0.9)	14.1 – 15.1	15.2 (1.0)	14.7 – 15.7	15.3 (0.7) *	14.9 – 15.7
<b>After M</b>	15.3 (0.9) <sup>‡</sup>	14.8 – 15.8	15.6 (0.9) <sup>#</sup>	15.0 – 16.1	15.6 (0.7) <sup>‡</sup>	15.2 – 16
<b>Δ (%)</b>	3.3 (1.5)	4.2 – 5.4	2.9 (2.1)	1.4 – 3.7	2.5 (1.7)	1.5 – 3.5
<b>BV (ml)</b>						
<b>Before M</b>	100.0 (0.0)		96.0 (3.7)*	93.9 – 98.1	99.5 (4.1)	97.2 – 101.8
<b>After M</b>	95.4 (1.0) <sup>¥</sup>	94.9 – 96	93.7 (4.3) <sup>‡</sup>	91.3 – 96.2	97.1 (3.6) <sup>¥</sup>	95.1 – 99.1
<b>Δ (%)</b>	-4.56 (1.0)	-5.1 – (-4.0)	-2.4 (2.0)	-3.5 – (-1.3)	-2.4 (2.0)	-3.4 – (-1.4)
<b>Δ PV (%)</b>	-7.1 (1.2)	-7.8 – (-6.4)	-4.4 (2.0)	-5.4 – (-3.2)	-4.1 (1.9)	-5.2 – (-3.1)
<b>Plasma osmolarity (reference range: 285-295 mOsm/l)</b>						
<b>Before M</b>	284.7 (3.2)	282.9 – 286.5	291.3 (3.6) <sup>⊗</sup>	289.3 – 293.3	292.8 (2.1) <sup>⊗</sup>	291.6 – 294.0
<b>After M</b>	295.9 (4.6) <sup>‡</sup>	293.3 – 298.5	304.1 (3.9) <sup>⊗</sup> <sup>‡</sup>	301.9 – 306.3	305.1 (2.6) <sup>⊗</sup> <sup>‡</sup>	303.6 – 306.6
<b>Δ (%)</b>	3.7 (0.7)	3.5 – 4.3	4.2 (0.7)	4.1 – 4.7	4.0 (0.7)	3.8 – 4.6

Significantly different from before Ramadan: \* ( $P<0.05$ ); <sup>⊗</sup> ( $P<0.001$ ). Significantly different from before M: # ( $P<0.05$ ); <sup>‡</sup> ( $P<0.01$ ); <sup>¥</sup> ( $P<0.001$ ). M: rugby sevens match / Δ (%): calculated percentage change from the pre match levels / BV: blood volume / ΔPV (%): calculated percentage change in plasma volume from before to post match levels / CI: confidence interval  
 Before Ramadan: 1 day before the starting fasting / Beginning Ramadan: 7 days after starting fast / End of Ramadan: 30 days after starting fast

## DISCUSSION

The aim of this study was to evaluate the effect of Ramadan fasting on the body water status of players at basal condition and following a simulation of a rugby sevens match. Our results show that Ramadan fasting altered the body water status of players at basal conditions and following a simulation of a rugby sevens match. In addition, playing a rugby sevens match

during Ramadan did not exacerbate the magnitude of responses of blood body water status markers to matches.

Previous studies have reported that Ramadan fasting decreases body weight and body fat percentage [3,10]. It appears that the observed decrease in body weight may be due – at least in part – to dehydration as suggested by Bouhlel et al [3]. These decreases may also be partly a function of increased utilization of stored body fat;

**Table 5:** Body weight and percentage of body weight lost [mean (SD)] before and after different matches of the three phases of the study

Body weight (Kg)	Before Ramadan		Beginning Ramadan		End of Ramadan	
	Values mean (SD)	95% CI	Values mean (SD)	95% CI	Values mean (SD)	95% CI
<b>Before M</b>	86.9 (16.2)	77.7 – 96.1	85.1 (14.8)*	76.7 – 93.4	84.5 (14.9) <sup>‡</sup>	76 – 92.9
<b>After M</b>	85.7 (16.0) <sup>#</sup>	76.7 – 94.7	84.2 (14.7)* <sup>#</sup>	75.9 – 92.5	83.5 (14.9) <sup>#</sup> <sup>‡</sup>	75.1 – 91.9
<b>Δ (%)</b>	-1.4 (0.3)	-1.5 – (-1.2)	-1 (0.8)	-1.5 – (-0.5)	-1.1 (0.4)	-1.4 – (-0.9)

Significantly different from before Ramadan: \* ( $P<0.01$ ); <sup>‡</sup> ( $P<0.001$ ). Significantly different from before M: # ( $P<0.001$ )  
 M: rugby sevens match / Δ (%): calculated percentage change from the pre-match levels / CI=confidence interval / SD: Standard deviation  
 Before Ramadan: 1 day before the starting fasting / Beginning Ramadan: 7 days after starting fast / End of Ramadan: 30 days after starting fast

this has been reported in previous investigations [6,23]. In the present study, carbohydrate consumption decreased by 24% during Ramadan, which may have resulted in an increased reliance upon fat oxidation at rest and during physical activity. However, due to the fact that we did not measure the respiratory exchange ratio, we cannot know this with certainty.

During Ramadan, signs of dehydration have been identified by increased measures of hematocrit, hemoglobin and plasma osmolarity [3,6,10]. The present study also observed a similar hemoconcentration such that in the resting state, hematocrit, hemoglobin and plasma osmolarity increased significantly during Ramadan. This state of dehydration has been attributed to the reduction of fluid intake [3]. It is likely our results can be similarly explained. Interestingly, our results conflict with the recent findings of others [10,13,24]. Differences between studies in exercise regimens and climate are likely to account for these heterogeneous findings.

Following the match, hematocrit values recorded during Ramadan were significantly higher compared to those of the control period. Our results are consistent with those of Bouhlel et al [3] who showed an increase in hematocrit after aerobic exercise achieved by elite rugby players during Ramadan. Those results could be partly attributed to an initial hypohydration of subjects prior to exercise [25]. Indeed, Maresh et al [25] showed that sedentary subjects initially dehydrated and deprived of fluid intake during physical exertion have greater values of hematocrit than when they are euhydrated and deprived of water following the completion of a submaximal exercise in a hot environment.

In the present study, post competition hemoglobin remained unchanged during Ramadan compared to before Ramadan. Our results contrast with those of Bouhlel et al [3], who showed that following the completion of aerobic effort, the values of hemoglobin were higher during Ramadan. The difference in the method and duration of the effort employed in our study could explain the dissonance of results.

Our results regarding the change in plasma volume following the various matches showed that this parameter was not affected by Ramadan fasting. These results do not agree with those of Bouhlel et al [3] who

demonstrated a greater decrease in plasma volume during the control period compared to that obtained during the month of Ramadan after the completion of moderate aerobic exercise; so again, the slightly different study protocols may explain the difference in results.

In the resting state, our results showed that the values of plasma osmolarity increased significantly during Ramadan. Our results are in disagreement with those of Ramadan et al [6]. The latter showed an increase in plasma osmolarity in sedentary men during a cool spring month of Ramadan but no similar change in physically active men. Ramadan et al [6] suggest that the high fluid turnover present in the physically active group allows more precise regulation of body fluids than the lower water turnover present in the sedentary subjects. Perhaps a lack of body fluids regulation in our rugby sevens players can be explained by the fact that the sessions of training and matches during the month of Ramadan took place in a hot and humid weather.

Following the match, values of plasma osmolarity were higher during Ramadan compared to the control period. This result could be explained by an initial state of hypohydration inducing higher plasma osmolarity during Ramadan. The increase in post match plasma osmolarity occurring during Ramadan may be the result of the cumulative effect of not restored fluid and electrolytes losses, linked to fluid abstinence and to exercise [26]. The percentage change in plasma osmolarity following various matches remained unchanged during the whole period of investigation. Armstrong et al [27] demonstrated that the initial body water status before physical exertion does not affect the rate of increase in plasma osmolarity.

Regarding the percentage of body weight lost through sweating, we note that it is not affected by fasting during Ramadan. This could be explained by the lack of any effect of body water status prior to physical exertion [1].

Although plasma osmolarity and hematological parameters showed the presence of a state of dehydration, total body water remained unchanged. This could be explained by changes in electrolyte concentrations that may distort the measurements of impedance [28,29]. In contrast, Karli et al [14] demonstrated stability of total body water during the month of

Ramadan among professional athletes and the absence of change in the urine density. Clearly, there are difficulties in the reliability of this tool for measuring total body water during Ramadan.

An obvious limitation of our study is the absence of a true control group; changes in season, diet or training load could have influenced findings independently of Ramadan. During Ramadan, players should drink plentiful amounts of fluid during the nighttime to compensate for the dehydration that occurs during daylight. In addition, long and intense training sessions, leading to important sweat loss, should be avoided during Ramadan.

## CONCLUSION

We conclude firstly that in the basal (resting) situation, Ramadan fasting induces dehydration marked by an

increase in the values of blood and body water status markers. Secondly, participation in a rugby sevens match during Ramadan does not exacerbate the magnitude of responses to matches of blood and body water status markers.

## ACKNOWLEDGMENTS

The authors express thanks to individuals who participated with their helpful comments, their copy/editing of the manuscript, and their assistance with the exercise experiment. This study was conducted with the approval of the Research Ethics Committee of the Faculty of Medicine, University of Sousse, Tunisia.

**Conflict of interests:** None

## REFERENCES

1. Bahammam A. Assessment of sleep patterns, daytime sleepiness, and chronotype during Ramadan in fasting and nonfasting individuals. *Saudi Med J* 2004;26:616-22.
2. Husain R, Duncan MT, Cheah SH, et al. Effects of fasting in Ramadan on Tropical Asiatic Moslems. *Br J Nutr.* 1987;58:41-8.
3. Bouhlel E, Salhi Z, Bouhlel H, et al. Effect of Ramadan fasting on fuel oxidation during exercise in trained male rugby players. *Diabetes and Metabolism* 2006;32:617-24.
4. Sweileh N, Schnitzler A, Hunter GR, et al. Body composition and energy metabolism in resting and exercising muslims during Ramadan fast. *J Sports Med Phys Fitness* 1992;32:156-63.
5. Ziaee V, Razaeei M, Ahmadinejad Z, et al. The changes of metabolic profile and weight during Ramadan fasting. *Singapore Med J* 2006;47:409-14.
6. Ramadan J, Telahoun G, Al-Zaid NS, et al. Responses to exercise, fluid, and energy balances during Ramadan in sedentary and active males. *Nutrition* 1999;15:735-9.
7. Bigard AX, Boussif M, Chalabi H, et al. Alterations in muscular performance and orthostatic tolerance during Ramadan. *Aviat Space Environ Med* 1998;69:341-6.
8. Edwards AM, Mann ME, Marfell-Jones MJ, et al. Influence of moderate dehydration on soccer performance: physiological responses to 45 min of outdoor match-play and the immediate subsequent performance of sport-specific and mental concentration tests. *Br J Sports Med* 2007;41:385-91.
9. Aziz AR, Wahid MF, Png W, et al. Effects of Ramadan fasting on 60 min of endurance running performance in moderately trained men. *Br J Sports Med* 2010;44:516-21.
10. Chaouachi A, Chamari K, Roky R, et al. Lipid profiles of judo athletes during Ramadan. *Int J Sports Med* 2008;29:282-8.
11. Shirreffs SM, Maughan RJ. Water and salt balance in young male football players in training during the holy month of Ramadan. *J Sports Sci* 2008;26:47-54.

12. Wilson D, Drust B, Reilly T. Is diurnal lifestyle altered during Ramadan in professional Muslim athletes? *Biol Rhythm Res* 2009;40:385-97.
13. Maughan RJ, Leiper JB, Bartagi Z, et al. Effect of Ramadan fasting on some biochemical and haematological parameters in Tunisian youth soccer players undertaking their usual training and competition schedule. *J Sports Sci* 2008;26:39-46.
14. Karli U, Guvenc A, Aslan A, et al. Influence of Ramadan fasting on anaerobic performance and recovery following short time high intensity exercise. *J Sports Sci Med* 2007;6:490-7.
15. Shireffs SM, Aragon-Vargas LF, Chamorro M, et al. The sweating response of elite soccer players to training in the heat. *Int J Sports Med* 2004;26:90-95.
16. Ekblom B. Applied physiology of soccer. *Sports Med* 1986;3:50-60.
17. Mustafa KY, Mahmoud NEA. Evaporative water loss in African soccer players. *J Sports Med Phys Fitness* 1979;19:181-3.
18. Harvey G, Meir R, Brooks L, et al. The use of body mass changes as a practical measure of dehydration in team sports. *J Sci Med Sport* 2007;11:600-3.
19. Edwards AM, Clark NA. Thermoregulatory observations in soccer match play: professional and recreational level applications using an intestinal pill system to measure core temperature. *Br J Sports Med* 2006;40:133-8.
20. Takahashi I, Umeda T, Mashiko T, et al. Effects of rugby sevens matches on human neutrophil-related non-specific immunity. *Br J Sports Med*. 2007;41:13-8.
21. Durnin JVGA, Womorsley J. Body fat assessed from total density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. *Br J Nutr* 1974;32:77-97.
22. Dill DB, Costill DL. Calculation of percentage changes in volumes of blood, plasma, and red cells in dehydration. *J Appl Physiol* 1974;37:247-8.
23. El Ati J, Beji C, Danguir J. Increased fat oxidation during Ramadan fasting in healthy women: An adaptive mechanism for body-weight maintenance. *Am J Clin Nutr* 1995;62:302-7.
24. Tayebi SM, Hanachi P, Niaki AG, et al. Ramadan fasting and weight-lifting training on vascular volumes and hematological profiles in young male weight-lifters. *Global J Health Sci* 2010;2:160-6.
25. Maresh CM, Gabaree-Boulant CL, Armstrong LE, et al. Effect of hydration status on thirst, drinking, and related hormonal responses during low-intensity exercise in the heat. *J Appl Physiol* 2004;97:39-44.
26. Fall A, Sarr M, Mandengue SH, et al. Effets d'une restriction hydrique et alimentaire prolongée (Ramadan) sur la performance et les réponses cardiovasculaires au cours d'un exercice incrémental en milieu tropical chaud. *Science & Sports*. 2007;22:50-3.
27. Armstrong LE, Maresh CM, Gabaree CV, et al. Thermal and circulatory responses during exercise: effects of hypohydration, dehydration, and water intake. *J Appl Physiol* 1997;82:2028-35.
28. O'Brien C, Young AJ, Sawka MN. Bioelectrical impedance to estimate changes in hydration Status. *Int J Sports Med* 2002; 23:361-6.
29. Pialoux V, Mischler I, Mounie R, et al. Effect of equilibrated hydration changes on total body water estimates by bioelectrical impedance analysis. *Br J Nutr* 2004;91:153-9.