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Effect of ramadan fasting on renal function markers and serum electrolytes after a rugby sevens match

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Abstract*—*The effect of Ramadan fasting on renal function markers, serum electrolytes and cardiovascular parameters at basal conditions and after a simulation of a rugby sevens match was studied in twelve recreational rugby sevens players. Three matches were played: 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, subjects provided a fasting blood sample for the measurement of hematological parameters and serum biochemistry. In addition, systolic arterial pressure (SAP) and diastolic arterial pressure (DAP) were measured. At rest, players experienced an increase in the following parameters from before Ramadan to End-R: urea (+9.9%, p<0.001), uric acid (+15.2%, p<0.001), creatinine (+22.4%, p<0.001), sodium (+2.9%, p<0.001), and chloride (+2%, p<0.001). Following the competition, players experienced an increase in the following parameters from before Ramadan to End-R: urea (+8.7%, p<0.05), uric acid (+15.2%, p<0.001), creatinine (+17.1%, p<0.001), sodium (+3.2%, p<0.001) and chloride (+2.9%, p<0.001). Post match values of SAP were significantly higher at End-R compared to the control period (p<0.05).The percentage of change of all biochemical and cardiovascular parameters in response to matches remained unchanged over the whole period of the investigation.
We conclude that at basal conditions, the state of dehydration induced by Ramadan fasting was implicated in the increase of renal function markers values and serum electrolytes. Also, rugby sevens match played during Ramadan did not exacerbate the magnitude of responses to matches of biochemical and cardiovascular parameters.

Keywords*—*dehydration; intermittent exercise; Islamic fasting; renal function; rugby sevens; serum electrolytes.

I. INTRODUCTION

Ramadan is the holiest month in the Islamic calendar (Chtourou et al. 2011, 2012). Because its timing is dependent upon the lunar cycle, Ramadan month occurs 11 days earlier every year and therefore may occur in any of the four seasons, making the length of fasting hours variable from 11-18 hours in tropical countries (Sakr 1975; Hamouda et al. 2012). During this month eating and drinking is not allowed during the day, and are permitted only at night (Aloui et al. 2012a,b). Therefore, food habits, sleep/wake cycle and behavior can be affected during this month (Lotfi et al. 2010b; Chaouachi et al. 2012).

During Ramadan, Muslim athletes continue to train and to compete. However, high workload for training and psychophysical stress due to training and competition could modify the body's homeostasis and affect biochemical and cardiovascular parameters.

Studies focusing on the effect of Ramadan fasting on biochemical and cardiovascular parameters of Muslims athletes are relatively rare and have divergent results. During Ramadan, a decrease in serum glucose has been noted in runners (Faye et al. 2005) and moderately-trained men (Aziz et al. 2010; Aziz et al. 2011), while an absence of change has been observed in soccer players (Maughan et al. 2008), elite rugby players (Bouhlel et al. 2006), physically active men (Trabelsi et al. 2011, Trabelsi et al. 2012a) and recreational bodybuilders (Trabelsi et al. 2012b).

Several markers of renal function have been studied during Ramadan. Maughan et al. (2008) reported an increase in creatinine concentrations and a decrease in urea concentrations. However, other investigations (Trabelsi et al. 2011, Trabelsi et al. 2012a, Trabelsi et al. 2012b) noted an increase in both parameters. Uric acid has been reported to increase in elite judokas (Chaouachi et al. 2008), physically active men (Trabelsi et al. 2011, Trabelsi et al. 2012a) and bodybuilders (Trabelsi et al. 2012b) but not change in soccer players (Maughan et al. 2008).

Several studies have examined the combined effects of physical activity and Ramadan fasting on serum electrolytes. Maughan et al. (2008) noted an increase in serum potassium concentrations and no change in serum sodium concentrations in soccer players. However, Trabelsi et al (2011) reported an increase in serum sodium and chloride concentrations and no change in serum potassium concentrations in physically active men.

Fluid and electrolytes losses can potentially lead to changes in some cardiovascular parameters during Ramadan. Diastolic arterial pressure has been reported to decrease in resistance athletes (Lotfi et al. 2010a) but no change in sport and physical education students (Fall et al. 2007). Bouhlel et al. (2006) highlighted the effect of moderate aerobic effort during the month of Ramadan on blood glucose concentrations in rugby players and noticed the absence of change in this parameter. Decreased systolic arterial pressure in response to aerobic exercise during Ramadan has also been reported (Fall et al. 2007); authors explaining this result as the cumulative effect of fluid and electrolyte losses, not restored, related to abstinence and to exercise.

Rugby Sevens is a variant of the traditional fifteen-aside 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 (Takahachi et al. 2005). As there are only seven players per team, it follows that they have a potentially higher aerobic exercise loading than under the conditions of a normal game (Takahachi et al. 2005).

National and international Sevens tournaments are held throughout the year and can consequently take place during Ramadan. During sporting activities occurring in hot and humid environmental conditions and associated with fluid restriction, a state of dehydration is likely. The latter can induce numerous changes in some renal function markers, serum electrolytes concentrations and cardiovascular parameters.

Most studies interested in the effect of Ramadan fasting on biochemical and cardiovascular parameters of athletes have focused on aerobic (Fall et al. 2007, Bouhlel et al. 2006; Lotfi et al. 2010; Aziz et al. 2010) or anaerobic exercise (Karli et al. 2007).

To our knowledge, no published study has focused on the effect of rugby sevens match, mixed exercise, on renal function markers, serum electrolytes and cardiovascular parameters of players during Ramadan. Therefore, the aim of this study was to evaluate the effect of Ramadan fasting on renal function markers, serum electrolytes and cardiovascular parameters of rugby sevens players at basal condition and following a simulation of rugby sevens match.

II. METHODS

Subjects

Twelve healthy male recreational rugby sevens players participated in the study. All players maintained their regular training schedule before and during the Ramadan month (four two-hours training sessions each week). The mean and standard deviation (±SD) of their age, body mass (BM), and body mass index (BMI) were 23.8±4 years, 86.9±16.2 kg and 26.6±4.1 kg/m^2, respectively. All participants had competitive experience in national tournaments for at least 5 years. None of the group were affected by chronic disease or endocrine disorders, and 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 to an experimental protocol approved by the Research Ethics Committee of the Faculty of Medicine, University of Sousse, Tunisia.

Experimental design

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 simulated 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 provided a fasting blood sample for measurement of serum biochemistry and hematological parameters. Systolic arterial pressure (SAP) and diastolic arterial pressure (DAP) were also measured. Ratings of perceived exertion were determined only after 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.

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.

Rugby sevens match

The basic rules of 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 seven players. The duration of a match is 14 min with a recovery of one min at half-time.

Maximal temperature and relative humidity

The maximal temperature and relative humidity of two weeks before and during Ramadan were recorded by the meteorological department of Sfax, Tunisia.

Hematological measurements and serum biochemistry

Before and after each rugby sevens match, players provided venous blood samples (~7ml) in a sitting position from an antecubital vein of the right arm into plain Vacutainer tubes.

An aliquot of blood was immediately removed and mixed with ethylene diaminetetraacetic acid (EDTA) as an anticoagulant. This blood samples were analyzed for hemoglobin and hematocrit using an automated analyzer (Beckman Coulter, UK) according to the manufacturer's protocol. The remainder of blood was allowed to clot and then was centrifuged at 1500*g* 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 and uric acid were determined using an enzymatic colorimetric method (Biomérieux, France). Urea was determined using an enzymatic method (Biomaghreb, Tunisia). Creatinine concentrations were determined by the Jaffé method. Sodium, potassium, and chloride concentrations were determined by potentiometry.

Cardiovascular parameters

Systolic and diastolic arterial pressures were measured whilst in a seated position, with an appropriately sized cuff placed on the right arm, using a validated digital electronic tensiometer (Omron, Japan).

Statistical analyses

All statistical tests were processed using STATISTICA Software (StatSoft, France). All data are expressed as mean ± SD. A two-way ANOVA, 3 (Ramadan) × 2 (pre and post match) with repeated measures on both factors was applied. A paired t test was used to compare the nutritional assessment data. A one-way ANOVA was used to compare the temperature and relative humidity data, the ratings of perceived exertion and the percentage of change in hematological, biochemical and cardiovascular parameters. When appropriate, significant differences among means were tested using the Scheffé's post hoc test. Statistical significance was set at $p < 0.05$.

III. RESULTS

Temperature and relative humidity (Table 1)

Compared to values at before Ramadan, maximum environmental temperatures recorded during the 2nd, 3rd and 4th week of Ramadan were significantly lower ($p<0.01$, $p<0.001$ and $p<0.001$ respectively). In addition, we find 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 3rd and 4th 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 less (- 15.4%, $p<0.05$), the fractional contribution of protein and fat to the daily diet was greater (+13%, $p<0.01$ and +18.6%, $p<0.05$ respectively) whereas the fractional contribution of carbohydrates to the daily diet was significantly lower (-12.3%, $p<0.05$). Potassium intake was reduced during Ramadan compared to before Ramadan (-15%, $p<0.01$). Total water intake (the sum of the water content of cooked foods plus ingested drinks) was significantly higher (+14.2%, $p<0.01$) before than during Ramadan.

Biochemical parameters

Blood body water status markers

Compared to before Ramadan, the resting values of Hct measured at Beg-R and at End-R were significantly higher (+3.9% and +4.4%, $p<0.05$ respectively). Matches induced an increase in Hct under the three situations ($p<0.001$) and the magnitude of increase during Ramadan was the same as before Ramadan (Table 3).

Compared to before Ramadan, the resting values of Hb recorded at End-R were significantly higher (+3.4%, $p<0.05$). The match induced a significant increase in hemoglobin concentrations for the three periods studied ($p<0.001$, $p<0.01$, $p<0.001$ respectively) and the magnitude of the increase during Ramadan was the same as before Ramadan (Table 3).

Matches induced a decrease in plasma volume and the percentage of decrease in plasma volume remained unchanged over the whole period of the investigation (Table 3).

Compared to before Ramadan, the resting values of plasma osmolarity measured at Beg-R and End-R was significantly higher (+2.3%, +2.8% respectively, $p<0.001$). Matches induced an increase in plasma osmolarity under the three situations ($p<0.001$) and the magnitude of increase during Ramadan was the same as before Ramadan (Table 4).

Renal function markers (Table 4)

Compared to before Ramadan, resting values of urea recorded at End-R were significantly higher (+ 9.9%, $p<0.001$). The match induced a significant increase in uremia for the three periods studied ($p<0.05$, $p<0.001$, $p<0.001$ respectively) and the magnitude of the increase during Ramadan was the same as before Ramadan.

Compared to before Ramadan, the pre match values of serum creatinine concentrations recorded at Beg-R and at End-R were significantly higher (+18.5%, +22.4%, $p<0.001$). Matches induced an increase in serum creatinine concentrations under the 3 situations ($p<0.001$) and the magnitude of increase during Ramadan was the same as before Ramadan**.**

Compared to before Ramadan, the resting values of serum uric acid concentrations recorded at Beg-R and End-R were significantly higher (+11.4%, +15.2%, $p<0.05$, $p<0.001$ respectively). Matches induced an increase in serum uric acid concentrations under the 3 situations ($p<0.001$) and the magnitude of increase during Ramadan was the same as before Ramadan.

Serum electrolytes and plasma glucose (Table 5)

Compared to before Ramadan, the resting values of serum sodium concentrations recorded at Beg-R and at End-R were significantly higher (+2.4%, +2.9%, $p<0.001$).

Compared to before Ramadan, the resting values of serum chloride concentrations recorded at Beg-R and at End-R were significantly higher (+1.4%, +2%, $p<0.01$, $p<0.001$ respectively).

Matches induced an increase in serum sodium and chloride concentrations under the three situations ($p<0.001$) and the magnitude of increase during Ramadan was the same as before Ramadan.

The resting values of serum potassium concentrations remained unchanged over the whole period of the investigation and the post match values of kalemia did not differ significantly from those of pre match values.

Resting values of glucose remained unchanged during Ramadan compared to before Ramadan.

The match induced a significant increase in glycemia for the three periods studied ($p<0.01$, $p<0.001$, $p<0.01$ respectively) and the magnitude of the increase during Ramadan was the same as before Ramadan.

Cardiovascular parameters (Table 6)

The resting values of SAP recorded before Ramadan did not differ significantly from those of during Ramadan. Matches induced an increase in SAP under the three situations ($p<0.001$) and the magnitude of increase during Ramadan was the same as before Ramadan.

The resting values of DAP remained unchanged over the whole period of the investigation and the post match values of DAP did not differ significantly from those of pre match values.

IV. DISCUSSION

Our results show that Ramadan intermittent fasting induces a state of dehydration at basal conditions which is implicated in the increase of renal function markers values and serum electrolytes. In addition, rugby Sevens match played during Ramadan did not exacerbate the magnitude of response to matches of biochemical and cardiovascular parameters.

During Ramadan, signs of dehydration have been identified by increased measures of hematocrit, hemoglobin (Bouhlel et al. 2006, Chaouachi et al. 2008, Trabelsi et al. 2011). The present study also observed a similar hemoconcentration such that in the resting state, hematocrit and hemoglobin increased significantly during Ramadan. This state of dehydration has been attributed to the reduction of fluid intake (Bouhlel et al. 2006; Trabelsi et al. 2011, Trabelsi et al. 2012a, Trabelsi et al. 2012b). It is likely our results can be similarly explained.

Therefore, this state of dehydration was implicated on the rise of renal function markers values and some serum electrolytes concentrations. In fact, our results showed that resting values of urea recorded during Ramadan was higher compared to those of the control period. This result can be explained by dehydration and the decreased of the renal blood flow. In addition, the increase in uremia could be attributed to the combination of training and dietary restriction (Opstad 1991; Degoutte et al. 2006).

In sports medicine, creatinine is used for evaluating general health status of athletes, particularly in events where hydroelectrolytic balance reaches crucial levels (Banfi 2010). Our results showed that resting values of serum creatinine were higher during the month of Ramadan compared to the control period. Maughan et al. (2008) attributed a Ramadan-related rise in creatinine to the increase in protein intake, which is not the case in our study. Therefore, dehydration can be implicated in the rise of serum creatinine values during Ramadan.

Following the competition, our results showed an increase in urea and creatinine during the month of Ramadan compared to the control period. Dehydration and the decreased renal blood flow and glomerular filtration likely explain our results.

Uric acid, is the end product of purine metabolism (Kand'a'r et al. 2006) and contributes to 58% on average antioxidant capacity of plasma (Hellsten et al. 1998).

In a basal situation, serum uric acid values recorded during Ramadan was significantly higher compared to the control period. Our results are consistent with those of Chaouachi et al. (2008) who attribute the increase uric acid to the increase in protein breakdown, coupled with dehydration while fasting. Following competition, the increase of serum uric acid during Ramadan compared to before Ramadan can be explained by dehydration.

Despite the initial state of dehydration during Ramadan, the magnitude of response of renal function markers during Ramadan was the same as pre-Ramadan. Therefore, we can conclude that renal responses to matches occurring during Ramadan are not different. The short duration (14 min) of the rugby Sevens match can explain the latter finding. However, future studies including high intermittent exercise intensity with a duration longer than a rugby Sevens match (e.g., football, rugby union) should be carried out to explore the evolution of renal function markers in response to exercise during participation in Ramadan.

Some serum electrolytes values recorded at basal conditions and after competition were affected by the Ramadan month. In fact, resting values of serum sodium concentrations recorded during Ramadan were significantly higher than that recorded during the control period. Our results disagree with the study of Maughan et al. (2008). Indeed, the latter study noticed no change in serum sodium during Ramadan. Likewise, Ramadan et al. (1999) observed no change in serum sodium concentrations recorded during a cool spring month of Ramadan in physically active men. Therefore, the increased serum sodium concentrations noticed in our study could be explained by the fact that training and matches occurring during Ramadan take place in hot and humid weather causing significant sweat losses not fully restored after breaking the fast.

Following the competition, the serum sodium values were higher during Ramadan compared to the control period. This result could be explained by an initial state of hypohydration inducing higher plasma sodium concentrations during Ramadan.

Indeed, Gonzalez-Alonso et al. (1997) showed that sedentary subjects initially dehydrated and deprived of fluid intake during physical exertion have values of sodium concentrations greater than when they are euhydrated and deprived of water after the completion of aerobic exercise.

The limitation of our study is the absence of a true control group; changes in season, diet, training and matches intensities could have influenced findings independently of Ramadan.

Our results show a significant increase of pre- and post-competition serum chloride during the month of Ramadan compared to those of the control period.

This increase can be explained by dehydration and a movement of chloride ions linked to that of sodium (Anagnostopoulos et al. 1984).

Serum potassium remained unchanged during the month of Ramadan compared to the control period. Our results are consistent with those of Trabelsi et al (2011). Due to the dehydration and the elevations in serum sodium and chloride concentrations that occurred, one might expect that increases in serum potassium concentrations would also be observed. However, the decrease in potassium intake may have offset any effects on serum potassium caused by dehydration. The absence of change in serum potassium recorded following competition occurred during the month of Ramadan and that of the control period can be attributed to the intermittent nature of the effort. Indeed, serum potassium returns rapidly to baseline after brief recovery periods during the rugby sevens match (mid-time, scrum, penalty).

During basal conditions the results of our study did not show a significant difference between the blood glucose concentration recorded during Ramadan and that of the control period. Our results are consistent with some studies in the literature (Bouhlel et al. 2006; Maughan et al. 2008, Trabelsi et al. 2011, Trabelsi et al 2012a, Trabelsi et al. 2012b). Despite a decrease in carbohydrate intake during Ramadan, blood glucose did not change, which may be due to an upregulation of gluconeogenesis. Similarly, following the competition, glycemia recorded during Ramadan was not significantly different from that recorded during the control period. Our results are in agreement with those of Bouhlel et al. (2006) who noticed no change in blood glucose following the completion of an aerobic exercise by rugby players. The result of our study could be explained by

the lack of influence of the practice of physical activity in a state of dehydration and a water deprivation on blood glucose values (Armstrong et al. 1997).

Systolic blood pressure recorded following competition taking place during Ramadan was significantly lower compared to that of the control period. Our results are in agreement with those of Fall et al. (2007) and could be explained by the cumulative effect of fluid and electrolyte losses non-restored. Indeed, studies have shown that the hydrosodic restriction reduces blood pressure and provokes arrhythmias (Muntzel & Duerke. 1992) and circulatory collapse (Lacour & Flandrois. 1977).

We conclude that at basal conditions, the state of dehydration induced by Ramadan intermittent fasting was implicated in the increase of the resting values of renal function markers values and serum electrolytes. Despite this state of dehydration, rugby sevens match played during Ramadan did not exacerbate the magnitude of responses to matches of biochemical and cardiovascular parameters.

V. ACKNOWLEDGMENTS

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Table1: Temperature and relative humidity (mean ± SD) before and during Ramadan month

	Temperature (°C)	Relative humidity (%)
$\bar{x}$ of two weeks before Ramadan	35.1±1.8	43.5±1.2
M0	35	41
$\bar{x}$ of the 1st week of Ramadan	35.4±1.3	54.4±7.5
M1	30	60
$\bar{x}$ of the 2nd week of Ramadan	31.7±1.6**	60.1±6.6
$\bar{x}$ of the 3rd week of Ramadan	27.9±1.6***	72.1±5***
$\bar{x}$ of the 4th 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).Note: = mean; M0 = match in the day before the beginning of Ramadan; M1 = match in the 7th day after the beginning of Ramadan; M2= match in the 30th day after the beginning of Ramadan

Table 2. Estimated daily dietary intake (mean ± SD) before and during Ramadan month

	Before Ramadan	During Ramadan
Energy intake (Kcal.d^{-1})	3317±688	2806±330*
Proteins (g.d^{-1})	93.1±18.5	91.1±11.8
Proteins (% of energy)	11.5±1.9	13±1.1**
Fats (g.d^{-1})	115.5±57.2	111.4±20.3
Fats (% of energy)	30.1±8.6	35.7±3.9*
Carbohydrates (g.d^{-1})	475.3±68	359.8±55.5***
Carbohydrates (% of energy)	58.4±7.9	51.2±3.9*
Sodium (g.d^{-1})	6.4±1.7	7.1±1.4
Potassium (g.d^{-1})	2.7±0.6	2.3±0.4**
Total water intake (L.d^{-1})	4±0.5	3.4±0.5**

* Significantly from before Ramadan (p<0.05); ** (p<0.01); *** (p<0.001)

Table 3. Hematocrit, Hemoglobin, plasma volume changes measured before and after Matches during the three phases of the study (mean ± SD)

	Before Ramadan	Beg-R	End-R
Hematocrit (%)			
Before M	43.5±3.3	45.2±2.2 *	45.4±1.9 *
After M	45±2.9##	46.3±2.5 *##	46.4±2 *##
Δ (%)	3.6±2	2.4±1.8	2.1±1.2
Hemoglobin (g.dl^{-1})			
Before M	14.8±0.9	15.2±1	15.3±0.7 *
After M	15.3±0.9##	15.6±0.9#	15.6±0.7##
Δ (%)	3.3±1.5	2.9±2.1	2.5±1.7
Δ PV (%)	-7.1±1.2	- 4.4±2	- 4.1±1.9

Significantly different from before Ramadan: * (p<0.05).Significantly different from before M: # (p<0.01);## (p<0.001). Note: M = rugby sevens match;Δ (%)= calculated percentage change from the pre match levels; Δ PV (%) = calculated percentage change in plasma volume from before to post match levels. before

Ramadan = 1 day before the beginning of 30 days fasting; beginning Ramadan (Beg-R) = 7 days after starting fast; end of Ramadan (End-R) = 30 days after starting fast

Table 4. Values of renal function markers recorded before and after matches during the three phases of the study (mean ± SD)

	Before Ramadan	Beg-R	End-R
Urea (mmol.l^{-1})			
Before M	4.7±0.4	4.9±0.5	5.1±5.2 **
After M	4.9±0.5#	5.3±0.5 *###	5.3±0.5 *###
Δ (%)	5.7±6.5	7.6±3.6	4.4±2.5
Creatinine (mmol.l^{-1})			
Before M	89.2±9	105.2±10.5***	108.6±9.8***
After M	107.2±15.4###	121.7±17.1 ***###	124.6±11.1 ***###
Δ (%)	20.3±12.2	15.7±10.3	14.9±6.1
Uric acid (µmol.l^{-1})			
Before M	326.4±70.4	359.8±69.1*	368.8± 54.1***
After M	406.3±76.3###	436.7±76.5*###	470.1±55.7***###
Δ (%)	25.5±9.2	22±8.7	28±5.6

Significantly different from before Ramadan: * ($p<0.05$); ** ($p<0.01$) *** ($p<0.001$). Significantly different from before M: # ($p<0.05$); ### ($p<0.001$). Note: M = rugby sevens match; Δ (%) = calculated percentage change from the pre match levels. before Ramadan = 1 day before the beginning of 30 days fasting; beginning Ramadan (Beg-R) = 7 days after starting fast; end of Ramadan (End-R) = 30 days after starting fast

Table 5. Serum electrolytes and glycemia recorded before and after matches during the three phases of the study (mean ± SD)

	Before Ramadan	Beg-R	End-R
Sodium (mmol.l^{-1})			
Before M	137.6±1.5	140.8±1.7***	141.5±1.2***
After M	142.7±2.2###	146.7±1.8***###	1.47.3±1.4***###
Δ (%)	3.7±0.8	4.2±0.5	4.1±0.7
Chloride (mmol.l^{-1})			
Before M	102.3±1.7	103.7±1.4**	104.3±1.1***
After M	104.3±1.8	106.2±1.5**	107.3±1.8***
Δ (%)	2±1.4	2.4±1.1	2.9±1.1
Potassium (mmol.l^{-1})			
Before M	4.4±0.4	4.5±0.3	4.5±0.4
After M	4.2±0.6	4.3±0.4	4.4±0.4
Δ (%)	-5.4±11.3	-3.7±7.1	-2.5±9.6
Glycemia (mmol.l^{-1})			
Before M	4.9±0.4	4.7±0.6	4.6±0.6
After M	5.4±0.4##	5.3±0.7###	5.1±0.5##
Δ (%)	10.8±8.8	12.7±7.8	10.7±10.3

Significantly different from before Ramadan: ** ($p<0.01$) *** ($p<0.001$). Significantly different from before M: ## ($p<0.01$), ### ($p<0.001$). Note: M = rugby sevens match; Δ (%) = calculated percentage change from the pre match levels. before Ramadan = 1 day before the beginning of 30 days fasting; beginning Ramadan (Beg-R) = 7 days after starting fast; end of Ramadan (End-R) = 30 days after starting fast

Table 6. Systolic and diastolic arterial pressures (mean ± SD) measured before and after matches during the three phases of the study

	Before Ramadan	Beg-R	End-R
Systolic arterial pressure (mmHg)			
Before M	126.2±8	124.6±5.8	126.2±7.4
After M	167.5±6.6###	158.3±6.5***###	158.7±6.1*###
Δ (%)	33.1 ±8.5	27.3±8.1	26.1±7.9
Diastolic arterial pressure (mmHg)			
Before M	82.5±11	80.8±8.7	82±10.1
After M	81.2±9.1	79.6±8.4	81.7±9.8
Δ (%)	-0.3±14.8	-1±0.8	-2.1±1.2

Significantly different from before Ramadan: * ($p<0.05$);***($p<0.001$).Significantly different from before M: ### ($p<0.001$).Note: M = rugby sevens match;Δ (%)= calculated percentage change from the pre match levels. before Ramadan = 1 day before the beginning of 30 days fasting; beginning Ramadan (Beg-R) = 7 days after starting fast; end of Ramadan (End-R) = 30 days after starting fast