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RESEARCH ARTICLE

Effect of Ramadan Intermittent fasting on hydro-electrolytic parameters and physical performance among Division 1 amateur handball players of Porto Novo (Republic of Benin)

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Abstract

This prospective controlled study was undertaken to assess the effects of Ramadan fasting on hydro-electrolytic parameters and physical performance of handball players in Benin. Blood K^+, Na^+, Cl^-, Ca^{++} and albumin (ALB) as well as weight, body mass index (BMI), waist circumference (WC), body fat percentage (BFP), resting heart rate (rHR) and maximal aerobic speed (MAS) were measured three days before and on the 28^{th} day of fasting, in 13 handball players of Division 1 amateur (EG) and six non-athletes used as control group (CG). At the end of the fasting period 1) weight, BMI ($p < 0.05$), AC ($p < 0.01$), ALB ($p < 0.01$) and K^+ ($p < 0.05$) decreased; 2) there was no variation in blood Na^+, rHR and MAS($p > 0.05$); 3) an increase in blood calcium and Na/K ratio was recorded ($p < 0.05$). These results suggest the implementation of new strategies of nutritional education for Muslim athletes living in hot climates, in order to reduce the negative effects of Ramadan fasting on their sports performance.

Introduction

Islam is a monotheistic religion practised by nearly two billion people in the world, and Africa ranks second behind Asia with 554.32 million Muslims representing 53.1% of its population (World Muslim Population, 2013; Africa Muslim Population, 2013). Ramadan fasting is an important event in the life of Muslims, since it is Islam's fourth pillar. In 2005, 1.57 billion Muslims representing 23% of the world population have observed fasting (Kaba, 2005). In Africa, 24.4% of the population devote themselves to this rite (CIA World Factbook, 2009) which requires the healthy believer to abstain from eating and drinking from dawn till dusk (Fall et al., 2007).
The Islamic calendar is based on lunar months of 29 to 30 days. There is then an annual gap of 11 days and a quarter on the Gregorian calendar, justifying that Ramadan can take place in tropical countries such as Benin, both in the rainy and the dry hot seasons (Hamouda et al., 2012). When Ramadan fasting coincides with the hot season, the fasting person would deal with water and energy substrates loss, accentuated by high thermal stress. The body can better support food (Chaouachi et al., 2009) than water deprivation, which is more continuously lost through evaporation, thermolysis, breathing, urine, etc. (Koulmann et al., 2003). With the loss of this vital liquid for life and cellular homeostasis (Popkin et al., 2010), fasting individuals lose minerals and mainly electrolytes. The consequence of this minerals loss which is reduced store, is not well investigated among amateur athletes practising in hot and humid climates (Trabelsi et al., 2012). Water loss is increased during exercise, especially when the environment is hot and humid as it is in the Republic

of Benin. Indeed this black African country is characterized by a subtropical climate, with a temperature varying from 32 to 35 °C and a relative humidity from 65 to 80%. From 1 to 2% of body weight loss, the resulting dehydration in the event of insufficient water intake, can affect body physiological functions and physical performance (Casa et al., 2000). The body must be rehydrated throughout the day with 1.5 to 10 L of beverage, depending on the degree of activity and environmental conditions (Casa et al., 2005). To avoid these mishaps, water must be consumed during exercise in quantities of 200 to 300 mL every 10 to 20 minutes (Casa et al., 2000). Unfortunately the fasting sportsman, especially in sub-Saharan Africa, practises during the day, loses a lot of water and electrolytes due to the combined effects of environment and physical stress, without the possibility of compensating for this loss for 11 to 18 hours (Hamouda et al., 2012). With the recurrence of this situation over a period of 29 to 30 days, it is worth considering whether the water and electrolyte contents of the two meals taken at dawn and in the evening are sufficient to meet the needs of athletes engaged in high-level competition or not. The case of a senior men's team in Porto-Novo, of which nine of the 13 players have scrupulously followed the prescriptions of Ramadan fasting during a final of Division 1 Handball Championship, which they finally lost in the second half-time, is illustrative of the situation. Research undertaken to understand this type of situation has not always given consistent results. Indeed, while some authors (Maughan, 2008) reported a blood potassium increase in football players but no change in sodium, others (Trabelsi et al., 2011) rather observed an increase of blood sodium and chloride without significant variation in potassium among swimmers and runners. To our knowledge, no study has focused on the modifications of electrolytes in amateur handball players in sub-Saharan Africa. Therefore this study aimed at measuring the cumulative impact of Ramadan fasting and handball practice in competition on the hydro-electrolytic parameters and physical performance in Division 1 amateur players in Benin.

MATERIALS AND METHODS

Type of study and data collection design

It was a prospective and controlled study, using a 2 x 2 design. Data were collected in Porto-Novo (Republic of Benin) 31 days apart, i.e. prior to and at the end of the 2008 Ramadan fasting period, among handball players and non-athletes. Fifteen days before the start of fasting, the participants gave their written inform consent after receiving information related to the study design and objectives. The study was conducted according to the recommendations of Helsinki and approved by the Scientific Committee on Science and Sports of the University of Abomey-Calavi, acting as Ethic Committee. Three days before the start (M1) and on the 28th day of fasting (M2), anthropometric and cardiovascular measures as well as blood samples were taken and all the participants undertook the VAMEVAL field track racing test. At the same time, they also filled a form designed for food survey.

Participants

The study was carried out with a non-probabilistic sample of 19 Muslim volunteers, including 13 handball players of Division 1 amateur, used as the experimental group (EG). The other six non-athletes constituted the control group (CG) and were engaged in occasional sports practice. All the participants used to observe the Ramadan fasting strictly. Unlike the EG members who trained to prepare for the finals of the National Handball Championship of Division 1, those of the CG did not exercise during the study period. The EG members had three to four two-hour training sessions per week, of which one or two was devoted to physical work (muscular reinforcement, sprint bouts, and shuttle runs, using circuit training). Handball drills and tactical combinations constituted the main workouts of the other two sessions. Participants who were sick, under drug treatment or any other therapy (anti-malarial, diuretic, etc.) that might influence their hydric status had to be excluded from the study.

Measures

An automatic scale (Seca, Japon), with a 0.1 kg precision, a two meters stadiometer, a heart rate monitor RS800sdTM (Polar, Finland) were used to measure respectively weight, height and heart rate of the participants. The percentage of fat (PF) was determined using a bio-impedancemeter BF 302 (Omron, Belgium) and waist circumference (WC) was measured with a non-extensible tape. A pre-recorded tape was used for estimation of maximal aerobic speed (MAS) from the results of the VAMEVAL progressive and maximal field track racing test (Cazorla& Léger, 1993). A multifunction portable device (Météo-star) was used to measure ambient temperature and relative humidity throughout the study. Body mass index (BMI) was calculated using the formula BMI = weight (kg)/height (m^2). Blood samples (5 mL) were taken in dry tubes from the antecubital vein of the left elbow at 3:30 p.m., i.e. at least 10 hours after the morning meal. Calcium and electrolytes (Na^+, K^+, chloride) were assessed in the blood samples that were kept

cold (4 °C), by enzymatic and colorimetric method, using a STAX3 Electrolyte Analyser (Technico Medico, Japan). The plasma albumin was assessed by the endpoint technique (Pinnell&Northam, 1978) using a RT-9200 spectrophotometer (Rayto, Germany). A questionnaire was used to carry out the food survey in order to determine the quality of food consumed before and during the Ramadan fasting.

Three successive measurements were made for each anthropometric, cardiovascular parameter and the average value was retained. Since salt (sodium-chloride) was consumed with every meal especially in sauces, the analysis of the results of the dietary survey highlighted foods with high potency of potassium (fruits, vegetables), proteins (meat, fish, eggs) or calcium (milk and dairy products) that could account for weight loss, dehydration and decreased performance.

5. Statistical Analysis

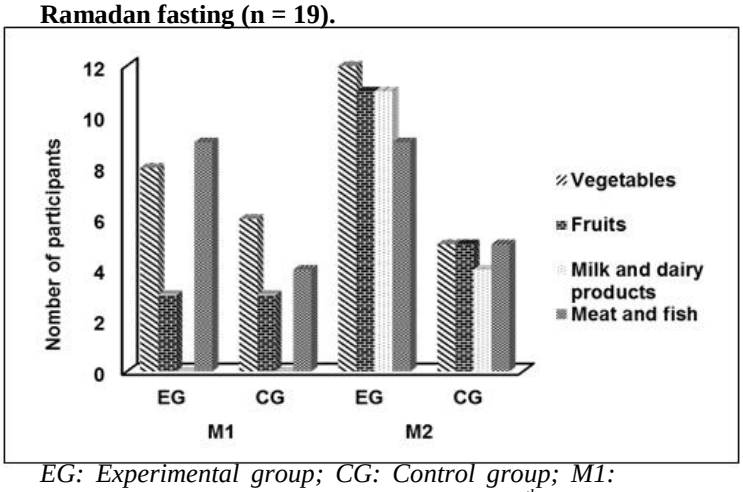
Data were processed with the software Statistica (Stat Soft Inc., Version 7.0). For each variable, results are presented as mean value (m) ± standard deviation (s) after checking for normal distribution, using the Kolmogorov-Smirnov test. The Wilcoxon rank test was used to compare measurements before and after fasting in the same group. Comparisons between EG and CG groups were made with the Mann andWhitney U test. The significance level of statistical tests was set at $p < 0.05$.

Results

Participants in this study were on average 24.5 ± 4.4 years old, with a mean height of 171.9 ± 10.3 cm and a weight of 67.9 ± 12.8 kg (Table 2). At the end of Ramadan fasting, a significant decrease in weight ($p = 0.016$), BMI ($p = 0.015$) and WC ($p = 0.0014$) was recorded in EG, while the changes recorded in CG were non-significant ($p > 0.05$). Ramadan fasting did not change rHR nor MAS ($p > 0.05$) significantly in EG but MAS was reduced in CG ($p = 0.04$) so that the difference between the two groups was significant ($p < 0.05$).

Significant reductions were observed in EG at the end of the Ramadan fasting regarding K^+ ($p = 0.015$) and ALB ($p = 0.0018$), whereas Ca^{++} ($p = 0.015$) and Na/K ratio ($p = 0.04$) rather increased (Table 3). Before the fasting period, the number of participants who used to consume vegetables, fruits, milk, and dairy products were respectively 14, 6 and zero. Respectively 17, 16 and 15 have consumed these foods during the Ramadan fasting (Table 1 and Fig 1).

Fig 1: Frequencies of vegetables, fruits and dairy products consumption before and during Ramadan fasting (n = 19).



EG: Experimental group; CG: Control group; M1: three days before Ramadan fasting; M2: 28th day of Ramadan fasting.

Tableau 1: Meals frequently consumed by studied handball players before and during the Ramadan intermittent fasting (n = 19).

	Measure 1		**Measure 2**	
	Meals	**Food groups**	**Meals**	**Food groups**
Morning	*Koko*, sugar, pate or rice, tomatoesauce, fish	Cereals/starchies, sugar Lipids Animal protids	Thea or coffee with milk + sugar Rice, *Wô* or *Bâ* and tomatoe sauce and G*ombo or Crincrin* + meat or fish Orangina, lemon orpeanapple, *Koko*, water	Milk Cereals/starchies Sugar Lipids Animal protids Fruits, vegetables
Midday	Rice, *Akansan*, B*â*,tomatoesauce or *Môyo*, water	Cereal/starchies, Lipids Animal protids	Nothing	Nothing
Evening	*Wô*, tomatoe sauce, *Akansan* + *Gombo* or *Crincrin*, water	Cereals/starchies, Lipids Vegetables	Rice, *Wô* or B*â* and tomatoe sauce and G*ombo* or *Crincrin* Orangina, lemon or peanapple *Koko*, sugar, water	Cereals/starchies, Sugar Lipids, protids Fruits, vegetables water

Measure 1: three days before the Ramadan fasting; Measure 2: 28th day of Ramadan fasting; *Akansan*: paste of fermented corn flour; *Wô*: paste of corn flour; K*oko*: porridge of corn flour; *Bâ:* paste of cassava flour; *Môyo:*.crude sauce made of tomatoes, pepper, onion and so on; *Gombo*: a kind of sticky vegetable rich in calcium, often eaten with tomatoe sauce.

Tableau II: Biometric characteristics and physical performanceof studied handball players of Benin (n = 19).

	Experimental group (EG: n1 = 13)			**Controlgroup (CG: n2 = 6)**		
	Measure 1	**Measure 2**	Δ	**Measure 1**	**Measure 2**	Δ
Age (years)	25.5 ± 4.9	-	-	22.8 ± 2.7	-	-
Height (cm)	172.2 ± 10.8	-	-	169.8 ± 10.2	-	-
Weight (kg)	71.1 ± 13.4	68.9 ± 11.5	-2.3 ± 2.8*	60.7 ± 10.0	60.1 ± 10.1	-0.6 ± 0.8
Weight loss (%)			3.2			0.9
BMI (kg/m^2)	23.8 ± 2.8	23.1 ± 2.2	-0.8 ± 1.0*	20.9 ± 1.3	20.7 ± 1.3	-0.5 ± 0.5
WC (cm)	81.6 ± 8.6	78.6 ± 8.2	-3.0 ± 1.6**	71.8 ± 4.1	70.5 ± 4.8	-1.3 ± 1.6
PF (%)	18.9 ± 7.7	17.2 ± 7.9	-1.7 ± 2.7	12.0 ± 5.4	11.3 ± 5.6	-0.7 ± 1.7
rHR (bpm)	60 ± 6	61 ± 9	+1 ± 8	65 ± 10	66 ± 14	+1 ± 5
MAS (km.h^{-1})	12.3± 2.0	12.5 ± 1.5	+0.1± 0.7	13.1 ± 1;8	12.2 ± 1.7	-0.8± 0.7*†

Numbers in the cases are mean values ± standard deviation ; BMI: body mass index; WC : waist circumference; PF: percentage of fat; rHR: resting heart rate; MAS: maximal aerobic speed; n: sample size; Measure 1: three days before Ramadan fasting; Measure 2: 28th day of Ramadan fasting; Δ: difference between mean values recorded before and at the end of the Ramadan fasting period;*****: difference between Measure 1 and Measure 2 significant at $p < 0.05$; ******: difference between measure 1 and measure 2 significant at $p < 0.01$;†: difference between EG and CG significant at $p < 0.05$.

Tableau III: Modifications in electrolytes after Ramadan intermittent fasting in handball players of Benin (n = 19).

	Experimental group (EG: n = 13)			**Control group (CG: n = 6)**		
	Measure 1	**Measure 2**	Δ	**Measure 1**	**Measure 2**	Δ
Ca^{++} (mmol.L^{-1})	93.7± 3.5	102.7 ± 12.8	+9.0 ± 11.4*	94.1 ± 3.6	95.7 ± 3.7	+1.5 ± 5.6
Cl^{-} (mmol.L^{-1})	101.2± 2.0	101.5 ± 1.0	+0.3 ± 2.0	100.8 ± 2.1	102.8 ± 0.6	+2.0 ± 2.2†
Na^{+} (mmol.L^{-1})	140.6 ± 2.0	139.8 ± 0.9	-0.7 ± 2.5	140.6 ± 1.9	140.7 ± 0.7	+0.1 ± 1.9
K^{+} (mmol.L^{-1})	4.4 ± 0.4	4.0 ± 0.2	-0.3 ± 0.5*	4.1 ± 0.1	4.2 ± 0.2	+0.1 ± 0.4†
Na/K	32.1 ± 3.2	34.4 ± 1.9	+2.2 ± 3.5*	33.6 ± 1.3	33.2 ± 1.6	-0.5 ± 2.1
ALB (g.L^{-1})	42.3 ± 2.6	36.8 ± 2.2	-5.4 ± 3.6**	41.3 ± 2.7	37.4 ± 2.2	-3.4 ± 3.3

Numbers in the cases are mean values ± standard deviation; EG: experimental group; CG: control group; **Ca^{++}**: calcium; **Cl^{-}**:chlorure; **Na^{+}**: sodium; **K^{+}**: potassium; **n**: sample size; ALB: albumin; Measure 1: three days before Ramadan fasting; Measure 2: 28th day of Ramadan fasting; Δ: differences between mean values recorded before and at the end of Ramadan fasting;*****: difference between measure 1 and measure 2, significant at $p < 0.05$; ******: difference between measure 1 and measure 2, significant at $p < 0.01$; †:difference between EG and CG groups significant at $p < 0.05$.

Discussion

The objective of this research carried out with Muslims playing handball in Porto Novo, was to find out whether the two meals taken at dawn and in the evening, during Ramadan fasting is sufficient to cover their needs for water and electrolytes. The results of such work could justify the need to draw the attention of sportsmen on the risks they face and the need for them to have a balanced diet, when fasting coincides with a hot period and intense sports practice.

The anthropometric changes recorded on the handball players corroborate the results of other studies that associate reduced weight, BMI and waist circumference with Ramadan fasting (Sadeghirad et al., 2012;Trabelsi et al., 2011). Weight loss due to fasting is estimated to an average of 1.24 kg in Asian, African, European and American populations (Sadeghirad et al., 2012). It has also been reported that men are more affected than women with a weight loss corresponding to -1.51 kg *vs* -0.92 kg. Asians are more affected than Africans and Europeans. Weight loss associated with fasting is generally attributed to low energy consumption (Shariatpanahi et al., 2008; El Ati et al., 1995), dehydration (Bouhlel et al., 2006) and a greater use of body fat as activity fuel (Ramadan et al., 1999). The current study showed a reduction in waist circumference and a decrease trend in the percentage of body fat. It seems then right to attribute the estimated loss of 3.2% of body weight to low energy intake (due to scarcity of meals), dehydration and selective use of abdominal fat, as suggested by some authors (Sadiya et al., 2011). The greater weight loss in our study, compared with the commonly reported data, could be justified by the athletic training which our players were subjected to during the same period, and that could have caused significant water loss by uncompensated sweating. The reduction in the indexes of adiposity is one of the beneficial effects of fasting on health (Kauser et al., 2013), as is the case with a participant in this study, who was previously overweight and became normally weighted at the end of the Ramadan fasting. However, this weight reduction should not lead to thinness. Unfortunately in many cases, weight loss is transitory and the fasting individual recovers his/her previous state, starting from the weeks following the end of the fasting period (Memari et al., 2011) if he/she does not adopt a healthy lifestyle (Sadeghirad et al., 2012).

The resting heart rate which is lower among the handball players than in non-athletes of the control group has not been affected by Ramadan fasting. The short duration of the study may explain this result, which is consistent with a previous study (Fall et al., 2005) that has not recorded any difference between the pre and post-fasting values among students. The stability of the maximal aerobic speed (MAS) recorded in handball players, is contrary to previous works which reported a decrease within the first week of fasting (Fall et al., 2005; Sweileh et al., 1992; Fall et al., 2005). The time of measurement (28^{th} day) could explain the difference found in this study. It is possible that between the beginning and the 28^{th} day of fasting, the body has sufficient time to adapt to the decrease in energy substrate stores and the resulting hypoglycaemia (Ba et al., 2005; Faye et al., 2005) and to the thermoregulatory challenges to which the athletes were subjected to during fasting (Ramadan, 2002; Naghii, 2000).

An increase in the blood Ca^{++} was recorded, in contrast with the results of most of the previous studies which rather indicate a slight decrease (Azizi&Rasouli, 1987) or almost the same values as those of the beginning of Ramadan fasting (Bogdan&Bouchared, 2001). In fact, the blood Ca^{++}, which is under the control of the parathyroid gland, gradually declines within the first two weeks of fasting, before rising and reaching or even exceeding in some cases, the primarily level (Kauser et al., 2013; Al-Kotobe, 2006). The main factor which might justify an increase in blood Ca^{++} in this study is the introduction of milk (source of calcium) into the daily dietary intake of the participants during the fasting period (Table 1). A study has also reported among fasting Tunisians, a higher frequency of milk consumption during Ramadan fasting, although this has not increased their total intake of Ca^{++} (Harifi et al., 2010).

Our results indicate a reduction in blood K^+, unlike those of some previous studies that reported no change in blood electrolytes among fasting sportsmen (Trabelsi et al., 2011; Trabelsi et al., 212). However, other authors have reported an increase in electrolytes among young soccer players at the end of a fasting period (Maughan et al., 2008). The reduction of K^+ recorded in our study could result from the absence in the players' meals, offruitsrich in K^+ like bananas and dry vegetables. Orangina, pineapple and *crincrin* vegetables, frequently consumed during the fasting period, are not major suppliers of K^+ likely to avoid the reduction observed.

The blood Na^+ has not decreased despite the association of physical stress and water deprivation throughout the day. This result, though consistent with those reported by some authors (Ramadan et al., 1999; Maughan et al., 2008), is in contradiction with those of other studies (Maughan et al., 2008; Trabelsi, 2012) which rather found higher blood Na^+ among athletes, at the end of a fasting period. Since the blood concentration of electrolytes is an indicator of the level of hydration of athletes (Oppliger&

Bartok, 2002), it is right to think that the food and water consumed in the evening and morning by the participants in this study were sufficient to compensate for the daily loss of water and Na^+. It is what seems to be confirmed by the stability of Cl^- and the decrease in serum albumin among the participants, who should then be considered as normally hydrated, although the weight loss (-3.2% of body weight) could allow us to suspectdehydration in them (Casa et al., 2000). However since the body fat was not reduced, only an inadequate protein intake associated with a potential autophagy, may explain the significant weight loss recorded after 28 days of Ramadan fasting.

LIMITATION OF THE STUDY

The main limitation of this study is related to the non-evaluation of the urinespecific gravity (USG) that might have helped to more objectively appreciate the hydric status in the study sample. However, blood albumin whose high values are associated with dehydration, has decreased at the end of the Ramadan fasting among the handball players who participated in the study, which supports the assumption of low hypohydration-related risk for them. The study sampling also limits the possibility for extending the conclusion to all the Muslim athletes playing team sports in the Republic of Benin.

CONCLUSION

This study focused on the effects of Ramadan fasting on hydro-electrolytic parameters of amateur-level handball players in Porto-Novo (Republic of Benin, West Africa). It showed: 1) an average weight loss of 3.2% associated with a reduction in plasma albumin, accounting for insufficient protein intake among these players during the fasting period; 2) no significant variation in blood sodium; 3) a decrease in blood potassium and an increase in calcium, probably in relation with the composition of meals consumed during the Ramadan fasting.

It is necessary to confirm and refine the results of this study in a near future, with broader study samples, assessment of hydric status, and dietary consumption during the Ramadan fasting. The current results suggest the implementation of new nutritional educational strategies for Muslim athletes, in order to reduce the negative effects of Ramadan fasting on their performance during sports competitions.

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