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Influence of *Sahour* Meal on Exercise Performance and Physiological Responses in Well-trained Muslim Runners during Ramadan

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ABSTRACT

Introduction: The objective of this study was to examine the influence of *sahour* meal on exercise performance, and physiological responses to a 10Km Time-Trial (10KTT) at two different times of the day during Ramadan.

Method: Three well-trained Muslim runners participated (age, 25±0.8years; maximal oxygen uptake, 54.87±3.45 $ml.kg^{-1}.min^{-1}$; body weight, 52.4±1.99 kg; height, 162.7±3.55 cm). Subjects ran a 10KTT on four occasions: 8.00am (Am), and 5.00pm (Pm), separated by one day rest two weeks before Ramadan (BRam) and during the second week of Ramadan (DRam). BRam, subjects consumed their usual diet. DRam, subjects consumed a standardized *sahour* meal containing 15.6±0.6kcal/kgBW; 2.3±0.1gCHO/kgBW; 0.6±0.0g Protein/kgBW; 0.5±0.0gFat/kgBW. During each 10KTT, the subject ran at 85%VO_2max for the first two Km, and then at a self-selected speed then onwards. Blood samples were collected before the run, and at 2, and the end of 10 Km. Time to complete 10KTT were recorded. Urine specific gravity was measured before each run.

Results: There was no difference in hydration status for the Am and Pm runs BRam and DRam. Running performance DRamAM, was better compared to the DRamPm. There were also no changes in blood glucose BRam and DRam. Serum Testosterone was highest at the end of 10KTT DRamPm when compared to the DRamAm, and was generally higher than BRam. Serum Cortisol showed no differences between the trials. All runners did not experience dehydration, lack of energy nor drop in performance DRam.

Conclusion: The results from this study suggest that when athletes are provided with a balanced *sahour* meal, during Ramadan, they can maintain their performance.

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Introduction

Ramadan fasting is a religious practice for Muslim, during which they do not eat or drink during daylight hours (sunrise to sunset), for a period of 28 to 30 days (1, 2). As the Islamic calendar is lunar, Ramadan occurs at different times of the calendar year with a 33 year cycle, resulting in markedly different environmental conditions in the same country from year to year

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(3). As the 2012 London Olympics fell during the Ramadan fasting month, there has been an increase in interest in the effects of Ramadan fasting on physical performance, particularly among Muslim athletes and coaches. Primarily, athletes and coaches are interested in knowing whether Ramadan fasting would affect their performance.

Muslim makes up around 1.9 billion of the world population (as at 2011), and 1.3 billion are from Asia (www.muslimpopulation.com). However, not only Muslims practice fasting, there are many groups who fast for their own reasons; such as Christians and Buddhists who may fast for health reasons. Strategies that can help sustain exercise performance of Muslim athletes during Ramadan fasting or other athletes, who practice fasting for their own reason, are very important.

During Ramadan fasting, typically two meals are eaten each day; one just before dawn, which is known as *sahour*, and the other after sunset, which is called *iftar* (1, 3-5). Although there are no restrictions on the quantity or type of food that can be consumed during Ramadan, but a number of nutritional and behavioral changes had been observed. For example, some people are unable to achieve energy balance due to the shift of eating time and sleeping time, some people increase fat consumption and/or consume excessive amounts of food due to the greater variety of foods available during Ramadan compared with the rest of the year (1-6). The dietary changes may affect the substrate availability and utilization (1, 7). Food and fluid intake before, during, and after both training and competition has important implications for performance (8).

Ingestion of carbohydrate (CHO) before and during exercise has been adopted as a useful strategy to improve exercise performance as only limited glycogen can be stored in the body (9-16), and can only last for few hours during moderate to high intensity training (65 – 85 % VO_{2max})(10, 11, 17). When body glycogen stores are reduced, exercise intensity and work output also decrease (11).

A prolonged period without access to food and drink can be potentially harmful to health and affects performance (15). There are a number of papers identified that fasting induces short term physiological adaptations which spares the remaining carbohydrates stores, and mobilizes lipid stores to provide a substitute fuel for tissues and organs functioning (15, 18-23). However, when compared with exercise in the fasting state, many researches have shown that ingestion of carbohydrate improved exercise performance (1, 9, and 24). The absence of food and drink for shorter periods of time (8-12hours) has not shown conclusive effects on health and performance (7).

Based on subjective feedback from some of the coaches, many coaches believe that performance of their athletes would drop during Ramadan fasting. In addition, other questions are raised up about the influence on performance when the athlete feels dehydrated, tired and lacks energy during the fasting period.

The *sahour* (before dawn) meal and the meal after sunset (iftar) are the opportunities for the athletes to replenish glycogen stores, and consume sufficient energy for daily activity during Ramadan. Some Muslims also consume an additional meal before sleeping (25); thus, fully maximizing food intake, and reducing the risk of not achieving the energy balance.

The purpose of this research is to determine if *sahour* meal during Ramadan fasting affects 10km time trial performance either in the morning (Am, 8am) or evening (Pm, 5pm).

Materials and Methods

Subjects

Six male well-trained Muslim runners were recruited to participate in the study. However three subjects were unable to complete the four testing sessions due to injuries, and work commitments leaving three runners to complete the study.

The study was approved by the Ethic Committee of Universiti Sains Malaysia (USM). The purpose and the nature of the study were explained to the subjects, and subjects provided written consent prior to the study.

Experimental Design

VO_{2max} was measured during an intermittent graded treadmill test conducted three weeks prior to the start of Ramadan using the National Sports Institute of Malaysia (ISN) protocol (3min work stages with 1min rest intervals, starting with 10km/h and 0% gradient, after which the treadmill speed and gradient were increased by 2km/hr, and 1% until the subject could not complete the 3min work). This protocol was established by ISN as standard operating procedures (SOP) for testing Malaysia national athletes.

Subjects ran a total of four time trials, at two times of the day (morning at 8 am, and afternoon at 5pm in a randomized order). This was to determine the effect of fasting running at different times of the day. Two time trials were

Table 1. Menu for *Sahour* Meal.

	Meal 1	Meal 2	Meal 3
Contents	• White rice, (152g) • Fish, fried in sambal chilli, (100g) • 1 whole fried egg • 1 wholemeal bun, (34g) • 2 pieces of kuih talam ubi kayu, (90g) • Orange juice (300ml) • Chicken soup with Chinese herb (1 bowl) • Vegetable (kalian), (1 scoop)	• White rice, (152g) • Beef (ginger, garlic & coconut milk), (69g) • Chicken, kurma, (65g) • 1 wholemeal bun, (34g) • Cake, orange flavor, (20g) • Syrup rose (300ml) • Chicken soup with Chinese herb (1 bowl) • Water melon, (250g)	• White rice, (152g) • Beef, fried, (69g) • Chicken kurma, (65g) • 1 wholemeal bun, (34g) • Pudding, (112g) • Guava juice, (300ml) • Tom-yam soup, (1 bowl) • Mix vegetables, (1 scoop)
Nutritional Analysis			
Energy (kcal)	812	811	833
Carbohydrate (g)	125.18 (62%)	115.12 (57%)	124.11 (59%)
Protein (g)	28.76 (14%)	26.70 (13%)	35.43 (17%)
Fat (g)	21.63 (24%)	27.42 (30%)	21.94 (24%)

conducted two weeks before Ramadan (BRam), at 8 am (BRamAm), and 5 pm (BRamPm) in a randomized order, separated by one day of rest. Another two time-trials were conducted during the second week of Ramadan (DRam), again at 8am (DRamAm), and 5 pm (DRamPm) in a randomized order, also separated by one day of rest. Before the DRam test, a standardized *sahour* meal containing 15.6±0.6kcal/kgBW; 2.3±0.1gCHO/kgBW; 0.6±0.0 g Protein/kgBW; 0.5±0.0 gFat/kgBW (choice of Meal 1, Meal 2 or Meal 3, see Table 1) was provided at the athletes' cafeteria at the National Sports Council of Malaysia. One of the investigators was there to ensure the athletes ate their *sahour* meal. Subjects recorded their diet and daily activity for seven days, two weeks before, and during the second week of Ramadan fasting.

All trials were completed under the same environment conditions with room temperature at 25.7±0.3 ^{0}C, and room humidity at 66.7 ± 1.7% in the Exercise Physiology laboratory of NSI.

Procedures

During each 10 Km time trial, the subject ran either at 8 am or 5 pm in a randomized order on a motorized treadmill at the speed of 85% VO_2 max for the first 2 km, and thereafter runners were allowed to adjust their own running pace for the rest of the time trial.

At the each trial, on reporting to the laboratory, subjects emptied their urinary bladder, and submitted a sample of urine for the measurement of urine specific gravity for hydration status which was measured using an Atago-pocket refractometer (PAL-10S). Then nude body weight was measured (Seca model 880, weighing accuracy of ±100 g). A rectal temperature probe (YSI series 400 temperature probe, Yellow Springs, Ohio) was then inserted to a depth of 10cm beyond the anal sphincter. Heart rate belt was worn at the chest, which measured heart rates via a telemetry heart rate monitor (Polar system Wirelink T31, Finland).

A polyethylene catheter was inserted into the cubital vein with a three-way stopcock for blood sampling; this remained in place during the time trial run. The patency of the catheter was maintained with heparinized saline (10IU/ml, B. Braun). Venous blood samples (4 ml) were collected 5 min (sitting) prior to the time trials, and post 1 min time trial using a 5 ml Terumo syringe. During the time trial, changes in heart rate, body temperature, room temperature, and humidity were recorded at the completion of each kilometer throughout the 10km time trial. After 5 minutes post recovery, the subjects' nude body weight was again obtained.

Analytical Procedure

An aliquot (2 ml) of each blood sample was transferred into an EDTA tube for the measurement of hemoglobin, hematocrit, and red blood cells using the blood analysis system (Nihon Kohden Celltac F, Mek8222k). This sample was then centrifuged at 3000rpm for 5 minutes at 4 ^{0}C, and the plasma was separated and frozen at -30 ^{0}C, and later analyzed for testosterone (Tes) and cortisol (Cor) using the Elisa system (Decan Sunrise). The balance of the blood sample was mixed with NaF anticoagulant, and later analyzed for blood glucose and lactate using the YSI 2300 STAT Plus system.

Table 2. Demographic, Physical Fitness, and Anthropometry of Subjects.

Variables	S1	S2	S3	Mean±SD
Age	24	26	25	25±1
Height (cm)	165.8	157.7	165.1	162.9±4.5
Weight (kg)	50.7	52.0	54.6	52.4±2.0
BMI (kg/m2)	18.5	20.8	20.1	19.8±1.2
Sum of 7 skinfold thicknesses (mm)	29.9	37.5	32.9	33.4±3.8
VO_{2max} ($ml.kg^{-1}.min^{-1}$)	57.7	56.9	50.0	54.9±4.2
Speed Max ($km.hr^{-1}$)	18.0	16.0	16.0	16.7±1.2
Maximum Heart Rate (bpm)	195	213	188	198.7±12.9

Table 3. Energy Intake (EI), Energy Expenditure (EE), Percent Macronutrient Intake and Breakfast Intake Before (BRam) and During (DRam) Ramadan (Mean±SD).

	EI (kcal)		EE (kcal)		CHO (%)		Prot (%)		Fat (%)		Breakfast (kcal)	
Sub	BRam	DRam**	BRam	DRam	BRam	DRam	BRam	DRam	BRam	DRam	BRam	DRam
1	1228±240	1552±330	--	--	65.5±6.5	62.9±5.8	14.9±2.5	15.2±3.4	19.6±5.1	21.9±5.3	480	833*
2	1839±352	1803±562	2502±297	2021±261	51.3±4.5	59.1±4.6	17.9±4.8	15.6±2.4	30.7±4.7	25.3±3.1	265	811*
3	2641±455	2211±453	2472±230	2341±188	51.1±9.3	54.1±5.9	16.6±2.8	17.9±3.6	32.8±8.8	28.2±7.0	489	812*

missing data as the physical activity diary was not completed
*Sahour Meal
** Energy intake DRam was measured the food consumed started from Iftar to Sahour

Table 4. Morning (Am) and Evening (Pm) Urine Specific Gravity Before (BRam) and During (DRam) Ramadan.

	Urine specific gravity (USG)			
Subject	BRamAm	DRamAm	BRamPm	DRamPm
1	1.029	1.026	1.027	1.020
2	1.010	1.003	1.013	1.012
3	1.009	1.013	1.014	1.017

Table 5. 10km Time Trial Performance (min) in the Morning (Am) and Evening (Pm) Before (BRam) and During (DRam) Ramadan.

	Time to complete 10Km Time Trail (min)			
Subject	BRamAm	DRamAm	BRamPm	DRamPm
1	42.95	40.30	39.28	42.22
2	47.18	46.87	48.67	47.23
3	49.97	48.02	48.87	48.90

Anthropometry, Food Intake and Physical Activity

Anthropometry was estimated from skinfolds measured by an ISAK (International Society for the Advancement of Kinanthropometry) level II anthropometrist. To obtain a representative sample of dietary intake, athletes were asked to record all food consumed for seven consecutive days using a food dairy two weeks before the Ramadan (BRam trial), and during the second week of Ramadan (DRam trial). Data from the nutritional diaries was used to calculate the intake of total energy, carbohydrate, protein, and fat using the Malaysian Food Composition tables, and Atlas of Food Exchanges and Portion Sizes (26, 27). At the same time as the food diaries were completed, subjects also recorded their physical activities. Data from the physical activity diaries was used to calculate daily energy expenditure. These activities were subdivided into categories of activity ranging from light to heavy, such as relaxing to fast running, respectively. Subjects were also required to record in detail their individual activities each day including type, intensity, and duration of activity. The Compendium of Physical Activity (28) was used to assign the metabolic equivalent of each activity.

Statistical Analysis

Where appropriate, dates were reported as means and standard deviations using a statistical analysis package (SPSS version 16, Chicago, IL).

Results

Mean age, height, weight, BMI, sum of 7 skinfolds, maximal oxygen uptake, maximal

Table 6. Heart Rate and Rectal Temperature at Rest, and at the End of the Time Trial in the Morning (Am) and Evening (Pm) Before (BRam) and During (DRam) Ramadan.

	Rest				At the End of Time Trial			
Subject	BRamAm	DRamAm	BRamPm	DRamPm	BRamAm	DRamAm	BRamPm	DRamPm
Heart rate (bpm)								
1	76	66	66	59	164	186	184	178
2	79	64	67	55	182	186	182	183
3	76	71	77	64	189	186	189	192
Rectal temperature (°C)								
1	36.7	36.8	36.2	36.3	38.9	38.9	39.2	38.6
2	37.4	37.1	37.4	37.0	39.9	39.7	39.8	39.5
3	37.6	37.0	37.5	37.1	40.4	40.2	40.6	40.1

Table 7. Lactate, Glucose, Cortisol and Testosterone at Rest, and at the End of the Time Trial in the Morning (Am) and Evening (Pm) Before (BRam) and During (DRam) Ramadan.

	Rest				At the End of Time Trial			
Subject	BRamAm	DRamAm	BRamPm	DRamPm	BRamAm	DRamAm	BRamPm	DRamPm
Lactate (mmol.L^{-1})								
1	0.99	1.07	1.51	1.27	2.09	8.92	10.60	6.12
2	1.65	1.98	2.81	2.20	8.53	9.35	8.06	9.03
3	1.78	1.84	2.44	3.41	9.77	10.30	9.19	11.60
Blood glucose (mmol.L^{-1})								
1	5.12	5.22	4.81	4.62	6.37	7.68	8.80	8.61
2	5.13	5.46	4.60	5.30	6.12	6.72	5.71	8.48
3	4.98	6.17	5.37	4.99	5.50	5.58	5.56	8.12
Cortisol (ng.mL^{-1})								
1	193.47	64.30	180.90	197.29	275.20	195.60	127.70	157.98
2	186.84	170.07	91.33	119.04	216.34	287.66	208.27	238.56
3	165.99	226.06	124.71	137.06	264.73	250.45	285.89	235.06
Testosterone (ng.mL^{-1})								
1	3.74	6.11	5.22	6.62	6.09	10.27	8.23	9.86
2	7.64	7.07	7.19	9.19	10.36	10.59	9.62	12.01
3	8.53	6.49	6.08	7.66	11.13	10.12	8.17	9.41

Table 8. Red Blood Cell, Hemoglobin and Hematocrit at Rest and at the End of the Time Trial in the Morning (Am) and Evening (Pm) Before (BRam) and During (DRam) Ramadan.

	Rest				At the End of Time Trial			
Subject	**BRamAm**	**DRamAm**	**BRamPm**	**DRamPm**	**BRamAm**	**DRamAm**	**BRamPm**	**DRamPm**
Lactate (mmol.L^{-1})								
1	0.99	1.07	1.51	1.27	2.09	8.92	10.60	6.12
2	1.65	1.98	2.81	2.20	8.53	9.35	8.06	9.03
3	1.78	1.84	2.44	3.41	9.77	10.30	9.19	11.60
Blood glucose (mmol.L^{-1})								
1	5.12	5.22	4.81	4.62	6.37	7.68	8.80	8.61
2	5.13	5.46	4.60	5.30	6.12	6.72	5.71	8.48
3	4.98	6.17	5.37	4.99	5.50	5.58	5.56	8.12
Cortisol (ng.mL^{-1})								
1	193.47	64.30	180.90	197.29	275.20	195.60	127.70	157.98
2	186.84	170.07	91.33	119.04	216.34	287.66	208.27	238.56
3	165.99	226.06	124.71	137.06	264.73	250.45	285.89	235.06
Testosterone (ng.mL^{-1})								
1	3.74	6.11	5.22	6.62	6.09	10.27	8.23	9.86
2	7.64	7.07	7.19	9.19	10.36	10.59	9.62	12.01
3	8.53	6.49	6.08	7.66	11.13	10.12	8.17	9.41

running speed, and maximal heart rate of the subjects are shown in Table 2. Values for energy intake (EI), energy expenditure (EE), and breakfast caloric intake of each subject BRam and DRam are shown in Table 3. The breakfast calorie intake of three subjects DRam was higher compared to BRam.

Urine specific gravity (USG), which indicates the level of dehydration of the subjects, with a USG of >1.020 considered to be dehydrated is shown in Table 4. At the 8am trial subjects S2 and S3 were considered to be in a hydrated state both BRam and DRam trials, while subject S1 was in a dehydrated state both BRam and DRam. Before the 5pm time trial, there were no differences in hydration status for subjects S2 and S3 before and during Ramadan, but S1 was in a dehydrated state before Ramadan (BRamPm).

The time to complete the morning 10km time trial was faster DRam than BRam for all the three subjects (Table 5). The improvement in times DRam, compared to BRam, were 6.1%, 3.9%, and 0.7% for subjects S1, S2, and S3 respectively. During the evening Ramadan trial (5 pm), the time to complete the 10KTT was mixed, with subject S2 completing 3% faster, and subject S1 7.5% slower. The time to complete the evening run was similar for S1 before and during Ramadan.

Resting heart rates DRam were lower for all the subjects when compared to BRam (Table 6). At the end of the time trials, the heart rates of all the subjects were similar in BRam and DRam trials irrespective of the time of the run, except S1, his BRamAm was lower, but BRamPm was higher at the end of the time trial. There were no differences in rectal temperatures BRam and DRam at rest or even at the end of the time trial (Table 6).

Blood glucose levels were within the normal range, and were similar in BRam and DRam at rest (Table 7). Interestingly, blood glucose levels were higher at the end of the evening time trial during Ramadan (DRamPm). Blood lactate levels were generally higher DRam at the end of the time trial for both morning and evening time trials, except S1 DRamPm. Cortisol levels were generally higher at the end of the time trial, irrespective of the time of the run, but were within the normal range. Similar trend were seen for testosterone levels (Table 7).

Hematocrit was generally higher DRam for both the morning and evening samples which increased at the end of the time trials (Table 8). All other blood parameters were within the normal range both BRam and DRam (Table 8).

Discussion

The major concerns of DRam fasting for athletes are hydration status, lack of energy, and drop of performance during competition. DRam fasting, the time to complete the 10km time trial was generally faster for all the three subjects after a *sahour* meal, which was provided 3 hours before the time trial. The calorie intakes three hours before the time trial were higher DRam compared to their normal breakfast BRam. In fact, the ingestion of meal before exercise resulted in improved exercise performance (29, 30). Three hours is usually sufficient to digest and absorb the nutrients, and thus providing adequate carbohydrate and energy for the athletes.

In addition, ingestion of a meal in combination of carbohydrate and protein would cause the rise of blood glucose and amino acid concentrations, and inhibits the breakdown of proteins, stimulating synthesis, and promotes net positive protein balance due to the effect of insulin (16, 31). Insulin would stimulate to promote storage of ingested nutrients including muscle glycogen synthesis, suppress mobilization of endogenous carbohydrate, and lipid stores (22, 31, 32).

In this study, a complete meal mixture with a variety food (rice, fish, chicken, vegetables, and fruits), and cooking methods during *sahour* meal may serve to lower the glycemic index of food. Studies have shown that the fat oxidation after 3 hours consuming low glycemic index meals was significantly higher compared to the consumption of high glycemic meal (33-34). This suggests that greater rate of fat oxidation is of potential benefit during prolonged constant pace running, because it reduces the rate of oxidation of carbohydrate, and thus delays the depletion of the limited fuel store (33).

In this study, we also found that no subject experienced low blood glucose DRam, even at 5pm after 12 hours of fasting. However, the performance during the 10km time trial at 5pm was varied (Table 5). The time to complete the 10KTT for the subject S1 was slower (7.5%) in DRam trial. However the time to complete the 10KTT was 3% faster for subject S2 but for subject S3 there was no change in performance. These results suggest that the influence of Ramadan fasting on performance is highly individualized. Based on heart rate, rectal temperature, and lactate, it is perceived that subject S1 did not push to his limit.

During the fasting state, and prolonged exercise body would rely on fat as an energy substrate due to insufficient glucose and glycogen. There would be an increase in fat mobilization from adipocytes to the contracting muscle for oxidation, and allowing muscle function to continue through gluconeogenesis (7, 15, 18, 20, 21, 23, 35). Hence, this might spare the carbohydrate storage. This may explain why during Ramadan fasting, none of the subjects experienced low blood glucose either during the morning or evening runs. Studies conducted on animals suggest that animal exposed to repeat fasting can develop a greater capacity to store, reserve, and manufacture carbohydrate in the liver (23).

Most importantly, the energy dense *sahour* meal in our study provided sufficient energy for the subjects for their daily activity, and indeed led to improvement in the time to complete the 10km DRamAM time trial, and prevented the drop of performance DRamPM time trial (5 pm).

Another interesting result from this case study showed that, there was no difference in hydration status for subjects S2 and S3 DRam at 5pm, and with subject S1 which was in a hydrated state following Ramadan at 5pm. Chaouaachi *et al* (2009) suggested that during Ramadan fasting, body water conservation occurs, and their data showed that hydration status, fluid and electrolyte balance during fasting are not chronically affected, in athletes (1). In addition, after sunset, individual are allowed to eat and drink freely, if athletes fully use this time frame, there should be sufficient time for rehydration.

Most studies indicate that cortisol output increases with exercise intensity, accelerating lipolysis, ketogenesis, and proteolysis. However, high serum concentrations of cortisol initiate excessive protein breakdown, tissue wasting, and negative nitrogen balance (16, 17). There was no evidence in this study to suggest that the athletes were affected in this way. In well trained athletes, plasma cortisol levels tend to increase less compared to sedentary subjects who perform the same absolute level of submaximal exercise (16, 35). Emotional or psychological stress may also induce a decline of cortisol response, and lead to peripheral fatigue, and impaired exercise performance (16, 17). This could explain the drop in cortisol for S1 after exercise during 5pm trial.

Studies also shown that, exercise would increase the serum concentration of testosterone (16), which is consistent with the results of our study. Based on the data, the testosterone levels were generally higher DRamPm, and after

exercise testosterone levels were further increased compare to BRamPm. This suggested that stress factor (fasting) may have an effect on testosterone, which can increase testosterone level (16).

Some of coaches and athletes worry about having insufficient energy during Ramadan fasting. However, a previous study has suggested that, although frequency of meal intake decreases during Ramadan, caloric intake per meal increases with an increased preference for fatty and sugary foods (1, 3, 23, 28). These results however may be affected by differences in food choices, geographical, socioeconomic, and cultural differences among groups and regions (1, 3, 19, 23, 32). In fact, the feeding time period allows for sufficient food intake during Ramadan, thus meaning caloric deficit does not occur, with some studies showing no significant weight change or only a small weight loss (1, 2, 3, 4, 36) and few studies also showed that there is a small drop-off in the amount of body fat, but is not significant (3, 6, 23, 37, 38).

Based on the 7-day energy intake and physical activity diaries, DRam fasting, subjects achieved energy balance compared to the negative energy balance reported BRam. This suggests that the subjects were able to maintain their energy input despite fasting during the day.

A few studies have reported that Ramadan fasting decreased athletic performance capacities, in 800 m, 3000 m, 5000 m races, maximal strength, and jump performance (1, 2, 4, 7); although other studies (7, 36, 38) have shown no effect in other different forms of exercise. The same case goes for the physiological parameters; little difference has been observed (2). In our study, during a 10 km race Ramadan fasting appeared to have little effect on performance. In fact during morning trial (DR am, 8 am), subjects performed better but for evening DRam trial (5 pm) performance result were mixed. This improvement in performance in the morning may have been due to the better premeal DRam compared to the premeal BRam.

Similar results were found by Chtourou *et al* (2012) who showed that there was a significant decrease in power output in the evening during Ramadan, with no changes during morning tests. In addition, the diurnal variations of muscle fatigue increased during the second week, and at the end of Ramadan for the evening test sessions only (39). This may have been due to the sleep loss or increased time awake leading to increased fatigue. Another study showed that 4 hours sleep deprivation at the end of the night starting from 3am to 6am, impaired anaerobic performance during the Wingate test in the evening, but not for the morning test (40).

Conclusion

Based on the results of this case study, no subjects demonstrated low blood glucose, serious dehydration, lack of energy, and there was no consistent fall in exercise performance. We concluded that, Ramadan does not affect the performance of a 10km race, and in fact the time for completing the morning 10km time trial during Ramadan was improved when subjects ate their *sahour* meal. The energy dense meal during *sahour* may sustain the performance of athletes during Ramadan fasting. While many athletes who fast (abstaining from food intake after dawn until the evening) may feel dizziness and fatigue, but none of the subjects in this study reported this condition. The food records showed that the subjects were in energy balance during Ramadan, thus providing sufficient substrate during Ramadan. Based on the blood profile, we could also conclude that there was no adverse effect during Ramadan fasting on the 10km run performance. This was achieved by providing a balanced *sahour* meal. Thus with appropriate nutrition strategies during Ramadan, athletes can sustain their 10km running performances.

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Conflict of interest

None

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