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Effects of Ramadan Observance on Repeated Cycle Ergometer Sprinting and Associated Inflammatory and Oxidative Stress Responses in Trained Young Men

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ABSTRACT

Introduction: The effects of Ramadan observance upon repeated sprints and associated inflammatory and oxidative stress responses are not well known. Indeed, the objective was to assess the impact of fasting on muscle performance and selected oxidative and inflammatory parameters in athletes.
Methods: Ten young trained boxers were tested during a control period (C), at the end of the first week (R-1), and during the fourth week of Ramadan observance (R-4). On each occasion, they performed three vertical jumps, 10 x 6 s repeated sprints on a cycle ergometer, followed by three final vertical jumps 1 min after. Surface electrodes measured the EMG activity of the vastus lateralis during jumps performed before and after sprinting. Oxidative stress (malondialdehyde, total antioxidant and catalase), inflammatory markers (C-reactive protein, Interleukin-6 and homocysteine), muscle damage (CPK and LDH) and blood glucose were measured at rest and after completing the exercise protocol.
Results: The overall sprint performance was reduced at R-1 compared to C (-6.3 ± 1.2%, p = 0.025), but had recovered by R-4. Jump height decreased after the repeated sprints (p<0.01), without significant changes in EMG parameters. Oxidative stress indices, inflammatory markers, and muscle damage measured after the protocol exercise were unaffected during fasting.
Conclusion: The correction of sprint performance may highlight some adaptive responses to fasting. The unchanged of the selected fatigue biomarkers after the repeated sprint protocol suggest that the dietary restriction related to Ramadan is not severe enough to induce significant changes in the metabolism of our trained athletes.

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Introduction

Exercise-induced fatigue and resulting decreases of muscular performance depend on many factors such as the required intensity, frequency, and duration of exercise, and available reserves of food energy and fluids. During the month of Ramadan, Muslim athletes confront the challenge of maintaining a high intensity and volume of training while observing repeated day-long fasts that can have substantial effects upon physical performance (1-6).

Repeated sprinting is a common component of training, intended to enhance both anaerobic and aerobic metabolism (7), but relatively few studies have examined the effects of Ramadan observance upon the ability to make repeated sprints (8-10). Potential factors disturbing performance include an increased perception of effort, hypohydration and changes in circadian rhythm (11,12). Reports have noted no significant reduction in individual sprint times (12), and a

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small (4-5%) decrease in the cumulative sprint performance, but few studies have investigated the possible neuromuscular and metabolic changes associated with repeated sprinting during Ramadan observance (10). Another issue needing further study is the impact of Ramadan observance upon cytokines, oxidative stress, antioxidant status and the secretion of pro-inflammatory cytokines.

Oxidative stress biomarkers have been examined in resting subjects (13), but no one has yet assessed the effects of Ramadan observance upon oxidative stress following repeated sprinting exercise. Resting levels of interleukin-6 (IL-6) are reduced (14) or maintained (15) during Ramadan. In contrast, Chennaoui et al. (16) noted that in middle-distance runners, there were marked increases in plasma concentrations of IL-6 by the end of Ramadan.

Therefore, the purpose of the present study was to investigate the effects of Ramadan observance upon explosive muscle force, repeated sprinting ability, and resulting fatigue, measuring selected parameters of EMG activity, oxidative stress and inflammatory markers both at rest and following a fatiguing exercise protocol based on repeated cycle ergometer sprints.

Material and methods

Participants and experimental design

The experimental protocol was approved by the Research Ethics Committee of the University of Sousse. After receiving a complete description of the protocol, risks and benefits of the study, 10 young moderately trained male boxers (mean ± SD, aged 18.8 ± 1 yr, height 1.72 ± 0.09 m) gave their written consent to participation in this study. Physical characteristics are summarized in Table 1. All subjects observed the traditional pattern of Ramadan fasting for the year 2011; this required abstaining from all food and liquids for about 15 hours daily for 29 days, from August 1st to 29th 2011. Nevertheless, they maintained 90-minute training sessions five times per week, from 15.00 to 17.30 h, with no reduction in either the volume or the intensity of their normal training.

Tests were performed on 3 occasions: before Ramadan (the control period, C), at the end of the first week of Ramadan (R-1), and during the fourth week of Ramadan (R-4). Subjects abstained from intensive exercise during the 24 hours preceding each of the 3 test sessions. Evaluations were made at a consistent time during the afternoon, when training would normally have been undertaken (15.00–17.30 h). The laboratory temperature was held between 22-24ºC, at a relative humidity of 75%. Before Ramadan, the last pre-test meal was taken at 12.00 -13.00 h. During Ramadan, subjects took their last meal at 2.00 a.m., so that they had been without food and water for at least 12 hours before testing.

Anthropometric parameters and dietary intake

Anthropometric parameters (height, body mass and skinfold thicknesses) were determined at the first laboratory visit. Subjects were weighted to the nearest 0.1 kg, using a force platform (Kistler 9281, Winterthur, Switzerland). Triplicate skinfold measurements (biceps, triceps, subscapular and suprailiac) were made on the right side of the body, using Holtain skinfold calipers (Holtain Ltd, Crosswell, UK). Body density and body fat content were calculated as described by Durnin and Womersley (17).

Subjects recorded their intake of food and fluids for one week before and during the final week of Ramadan. Nutrient intakes were estimated from these dietary records, using the Bilnut programme (Nutrisoft, Cerelles, France).

Exercise testing

After a preliminary medical and anthropometric examination, subjects performed a standardized warm-up that included 10 min of cycle ergometer exercise at a loading of 50 Watts, followed by 3 min dynamic stretching of the quadriceps, hamstrings and gastrocnemius muscles. Subjects then followed an exercise test sequence comprising (i) 3 vertical jumps (ii) ten 6-sec sprints on a cycle ergometer, and (iii) 3 final vertical jumps.

After 2 practice attempts, the jumps were made using the counter-movement technique. Subjects kept their hands on their hips to eliminate the influence of the arms; the knees were quickly flexed to 90º, and the subject then immediately jumped as high as possible. Two attempts were allowed, separated by a 30 s interval, and the best performance was recorded. A force platform (Kistler 9281, Winterthur, Switzerland) allowed calculation of the jump performance and other biomechanical parameters at a frequency of 500 Hz, using the "Kistler Quatro Jump" software. Observations were repeated 1-min after completing the repeated sprint protocol.

Cycle exercise was performed on a Monark ergometer (model 894 E, Vansbro, Sweden). Toe clips were provided to prevent the feet from slipping, the seat height was individually adjusted and the loading was set according to the individual's current body mass (18). One minute after completing the initial vertical jumps, each participant began pedalling at 60 rpm against zero external loading and when signalled he pedalled as fast as possible for 6 s against the predetermined resistance, with verbal encouragement throughout. Ten 6 sec cycle ergometer sprints were completed, with passive recovery intervals of 24 sec between sprints (19). The peak power output was calculated for each sprint, and the fatigue index was calculated by two methods:

a) By relating the highest peak power output (usually sprint 1 or 2) to the lowest peak power output (usually sprint 10):

$$\text{Fatigue index (\%)} = \left(\frac{\text{highest} - \text{lowest mean power output}}{\text{highest mean power output}}\right) \times 100$$

b) By calculating the relative decrement of peak power over the ten sprints (%dec) (20):

$$\%\text{dec} = 100 - \left[\left(\frac{\text{Total mean power output}}{\text{Ideal mean power Output}}\right) \times 100\right]$$

Where Total mean power output = sum of the power outputs from all sprints, and Ideal mean power Output = highest mean power output x the number of sprints performed.

EMG measurement and analysis

The EMG was recorded from the right vastus lateralis (VL) during the vertical jump, both before and after repeated sprinting, using surface electrodes (Delsys DE-2.1, Delsys® Inc, Boston, MA), The inter-electrode distance was 10 mm. After careful preparation (shaving, abrasion, and cleansing with alcohol) to ensure a skin-electrode impedance < 2 k-ohms, electrodes were placed over the middle of the VL belly, approximately 2/3 of the distance between the anterior superior iliac spine and the lateral part of the patella. A reference electrode was placed on the right patella. Adhesive tape was placed over the electrodes to prevent movement artefacts. The electrode positions were carefully noted and used consistently in all recording sessions.

The EMG signal was amplified (gain = 1000; Bagnoli-4 EMG System, DelSys® Inc., Boston, MA) and filtered to a bandwidth between 20 and 450 Hz. The signals were converted from analogue to digital form at a sampling rate of 1000 Hz and were stored for subsequent analysis (EMGworks 3.0 DelSys Analysis software, Boston, MA). The root mean square voltage (RMS), mean power frequency (MPF) and median frequency (MF) of the power spectrum (512 points, Hanning window processing, Fast Fourier Transform) were subsequently calculated for the better of each paired jump.

Biochemical parameters

All samples were taken at least 12 hours after the most recent meal, and 24 hours after the last training session. Blood was collected from a forearm vein at seated rest, and immediately after completing the exercise protocol. Specimens were placed in an ice bath and were immediately centrifuged for 10 min at 3000 rpm. Aliquots of the resulting plasma were stored at -80°C until analyzed.

Thiobarbituric acid reactive substance (TBARS) determinations were used to assess malondialdehyde (MDA) levels (21). C-reactive protein (CRP) was measured using an automated analyzer (Cobas Integra 400 plus, Rotkreuz, Switzerland). Creatine phosphokinase (CPK) and lactate dehydrogenase (LDH) determinations were also carried out on an automated analyzer (Beckman CX6, Beckmann-Coulter, Brea, USA). Total antioxidant status (TAS) and catalase levels were determined spectrophotometricaly (Genesys, San Diego, USA), as described by Goth (22). Respective intra-and inter-assay coefficients of variation were 7-9 and 8-10% for the selected measurements. Serum glucose concentrations were determined by a quantitative enzymatic method, using the Randox kit (Randox, Antrim, UK).

Plasma concentrations of IL-6 were determined by enzyme-linked immunosorbent assay (ELISA), using a commercial kit (Immunotech, Marseille, France) with intra- and inter-assay coefficients of variation of 1.5-6.5 and 8-10% respectively.

Statistical analyses

All statistical analyses were performed using the STATISTICA v.8.0 software (StatSoft Inc., Tulsa, OK, USA). Values were expressed as means ± standard deviations (SD). One-way (Ramadan time points) and two-way repeated (Ramadan time point vs. sampling time) analyses of variance examined the effects of Ramadan (C, R-1 and R-4) and of sampling time (rest vs. post-exercise). When a significant main effect or interaction was observed, differences were located using Tukey's post–hoc tests ($p<0.05$). Effect sizes for main effects and interactions were estimated by calculating partial eta squared ($\eta 2$) values, and the effect size for pair-wise comparisons was assessed by Cohen's d. Effect sizes were classified as small (0.2), medium (0.5) and large (0.8). Statistical significance was set at $p<0.05$ throughout.

Results

Anthropometric and dietary data

By the end of Ramadan, body mass showed significant reductions relative to control values ($P<0.05$, $\eta 2=0.28$, Table 1). Although the mass of body fat remained unchanged, the fat free mass had decreased by 1.6 kg ($p<0.05$, $\eta 2=0.32$, Table 1). The dietary records showed a small decrease in total energy intake (3.8%, $p<0.05$), but larger reductions in protein, fat and fluid intakes (17-24%, $p<0.05$). In contrast, carbohydrate intake was increased by ~15% during Ramadan ($p<0.05$, Table 2).

Table 1. Anthropometric characteristics of subjects (n= 10) before Ramadan (C), at the end of the first week of Ramadan and at the end of Ramadan. Values are expressed as means ± SDs

	Control	Ramadan week 1	Ramadan week 4
Body mass (kg)	62.9 ± 7	62.4 ± 6.9	61.8 ± 7.2*
Body fat (%)	6.1 ± 1.9	6.8 ± 2.3	7.0 ± 2.2
Fat mass (kg)	3.9 ± 1.4	4.2 ± 1.2	4.4 ± 1.5
Fat- free mass (kg)	59.0 ± 6.5	58.2 ± 7.3	57.4 ± 6.6*
BMI (kg/m2)	21.4 ± 1.7	21.2 ± 1.8	21.0 ± 1.9

BMI: body mass index; *: p<0.05: difference from Control data

Table 2. Total daily dietary intake measured before (Control) and during Ramadan. Data are means ± SDs for 10 subjects

Variable	Control	Ramadan
Energy, MJ/d	13.3 ± 0.3	12.8 ± 0.4*
Protein, g/d	115 ± 39	88 ± 32*
Protein, % of energy	14.0 ± 2.0	12.0 ± 3.4*
Total fat, g/d	147 ± 41.1	118 ± 41.2*
Total fat, % of energy	41.5 ± 5.4	35.0 ± 9*
Carbohydrates, g/d	358 ± 117	410 ±127*
Total CHO, % of energy	44.5 ± 5.5	53.0 ± 12*
Fluid intake, l	3.0 ± 0.7	2.5 ± 0.8*

*p<0.05 and ** p<0.01, Ramadan vs. control

Repeated sprints and vertical jump performance

The 2-way ANOVA for peak power output during the repeated cycle ergometer sprints showed main effects of Ramadan observance ($p=0.029$, $\eta 2=0.33$) and of sprint number ($p<0.001$, $\eta 2=0.93$), but no significant interaction ($p=0.66$, $\eta 2=0.08$). The post-hoc test showed that relative to C, the overall average peak power at R-1 was reduced by 6.3 ± 1.2% ($p = 0.025$, see inset of Figure 1). The overall sprint performance had recovered somewhat at R-4, to a value that was 4.3±2.1% less but no longer significantly different from C ($p=0.16$, $d=0.38$) (inset of Figure 1). A separate one-way repeated measures ANOVA based on the peak power

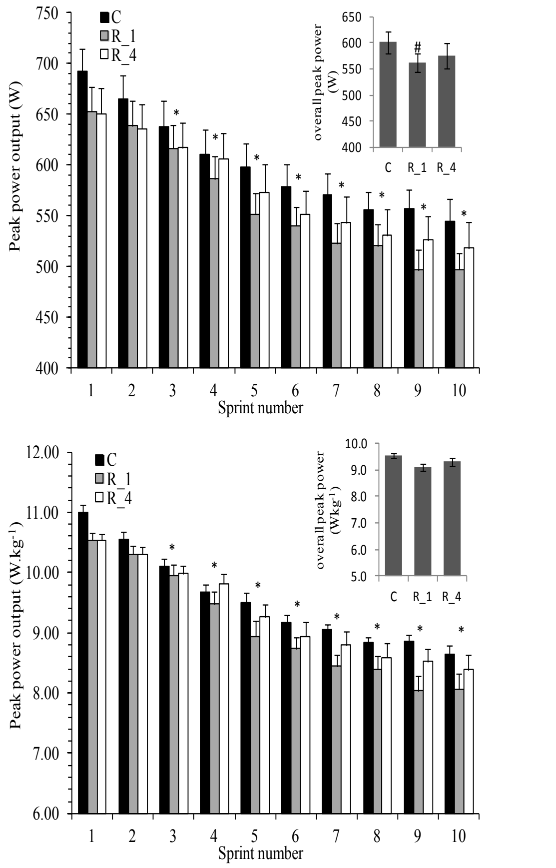

Figure 1. Peak power (W) during the repeated cycle ergometer sprint protocol before (C), at the beginning of the first week (R-1), and at the end of Ramadan fasting (R-4). Values are expressed as means ± SDs. * significant differences between C and R-1 (p<0.05)

output during sprint 1 showed a decrease of ~5.7% from control to R-1, but this did not show any recovery at R-4 ($p<0.001$, $\eta2=0.60$). The pattern of peak power decrease during repeated sprinting test did not change over Ramadan, as indicated by similar fatigue indices (21.6±1.8, 25.8±2.9, 21.5±2.0%) and % dec (13.3±1.1, 13.7±1.6, 11.6±1.1%) for the trials at C, R-1 and R-4.

When peak power output was scaled relative to current body mass, the impact of Ramadan was diminished. There was no longer a main effect of Ramadan observance ($p=0.12$, $\eta2=0.21$) or sprint x Ramadan fasting interaction ($p=0.63$, $\eta2=0.08$), but a sprint number main effect remained ($p<0.001$, $\eta2=0.94$). The decrease in peak power during the first sprint from C to R-1 and R-4, examined by a separate one way ANOVA, remained significant ($p=0.01$, $\eta2=0.42$), but was decreased in magnitude to ~4.3%.

The vertical jump height was decreased following the repeated sprints (main effect on jump height, pre vs. post sprints, $p<0.001$, $\eta2=0.88$, Figure 2). There was also a significant interaction (pre-post sprints vs. Ramadan, $p<0.04$, $\eta2=0.29$), with post-hoc tests showing that jump height and the peak power developed during the jump after repeated sprinting were significantly higher at R-4 than during C (Figure 2).

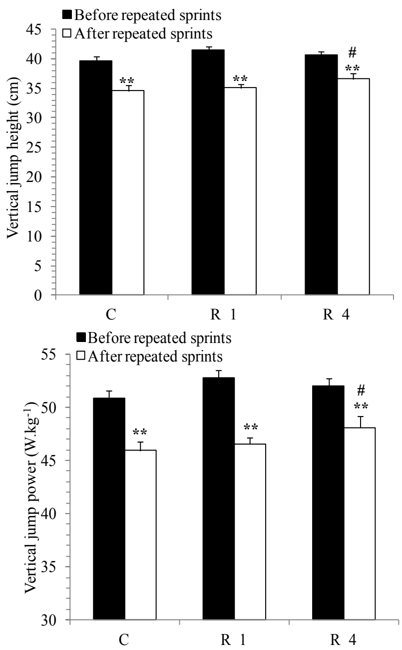

Figure 2. Vertical jump performances (m) measured before and after the repeated cycle ergometer sprint protocol during the control period (C), at the beginning of the first week (R-1), and at the end of Ramadan fasting (R-4). Values are expressed as means ± SDs. * significant differences after repeated sprints ($p<0.05$)

EMG parameters

Ramadan fasting had no effect on any of the EMG parameters during jumping (Table 3), with no significant main effects of time or interactions ($p>0.50$). The RMS remained unchanged ($p>0.50$), but the MF ($p=0.001$, $\eta2=0.71$) and the MPF ($p=0.04$, $\eta2=0.38$) were reduced after repeated sprinting (main effect, pre vs. post sprints, Table 3).

Oxidative stress, antioxidant status and muscle damage indices

The 2-way ANOVA showed no significant effects of Ramadan upon indices of oxidative stress. MDA was increased after repeated sprinting (main effects, $p<0.001$, $\eta2=0.72$ and 0.79), but this change was unaffected by Ramadan (Table 4). LDH and CPK were also mildly increased after repeated sprinting (main effects, $p<0.001$, $\eta2=0.56$ and 0.85), but this response was unaffected by Ramadan (Table 4). TAS showed a moderate increase after repeated sprinting (main effect, $p<0.001$, $\eta2=0.71$), but catalase activity remained stable throughout ($p>0.72$, Table 4).

Blood glucose and inflammatory markers

The analysis of variance showed a significant main effect of exercise testing upon the blood glucose concentrations ($p<0.001$, $\eta2=0.67$), but no main effect of Ramadan and no interaction ($p>0.10$, Table 4). Similarly, IL-6 and CRP

Table 3. Changes in EMG parameters of the vastus lateralis (RMS, MF, MPF) measured before and after repeated sprinting exercise during the control period (C), in the first week beginning and the fourth week of Ramadan fasting. Values are expressed as means ± SDs for 10 subjects

Variable	Control	Ramadan week 1	Ramadan week 4
RMS (µV)			
Before	0.31±0.12	0.28±0.11	0.25±0.12
After	0.28±0.10	0.28±0.11	0.29±0.13
MF (Hz)			
Before	109.7±13.	109.3±17.5	105.2±11.
After	90.8±9.4	97.9±14.0	93.1±15.8†
MPF (Hz)			
Before	91.0±21.4	101.0±20.	92.5±13.7
After	80.5±9.1	88.2±13.3	85.6±19.3†

†: main effect before vs. after sprinting exercise
RMS = root mean square voltage, MF = median frequency, MPF = mean power frequency

Table 4. Changes in blood glucose, inflammatory markers [Interleukin-6 (IL-6), Homocysteine (Hcy), c-reactive protein (CRP)], oxidative stress markers [Malondialdehyde (MDA)], anti-oxidant status parameters [Total anti-oxidant status (TAS) and catalase], and muscle damage indices (LDH and CPK) measured before and after repeated springing exercise in trained men. Data for the control period, the first week, and the fourth week of Ramadan observance. Values are expressed as means ± SDs for 10 subjects

Variable	Control	Ramadan week 1	Ramadan week 4
Glucose (mmol.l-1)			
Before	4.9 ± 0.7	5.2 ± 0.5	4.8 ± 0.8
After	5.5 ± 0.5	6.1 ± 0.5	5.8 ± 0.4 †
Hcy (µmol.l-1)			
Before	14.6 ± 4.1	14.1 ± 4.3	13.9 ± 2.1
After	14.5 ± 2.9	13.9 ± 2.4	13.7 ± 3.9
IL-6 (pg.ml-1)			
Before	2.7 ± 1.7	3.2 ± 2.6	3.5 ± 3.4
After	7.8 ± 6.6	6.4 ± 6.0	6.7 ± 4.3 †
CRP (mg.l-1)			
Before	1.7 ± 1.2	2.0 ± 1.9	1.2 ± 1.3
After	2.3 ± 1.4	2.5 ± 2.4	2.0 ± 1.6 †
MDA (µmol.l-1)			
Before	2.0 ± 0.3	2.2 ± 0.3	1.9 ± 0.2
After	2.2 ± 0.4	2.4 ± 0.2	2.2 ± 0.4 †
Catalase (ku.l-1)			
Before	40.1 ± 20.5	45.4 ± 20.5	45.3 ± 19.9
After	42.5 ± 19.0	42.1 ± 19.2	45.2 ± 16.6
TAS (mmol.l-1)			
Before	1.68 ± 0.29	1.59 ± 0.36	1.50 ± 0.36
After	1.76 ± 0.29	1.62± 0.34	1.59 ± 0.32 †
LDH (IU.l-1)			
Before	313 ± 45	297 ± 89	267 ± 65
After	347 ± 38	360 ± 70	307 ± 54 †
CPK (U.l-1)			
Before	126 ± 37	117 ± 43	98 ± 34
After	139 ± 32	134 ± 48	128 ± 40 †

†: main effect before vs. after sprinting exercise

concentrations were increased after sprinting (respective main effects, $p<0.001$, $\eta 2=0.72$ and 0.79), but there were no main or interactive effects of Ramadan ($p>0.63$, Table 4). Homocysteine concentrations remained unchanged at all sampling points (Table 4).

Discussion

The main findings of the present study were: (1) a significant decrease in repeated sprinting performance at the end of the first week of Ramadan, but at least a partial recovery by the end of Ramadan. (2) an increase of explosive muscle performance, as assessed by the jump height and peak power after sprinting at R-4 as compared to C (possibly suggesting a continuing training response during Ramadan); (3) unchanged EMG parameters in the face of the fatigue caused by sprinting and Ramadan observance; (4) an absence of effect of Ramadan upon indices of oxidative stress and antioxidant status (MDA, TAS and catalase), muscle damage indices (CPK and LDH), inflammatory markers (CRP, IL-6 and Hcy), and blood glucose concentrations either before or after the repeated sprint exercise.

The present study is one of very few to have examined the effects of Ramadan intermittent fasting upon repeated sprint performance. Studies of single sprints have reported either a small decrease in performance (8, 23), or no effect (9, 24). Meckel et al (9) observed a statistically significant impairment in the performance of both 6 x 40 m sprints and a vertical jump during Ramadan, although the magnitude of change was small (0.8-1%). Kirkendall et al. (25) evaluated 7 x 30 m sprints in football players, before and 2 and 4 weeks into Ramadan; they saw a 4.5% impairment in 10 m and a 3.5% impairment in 30 m sprint times, 2 weeks into Ramadan, although only when the tests were performed in the morning; moreover, sprint times had returned to baseline by the end of Ramadan. In their study, the fatigue index was not affected by either Ramadan or time of day. These results echo the present findings, where sprint performance decreased in the first week, but was partially restored by the end of Ramadan. However, in the present study the peak power was decreased by ~5.7% at week 1, and remained depressed at the end of Ramadan.

Despite the decrement in repeated sprinting ability, the explosive performance, as assessed by jump height and peak power output, was not adversely affected by Ramadan (Fig. 2); indeed, at the end of Ramadan the jump height and peak power were actually increased when in a fatigued condition (i.e. after the ten sprints). This supports the notion that if the training load is not decreased during Ramadan, anaerobic performance can even increase during Ramadan observance (12). The apparent discrepancy between a decrease in power output during the first in a series of repeated sprints and an unaltered jump performance has been reported in other studies of Ramadan (8, 24). It probably reflects the differing determinants of explosive power (efforts ~0.5 s in duration) and short sprints (6 s in duration) (Bogdanis 2012), with a potential for differing effects of disturbed sleep, increased perceived fatigue mood changes and altered circadian rhythms during Ramadan (12, 23).

Factors potentially altering performance during Ramadan include changes in energy availability, hydration status, and electrolyte balance. However, the energy required for sprinting exercise is unlikely to change during Ramadan (26). Also, maximal force, associated electrical activity and neuromuscular efficiency (torque/EMG ratio) are well maintained during Ramadan (10). We found no Ramadan-related changes in the RMS, MDF, and MF for the vastus lateralis either before or after the repeated sprinting, so that an electromyographic change could not explain the reduction of sprint performance. More likely, the decrease in performance has a central origin, reflecting the cumulative influences of hunger, thirst and sleep disturbance upon the individual's motivation to a 6-sec sprint. Several studies have shown that although anaerobic performance is normally better in the afternoon than in the morning, this diurnal variation disappears during Ramadan (8, 23, 27). In the present study, our measurements were made in the afternoon, between 15:00 and 17.30 h, with the last meal and fluids having been consumed 12 or more hours earlier. The overall energy intake remained unchanged, carbohydrate consumption was even increased, and blood glucose was well maintained, but the absence of fluid intake meant that athletes had to train and undertake the sprint tests when they were in a dehydrated state. Taking into account that July and August are the hottest months of the year in Tunisia, and that tests were performed at the hottest time of the day, dehydration may have contributed to general stress, fatigue and reduced motivation. Others have noted that fatigue is increased during Ramadan (24, 28), limiting the ability and/or the desire to sustain effort at the highest level (23). Partial sleep deprivation may also have disturbed circadian rhythms, exacerbating the decrement of anaerobic performance during the afternoon hours (23).

The recovery of sprint performance by the end of Ramadan has been noted previously (1, 12). Reasons include a progressive habituation of subjects to the demands of Ramadan observance, and possible benefits from the continued training program (12). However, Ramadan altered the timing of food and fluid intake relative to with training sessions, thus limiting any effect of continued training (2).

The few investigations of changes in oxidative stress and markers of inflammation and muscle damage during Ramadan have been limited mainly to resting subjects. Faris et al. (2012) reported a decrease in the resting proinflammatory cytokines, such as IL6 and tumor necrosis factor, at the end of Ramadan (29). In contrast, Chennaoui et al. (16) noted a substantial increase of IL-6 levels in middle distance runners at the end of Ramadan; however, in this study, the total energy intake was substantially reduced and sleep was also disturbed. In agreement with Askungar et al. (14) and Unalacak et al. (15), we found that Ramadan observance did not modify resting plasma levels of IL-6, MDA and pro-inflammatory parameters (Hcy and CRP). Chaouachi et al. (30) reported a slight increase of inflammatory responses at the end of Ramadan in elite judo athletes who had maintained high training loads throughout, but in contrast Hammouda et al., (31) reported a decrease of inflammatory markers. Such discrepancies may reflect differences in the regimens instituted by the coach, the local environment, the intensity of training, the duration of fasting (this differs from one season to another), the fitness level of the participants, and sport-specific training adaptations.

Recent studies have reported increased inflammatory markers such as IL-6 and oxidative stress responses following repeated sprint exercise (26, 32). However, only a few studies have examined the effects of Ramadan on the oxidative stress. Ibrahim et al (13) found a decrease of MDA in red cells, but no information was given on levels of either serum MDA or plasma protein-bound carbonyls. Furthermore, levels of glutathione or glutathione peroxidase and catalase activities in the red cells remained unchanged. Chaouachi et al. (30) reported a decrease in the vitamin E content of the blood, reflecting a reduced antioxidant capacity. In the present study, we noted an increase of oxidative stress as measured by MDA and total antioxidant status after sprint exercise, but these changes were unaffected by Ramadan. Further, catalase activity was unaffected by either sprint exercise or Ramadan (Table 4). These results suggest that Ramadan did not increase oxidative stress or the inflammatory response to repeated cycle ergometer sprinting.

There are obvious limitations related to the present study. Our observations were limited to afternoons, 12 hours or more after the most recent intake of fluid. Even at this time of day, the impact of Ramadan upon the anaerobic performance of well-motivated athletes was quite small. Further, our experimental design was limited by practical considerations, with only a single set of control observations obtained on the same group of moderately trained subjects. Differing results might be obtained in other populations, with different fitness level, in a different climate, and with other adjustments made to meet the challenges of Ramadan observance.

Conclusion

The present study showed a small but statistically significant decrease in the afternoon performance of repeated cycle ergometer sprints during the first week of Ramadan. This loss in overall performance was reversed by the end of Ramadan. Moreover, explosive muscle performance remained unaffected when measured at rest (before the repeated sprint protocol). Finally, Ramadan observance appeared to have no effect on indices of oxidative stress, indices of muscle damage, inflammatory markers, or blood glucose either before or after bouts of repeated sprint exercise. The early decrements of afternoon anaerobic performance seen during Ramadan may reflect changes in motivation, associated with disturbances of sleep and circadian rhythms.

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