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Ramadan observance and aerobic exercise in male Karatekas

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Abstract

*Background***:** Ramadan observance requires 29 days of abstinence from food and fluid from dawn till sunset, and this could compromise aerobic activity. We thus tested the null hypothesis that the observance of Ramadan would have no significant impact upon either ventilatory thresholds or maximal oxygen intake in well-trained young men. *Methods***:** Nine young male Karatekas (aged 18.5 ± 0.5 yr, height: 1.76 ± 0.50 m) were tested on three occasions: at the end of the first week of Ramadan, during the fourth week of Ramadan, and during a control period three weeks after Ramadan had ended. On each occasion, subjects performed a progressive cycle ergometer test to exhaustion, with determinations of first and second ventilatory thresholds, maximal oxygen intake and maximal aerobic power. Respiratory gas exchange was measured breath-by-breath, using a metabolic cart. Heart rates, blood pressures and ratings of perceived exertion were also measured before, during and after each bout of maximal exercise**.** *Results:* Neither maximal oxygen intake nor power output at maximal oxygen intake differed significantly between the three test sessions. The first ventilatory threshold also remained unchanged, but the second ventilatory threshold was reached at a slightly lower work rate during Ramadan. Perceptions of exertion during maximal effort were also increased slightly during Ramadan. *Conclusions***:** Ramadan has little effect upon the ability to perform aerobic exercise in well-trained and well-motivated young men who take care to maintain their daily fluid intake. The only small changes that we observed during Ramadan were a slight lowering of the second ventilatory threshold and an increase in the perception of effort during maximal exertion. **Health & Fitness Journal of Canada 2013;6(4):99-107.**

Keywords: Anaerobic threshold; Fasting; Dehydration; Maximal oxygen intake; Maximal aerobic power; Ventilatory thresholds

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Introduction

A growing proportion of the population in Canada and other "western" nations are becoming adherents to the Muslim faith. This involves the annual observance of Ramadan (a festival which requires abstention from food and fluid intake between sunrise and sunset on each of 29 successive days). Possible effects of any resulting nutritional changes upon health, training and competitive performance thus have growing practical interest both for active individuals and for those supervising exercise and sports programmes. Previous studies have examined several possible consequences of Ramadan observance (Adlouni et al., 1997; Aziz et al., 2010; Bigard et al., 1998; Bouhlel et al., 2008a; Bouhlel et al. 2008b; Brisswalter et al., 2011; Maughan et al., 2010; Meckel et al., 2008; Shephard, 2012, 2013; Souissi et al. 2007), but information about possible changes in the response to sustained aerobic activity remains limited and conflicting. Performance might be affected adversely by dehydration and a reduction in blood volume (Shephard, 2012; Sweileh et al., 1992), by a depletion of glycogen reserves and thus impairment of the anaerobic component of maximal effort (Aziz et al., 2010), by disturbance of sleep, by a relaxation of training schedules, or simply by anxiety about the reputed effects of intermittent fasting. One group studying young soccer players has commented specifically upon increases in the fatigue index during Ramadan (Chtourou et al., 2011, 2012).

We have now assessed the effects of Ramadan observance upon maximal aerobic power ($\dot{V}O_{2max}$), power output at maximal oxygen intake (MAP) and the two ventilatory thresholds (VT_1 and VT_2) (Wasserman et al., 1984), using as our subjects a group of well-trained and well-motivated young male kareteka. Our null hypothesis was that the observance of Ramadan would not influence these parameters provided that a normal training programme was continued, and the daily intake of fluid was maintained.

Methods

Participants and Experimental Design

The study participants were 9 young and clinically healthy, well-trained male karatekas (mean ± SD, age: 18 ± 0.5 yr, height: 1.76 ± 0.50 m). After receiving a complete verbal description of the protocol, risks and benefits of the study, they gave their written consent to an experimental protocol as approved by the Research Ethics Committee of the Faculty of Medicine, University of Sousse, Tunisia. All of this group followed the traditional pattern of Ramadan observance, as prescribed for the year 2010; they abstained from all forms of food and liquid for about 15 hours during each of 29 days from September 18th to October 16th, but they continued to engage without any relaxation in their customary five two-hour training sessions per week. A typical session comprised 75 min practice of karate skills, 15 minutes of aerobic training at 70-80% of maximal aerobic power, 15 minutes of resistance training involving different muscle groups, each of which underwent 3 sets of about 15 reps at 60-80% of IRM, and 15 minutes of flexibility training involving the major joints. There were no medical complications or symptomatic complaints during Ramadan.

The physical characteristics of the subjects are summarized in Table I. After a preliminary medical and anthropometric examination, study participants completed a questionnaire record of their normal dietary intake and performed a habituating test on an electronically braked cycle ergometer (Ergoline, Bitz, Germany). The seat position was adjusted both horizontally and vertically to fit the subject at this first visit, and the same position was maintained during subsequent test sessions. Three subsequent progressive cycle ergometer tests were performed: at the end of the first week of Ramadan, during the fourth week of Ramadan, and 3 weeks after the end of Ramadan. Subjects were asked to abstain from intensive exercise during the 48 hrs preceding each test session. The laboratory temperature was held between 22-24°C, at a relative humidity averaging 76%. During Ramadan, subjects took their last meal at about 2.00 a.m. On control days, subjects were allowed to eat and drink until 3 hours before testing. All exercise tests were performed in the afternoon, between 15.00 and 17. 30 h, so that during Ramadan subjects had been without food and water for some 12 hours.

Exercise test protocol

Cycle ergometer tests began with a 3 min warm-up at 50 W. After a further 15 min of seated rest, a ramp protocol was begun at a loading of 50 W; the work-rate was increased by 25 W at one-minute intervals until exhaustion was reached (typically, in 9-11 min). The test concluded with 4 min of active recovery at a loading of 50 W.

Gas exchange was recorded continuously throughout exercise, using a breath-by-breath metabolic system (ZAN 600, Meβgeräte, Germany) calibrated according to the manufacturer's guidelines; expired gas concentrations and heart rate (HR) values were subsequently averaged over 5 s intervals. The criteria used to determine attainment of a subject's maximal oxygen intake ($\dot{V}O_{2max}$) were a plateau of oxygen consumption (an increase < 2.1 $mL \cdot kg^{-1} \cdot min^{-1}$ despite an increase in power output), a respiratory gas exchange ratio (RER) >1.15 and a HR that was more than 90% of the individual's predicted maximal value (Howley et al. 1995). All except three of our tests met the primary criterion of maximal effort, and with one exception, all tests met our secondary criteria of maximal effort (RER > 1.15 in all tests, HR over 90% of the predicted value in 29 of 30 trials).

VT_1 and VT_2 were determined as proposed by Wasserman et al. (1984). VT_1 reflected an increase in the ventilatory equivalent for oxygen ($\dot{V}E/\dot{V}O_2$) without a concomitant increase in the ventilatory equivalent for carbon dioxide ($\dot{V}E/\dot{V}CO_2$) and a departure from linearity of the ventilation/ work-rate relationship, and VT_2 reflected an increase in both $\dot{V}E/\dot{V}O_2$ and $\dot{V}E/\dot{V}CO_2$. Two investigators determined VT_1 and VT_2 by inspection, in a blinded manner, and if they disagreed on location of the threshold, the ruling of a third investigator was sought.

Heart rates were monitored throughout exercise, using a ZAN 800 electrocardiograph (ZAN, Meβgeräte, Germany). Blood pressures, and ratings of perceived exertion on the 6-20 scale of Borg (1971) were recorded throughout exercise. Gross mechanical efficiency was calculated from the ratio of power output to the corresponding gross energy expenditure (Gaesser and Brooks 1975).

Other measurements

Anthropometric parameters were measured at the first laboratory visit. Subjects wearing light clothing but no shoes were weighed on a force platform (Kistler 9281, Winterthur, Switzerland). Triplicate skinfold measurements (biceps, triceps, subscapular and suprailiac) were made on the left side of the body, using Holtain skinfold calipers (Holtain Ltd., Crosswell, UK); measurement sites were as recommended by Durnin and Womersley (1974). When individual readings differed by more than 8-10%, measurements were repeated. The resulting data were used to calculate fat mass and fat-free mass.

Subjects recorded their intake of food and fluids for one week before and during the second week of Ramadan. Nutrient intakes were estimated from these dietary records, using the Bilnut programme (Nutrisoft, Cerelles, France), and the food-composition tables of the National Institute of Statistics of Tunis (1978).

Sleep duration was measured using a standard questionnaire developed by the Institute of Sleep and Vigilance at the Hospital of Toulouse (France).

Statistical procedures

All values were expressed as means ± SD. A one-way analysis of variance (ANOVA) was used to compare values between the control period, the beginnng and the end of Ramadan, with location of significant differences by *post hoc* analysis. Where appropriate, a Student's t-test with Bonferroni correction was used to make pair-wise comparisons. Statistical significance was set at $p < 0.05$ throughout.

Results

Anthropometric and dietary data

No significant changes in body mass, lean tissue mass, or fat mass developed during Ramadan (Table 1). The overall food intake showed a small decrease, with a small but statistically significant decrease in the ingestion of fat, but no changes in the relative proportions of fat, carbohydrate and protein, expressed as a percentage of the total energy intake (Table 2). The daily intake of water remained unchanged (Table 2), and although the reported duration of sleep was quite variable, it did not differ systematically between Ramadan and the control period.

Responses to aerobic exercise

There were no changes of $\dot{V}O_{2max}$, MAP, maximal ventilation, maximal HR or maximal gas exchange ratio during Ramadan (Table 3).

VT_1 remained unchanged, but VT_2 was reached at lower fractions of maximal aerobic effort during Ramadan ($p<0.05$, Table 4). The gross mechanical efficiency of cycle ergometer work remained unchanged during Ramadan. However, there was a small but statistically significant increase in ratings of perceived exertion during maximal exercise (Table 5).

Table 1: Anthropometric characteristics of subjects. Mean ± SD of data measured during the first week of Ramadan, the fourth week of Ramadan, and 3 weeks after Ramadan (Control).

	Control	First Week Ramadan	Final Week Ramadan
Body mass (kg)	62.4 ± 7.4	61.8 ± 7.2	61.9 ± 7.1
Body mass index ($kg·m^{-2}$)	20.1 ± 2.2	19.9 ± 2.1	19.9 ± 2.1
Fat mass (kg)	12.3 ± 3.5	12.2 ± 2.8	12.0 ± 3.6
Lean body mass (kg)	50.1 ± 6.2	49.8 ± 6.5	49.9 ± 5.7

Note: No significant changes were observed.

Table 2: Daily dietary intake and sleep duration before (control) and during the second week of Ramadan. Mean ± SD of data.

Measure	Control	Second Week Ramadan
Energy intake ($MJ·d^{-1}$)	16.9 ± 2.0	15.8 ± 2.1*
Protein intake ($g·d^{-1}$)	128 ± 23	124 ± 21
Protein intake (% of total energy)	11.8 ± 1.4	12.1 ± 2.1
Fat intake ($g·d^{-1}$)	185 ± 32	171 ± 20*
Fat intake (% of total energy)	39.8 ± 5.6	40.0 ± 5.6
Carbohydrate intake ($g·d^{-1}$)	495 ± 67	471 ±110
Carbohydrate intake (% of total energy)	48.3 ± 4.7	48.1 ± 5.5
Fluid intake ($L·d^{-1}$)	2.2 ± 0.6	2.2 ± 0.6
Sleep duration ($min·d^{-1}$)	457 ± 250	430 ± 244

ANOVA results: * $p < 0.05$, Second week of Ramadan vs. control

Table 3: Maximal cardio-respiratory variables measured during maximal aerobic effort on a cycle ergometer in the first week of Ramadan, the fourth week of Ramadan, and 3 weeks after Ramadan (control). Mean ± SD of data.

Measure	Control	First Week Ramadan	Final Week Ramadan
Maximal work rate W	244 ± 58	239 ± 36	243 ± 32
W.kg^{-1}	3.91 ± 0.58	3.86 ± 0.54	3.91 ± 0.56
$\dot{V}O_{2max,}$ (L·min^{-1})	3.3 ± 0.8	3.2 ± 0.6	3.2 ± 0.5
$\dot{V}O_{2max}$ (mL·min^{-1}·kg^{-1})	53.0 ± 8.0	51.1 ± 9.7	51.1 ± 10.1
Maximal RER	1.20 ± 0.05	1.16 ± 0.03	1.15 ± 0.07
Maximal $\dot{V}_E$ (L·min^{-1} BTPS)	111 ± 20	102 ± 18	103 ± 25
Maximal HR (beats·min^{-1})	191± 8	190 ± 7	188 ± 6
Systolic Blood Pressure (mmHg)	159 ± 6	156 ± 8	154 ± 11
Diastolic Blood Pressure (mmHg)	74 ± 6	75 ± 5	68 ± 7

Note: No significant changes were observed.

Discussion
Maximal Aerobic Power

Our empirical data seem in accord with our initial null hypothesis. At least in the present group of trained and well-motivated young athletes, Ramadan observance had no significant detrimental effect upon $\dot{V}O_{2max}$, MAP, or gross mechanical efficiency. The only small changes seen in our subjects when tested 12 hours after the last intake of food and fluid were the reaching of VT_2 at a slightly lower power output, and a small increase in the perception of exertion during maximal aerobic effort. We can accept the lack of significant change in $\dot{V}O_{2max}$, with some confidence, since most of our subjects consistently achieved a "good" oxygen plateau (an increase in oxygen consumption of less than 2 ml.kg^{-1}.min^{-1} with an increase of work rate)., and in the few exceptions, the secondary criteria of maximal effort, as proposed by Howley et al. (1995), were satisfied.

Table 4: Ventilatory thresholds during ramp-function cycle ergometer testing, as seen during the first week of Ramadan, the fourth week of Ramadan, and 3 weeks after the end of Ramadan (control). Mean ± SD of data expressed in terms of power output, heart rate, oxygen consumption and percentage of maximal oxygen intake.

	Control	First Week Ramadan	Final Week Ramadan
VT_1 Work rate (W)	145 ± 20	132 ± 23	126 ± 26
HR, (beats.min^{-1})	130 ± 11	135 ± 10	127 ± 12
$\dot{V}O_{2,}$ (L.min^{-1})	1.65 ± 0.38	1.47 ± 0.40	1.50 ± 0.41
%$\dot{V}O_{2max}$	50.0 ± 6.2	46.6 ± 7.8	47.5 ± 8.0
VT_2 Work rate (W)	179 ± 35	169 ± 42*	151 ± 39*
HR (beats.min^{-1})	174 ± 16	161 ± 19*	160 ± 17*
$\dot{V}O_{2,}$ (L.min^{-1})	2.3 ± 0.5	2.2 ± 0.6*	2.0 ± 0.6*
%$\dot{V}O_{2max}$	70 ± 8	68 ± 7	63 ± 10*

* Difference from control value, $p<0.05$

Our observations that $\dot{V}O_{2max}$ remained unchanged are in accord with several previous studies of aerobic performance during Ramadan. Nevertheless, the apparent difference between values reached before and during Ramadan (an average of 2-3 ml.kg^{-1}min^{-1}, and necessarily larger in some of our subjects) would be important from the viewpoint of competitive performance, and thus merit further evaluation on a larger sample of athletes. Many athletes certainly sense that their performance has worsened (Singh et al., 2011) during Ramadan, although there is generally little change in the track performance, $\dot{V}O_{2max}$ and MAP of well-trained and well-motivated subjects, provided that they have taken care to maintain their training schedules and their fluid intake (Brisswalter et al., 2011; Chaouchi et al., 2009; 2012; Chiha, 2008; Fall et al., 2007; Kirkendall et al., 2008; Mehdioui et al., 1996).

Table 5: Gross mechanical efficiency (%) and ratings of perceived effort (RPE) during maximal exercise as measured during the first week of Ramadan, the fourth week of Ramadan, and 3 weeks after the end of Ramadan (control). Mean ± SD of data.

	Control	First Week Ramadan	Final Week Ramadan
Gross mechanical efficiency (%)	21.1 ± 2.2	21.6 ± 2.4	21.9 ± 2.7
RPE (Borg units) End-exercise	16.7 ±1.7	17.2 ± 2.2	17.8 ± 1.1*

* Difference from control: $p<0.05$.

Nevertheless, some investigators have found decreases in aerobic performance. Fall et al (2007) noted a reduction of MAP during the third week of Ramadan, and two other studies reported a deterioration of aerobic performance at the beginning of Ramadan, with recovery towards the end of the intermittent fasting (Sweileh et al., 1992; Zerguini et al., 2007). Stannard and Thompson (2008) also observed that 4 of their 8 non-athletic men were unable to complete the final work- stage during Ramadan. Finally, a loss of performance was described in two groups of junior soccer players, although they appear to have relaxed their training schedules; Hamouda et al. (2012) reported a deterioration of afternoon shuttle-run performance, and Meckel et al. (2008) also saw a small decrease in 3000 m run times.

The conclusion seems that performance can be maintained during Ramadan by careful adjustments of lifestyle within the limits imposed by the Koran. Training schedules must be maintained, preferably in the late evening (after breaking the day's fast) or in the early morning, sleep disturbances must be minimized (by day-time napping, if necessary), and the night-time intake of food and fluid must be increased to compensate for the daytime fasting. Our subjects observed such a plan, and it is probably for this reason that they were able to sustain their aerobic performance.

Ventilatory thresholds

What conclusions can be drawn from the fact that the VT_2 was reached at a smaller fraction of $\dot{V}O_{2max}$, during Ramadan? The cycle ergometer protocol that we used is well adapted to the study of ventilatory thresholds; particularly in sedentary individuals, as loading is increased, lactate begins to accumulate in weak quadriceps muscles at a relatively low fraction of $\dot{V}O_{2max}$, because the heart is unable to develop sufficient pressure to perfuse the most actively contracting motor units (Shephard, 1982). Although our subjects maintained their daily fluid intake, blood volume was likely reduced somewhat during each afternoon of fasting, and although this did not reduce $\dot{V}O_{2max}$, It is possible that perfusion of the most vigorously contracting muscles was somewhat impaired, leading to an accumulation of lactate at a smaller fraction of MAP. This could explain the greater perception of effort during maximal effort, and it might also account for the deterioration of track performance that others have seen in athletes who were able to maintain their $\dot{V}O_{2max}$ (Brisswalter et al., 2010).

The ventilatory threshold could also be influenced by a change of diet during Ramadan (Bouhlel et al., 2006; Langfort et al., 2004; Mikulski et al., 2008). For instance, a lower blood glucose and earlier glycogen depletion in type I muscle fibres could lead to an earlier activation of type II fibres and thus an earlier lactate accumulation (Gutierrez et al., 2001). However, this seems unlikely in our study, since there was little change in either the total energy intake or the relative proportions of carbohydrate, fat and protein. A third possibility might be an increase of ventilation, either because of anxiety or in an attempt to compensate for a lesser peak cardiac output, but again our data show no difference of maximum ventilation between Ramadan and the control period. The first of our suggested explanations thus seems the most probable.

Limitations of data

Our present findings apply only to one specific group of athletes, young and well-trained male karetekas. There is plainly scope to repeat our observations in women, in subjects of differing age, at differing levels of training and in different classes of athlete. Future research could usefully look at sleep disturbance in more detail. There is also scope to confirm our explanation of the change in VT_2 by collecting data on lactates and blood glucose levels. Finally, our experimental design was not ideal, in that we were unable to recruit a matched group of competitors, living under the same conditions, yet not observing Ramadan.

Conclusions

The practical conclusion from our research seems that if a young athlete or physically active individual wishes to observe Ramadan, this is entirely possible, and with good planning of lifestyle, it need not have a significant adverse impact upon aerobic performance, at least as seen on a cycle ergometer. Further research should explore the significance of the apparent change in VT_2. This might call for some modification of training schedules, such as an increased emphasis upon interval training to develop tolerance for lactate accumulation.

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Authors' Qualifications

The authors' qualifications are as follows: H. Bouhlel: Doctoral student; Roy J. Shephard, M.B.B.S., M.D. [Lond.], Ph.D., D.P.E., LL.D., D.Sc., F.A.C.S.M., F.F.I.M.S.; I. Ghannouchi: MD; H. Adela: MD; N. Zarrouk: Doctoral student; Z. Tabka: MD, Ph.D.; X. Bigard, M.D., Ph.D; E. Bouhlel, Ph.D.

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