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ORIGINAL ARTICLE

The effect of the Ramadan fast on physical performance and dietary habits in adolescent soccer players

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Abstract The purpose of this study was to examine the effect of the Ramadan fast on performance capacities, dietary habits, and the daily behavioral patterns in adolescent (14–16-year-old) soccer players. Nineteen male players performed a series of fitness tests before and at the end of Ramadan fast. Caloric intake, physical activity pattern and sleep habits were evaluated during the week before the Ramadan fast and during the last week of the Ramadan fast. The fast resulted in a significant reduction in aerobic capacity [3,000 m run time (mean ± SD): 812.8 ± 73.3 s vs. 819.9 ± 73.4 s, $P < 0.001$], speed endurance (Sum 6 × 40 m run time: 46.36 ± 1.36 s vs. 46.73 ± 1.31 s, $P < 0.001$, and performance decrement: 9.0 ± 1.5% vs. 9.5 ± 1.7%, $P < 0.05$), and jumping performance (44.8 ± 4.5 cm vs. 44.0 ± 4.5 cm, $P < 0.05$), but had no significant effect on sprint performance (7.38 ± 0.25 s vs. 7.40 ± 0.26 s, $P = 0.20$) or agility (4 × 10 m shuttle run time: 9.53 ± 0.35 s vs. 9.55 ± 0.37 s, $P = 0.26$). Daily intense physical activity was significantly reduced during Ramadan (6.4 ± 0.2 h/week vs. 4.5 ± 0.1 h/week, $P < 0.005$). There were no significant differences in total caloric intake (3012 ± 412 kcal/day vs. 3240 ± 348 kcal/day, $P = 0.39$) or total daily sleeping hours (8.6 ± 0.7 h/day vs. 8.6 ± 0.5 h/day, $P = 0.80$) between Ramadan and a regular month. The results indicate that Ramadan fasting can lead to a significant decrease in athletic performance capacities. The decrease in performance does not necessarily relate to changes in caloric intake and sleeping hours during the fast.

Keywords Fitness · Ramadan fast · Nutrition · Adolescent · Soccer

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Introduction

During the month of Ramadan, the ninth month of the Islamic calendar, many millions of Muslims fast throughout the daylight hours. During this month eating and drinking is not allowed during the day, and are permitted only at night. Typically two meals are eaten each day—one just before dawn and one after sunset. The fast duration depends on the geographical location and the season of the year, and can be as long as 18 h a day in the summer of temperate regions. Naturally, eating habits during Ramadan are significantly different than those of the rest of the year. Food and fluid intake frequency are reduced and there is a tendency to consume foods and drinks that are richer in calories than those consumed during other months (Ziaee et al. 2006). In addition, fasting increases lipid oxidation during sub-maximal exercise (Bouhlel et al. 2006; Stannard and Thompson 2007), but these changes are moderated toward the end of the Ramadan month. An increase in serum urea and uric acid was also reported and this could be attributed to dehydration during this month (Ramadan 2002).

The effects of Ramadan fasting on body weight and composition vary among different studies. A reduction in body weight was found in some studies (Hallak and Nomani 1988; Husain et al. 1987; Ramadan et al. 1999), while others reported weight gain during this month (Frost and Pirani

1987; Siddiqui et al. 2005; Yucel et al. 2004). Other reports indicated no significant changes in body weight and body composition during the month of Ramadan (El Ati et al. 1995; Finch et al. 1998; Ramadan 2002).

During the Ramadan fast people also change their daily habits in that they tend to stay up later, watching television, praying or reading (Afifi 1997). It was also found that the prevalence of irritability and incidences of headaches, sleep deprivation, and lassitude increased. General fatigue, reduction in sense of well-being and impairment of cognitive function were also noted during Ramadan (Kadri et al. 2000; Leiper et al. 2003). These changes may explain the increase in accidental injuries and the increased demand for medical services among Muslims during Ramadan (Langford et al. 1994).

Previous studies focused mainly on health-related aspects of the Ramadan fast (Afifi 1997; Langford et al. 1994; Leiper et al. 2003; Siddiqui et al. 2005; Stokholm et al. 1991; Suwaidi et al. 2006; Ziaee et al. 2006). Very few studies have examined the effects of fasting on physical work capacity. These studies have found a small reduction in cardio-respiratory responses to sub-maximal exercise in sedentary adults (Ramadan and Barac-Nieto 2000; Ramadan 2002). Others found that maximal exercise capacity and walking efficiency were not influenced by the Ramadan fast (Ramadan 2002; Sweileh et al. 1992).

All over the world Muslim athletes continue to train and compete during the Ramadan month. However, to the best of our knowledge, the effect of the Ramadan fast on performance in trained athletes has never been tested. In addition, although Ramadan fasting is required from early adolescence, the effect of Ramadan fasting in the young population has not been tested. Therefore, the aim of the present study was to examine the effect of Ramadan fasting on performance capacity in well-trained adolescents, in this case soccer players. We hypothesized that performance capacity would be reduced following the Ramadan fast.

Methods

Subjects

Nineteen young (age range 14–16 years) male soccer players, members of a first division team in the Israeli youth league, agreed to participate in the study. The study was approved by the institutional ethical committee and the participants and their parents signed an informed consent form. Anthropometric characteristics of the participants are presented in Table 1. Standard, calibrated scales and stadiometers were used to determine height and body weight. Skinfold measurement at four sites (triceps, biceps, sub-scapular, and supra-iliac) were measured by an experienced technician.

Table 1 The effect of Ramadan fasting on anthropometric measures and test performance results

Test	Pre	Post
Age (year)	15.1 ± 0.9	15.1 ± 0.9
Height (cm)	166.4 ± 3.8	166.4 ± 3.8
Body weight (kg)	62.5 ± 7.4	62.8 ± 7.4
Sum of Skinfold (mm)	22.4 ± 2.2	22.6 ± 2.3*
Vertical jump (cm)	44.8 ± 4.5	44.0 ± 4.5*
40 m run (s)	7.38 ± 0.25	7.40 ± 0.26
4 × 10 m run (s)	9.53 ± 0.35	9.55 ± 0.37
Sum 6 × 40 m run (s)	46.36 ± 1.36	46.73 ± 1.31**
6 × 40 m performance decrement (%)	9.0 ± 1.5	9.5 ± 1.7*
3,000 m run (s)	812.8 ± 73.3	819.9 ± 73.4**

*$P < 0.05$

**$P < 0.001$

Subjects performed two similar sets of tests on two separate occasions. The first set of tests was conducted during two successive days just prior to the beginning of the Ramadan month. The second set of tests was conducted a month later during the last 2 days of Ramadan. Both sets of tests were performed using the same procedures, at the same time of the day, under the same environmental conditions and with the same technician. Before each set of tests the subjects performed a standard warm-up procedure that included 8 min of jogging followed by a 10-min stretching exercise and two 40 m sub-maximal runs (~80–90% of maximal perceived sprint speed). A 15–20 min period separated the different tests on each day. All running tests were performed on a hard, even grass surface. Subjects started each run from a standing position, and running time for each subject was measured using an electronic timer accurate to 0.01 s.

On the first day of each set of tests the subjects performed the following tests:

Vertical jump test. Vertical jump height was measured by a maximum vertical jump using a countermovement technique (CMJ). Subjects began in an erect standing position and moved into a semi-squat position before jumping. Three trials were completed with the subject using a vigorous double-arm swing as he jumped vertically. The highest CMJ height achieved was recorded. All jumps were performed on a 60cm × 40 cm force platform (Kistler 9286, Kistler Instrument Corporation, Amherst, MA, USA) connected to a digital timer that recorded the flight time of all jumps. The flight time was used to calculate the change in the height of the body's center of gravity (Bosco et al. 1983).

Agility test. The agility test involved a 4 × 10 m shuttle run. The subject began at the base line and ran at maximal speed to a marked line that was located 10 m ahead of him. He then turned and ran back to the baseline, turned again, and performed the same back and forth run. This procedure was performed twice and the fastest time of the two trials was recorded. The subject rested for 5 min between the two runs.

Speed endurance test. The speed endurance test (SET) consisted of 6 × 40 m sprints with a 30 s rest between the runs. Subjects were instructed to produce maximal effort for each sprint and to avoid pacing themselves. Each 40 m run was performed in a shuttle pattern of 20 m forth and 20 m back, so that the subjects started and finished each run at the same point. The two measures of SET were the total sprinting time of the six sprints, and the performance decrement during the test. Total sprinting time involved the summation of the six sprint times. Performance decrement was calculated by dividing the sum of the sprinting times for each of the six sprints by the best possible total score and multiplying by 100. The best possible total score was calculated as the best 40 m sprint time multiplied by six (Dawson et al. 1993; Fitzsimons et al. 1993).

On the second day the subjects performed the following tests:

Sprint test. The sprint test consisted of a 40 m all-out run performed in a shuttle pattern of 20 m forth and 20 m back (a pattern of movement typically performed in soccer). Two runs were completed and the subject rested for 5 min between the runs. The best time of the two runs was recorded.

Endurance test. The endurance test consisted of a 3,000 m run. The run was performed on a 400 m lap track. The subjects ran the 3,000 m as a group while each subject used his own tactics to produce the best possible result. Split times were reported to the subjects upon completion of each lap. Final times for the run were rounded to units of a full second.

During Ramadan the subjects continued their regular training program which consisted of three training sessions a week and a match during the weekend. Each training session was performed at 5 p.m. and lasted about 1.5 h. The nature of the different tests selected for the present study was based on their relevance to the game of soccer and the special fitness components that are required in this sport (Stolen et al. 2005).

Caloric intake, intense physical activity and sleep habits were evaluated during the week before the Ramadan fast, and during the last week of the Ramadan fast (Table 2). However, due to the delicate cultural, religious, educational, and familial intimacy characteristics of the community involved in the present study, complete, and reliable pre and post-dietary, physical activity, and sleep habit data were collected from a selected group of ten participants. The participants were instructed on how to keep a 2-day food record (for soccer training and non-soccer training days) and were evaluated on their understanding and accuracy by checking their 24-h recall prior to initiation of the study. Data of the food records were reviewed by a nutritionist and checked for omissions (e.g., to verify if dressing was used on a salad when it was listed as eaten with no dressing) and errors (e.g., inappropriate portion size). This approach was validated by Crawford et al. (1994) in children and adolescents.

Table 2 Differences in caloric intake, intense physical activity and sleep habits in a regular month and during Ramadan in the study participants

	Regular month	Ramadan
Caloric intake (kcal/day)	3012 ± 412	3240 ± 348
Carbohydrate (%)	49.8 ± 8.0	41.0 ± 8.5
Fat (%)	37.0 ± 8.2	47.6 ± 8.2
Protein (%)	13.2 ± 0.8	11.4 ± 1.3
Intense physical activity (hours/week)	6.4 ± 0.2	4.5 ± 0.1*
Sleep (hours/day)	8.6 ± 0.7	8.6 ± 0.5

*$P < 0.005$

Food records were analyzed using the Israeli Ministry of Health tables. A computer algorithm based on these tables calculated the total caloric intake and the proportion of the total calorie intake derived from protein, fat, and carbohydrates. The average intake of the two recorded days is reported in the manuscript.

Intense physical activity, defined as running activities, and daily sleeping habits were followed and recorded by the coach of the team each day during the week before fasting, and during the last week of the Ramadan fast. Typically, during the Ramadan fast physical education classes at schools were cancelled and the participants did not take part in any additional voluntary physical activity besides the soccer practice. During Ramadan, the subjects woke up every day before dawn (about 3.30 a.m.) for early breakfast (prior to the morning prayers) and then went back to sleep. The coach's report also demonstrated that the players tended to stay at home and rest more during the daytime in the Ramadan month.

Statistical analysis

A paired *t*-test was used to examine the effect of Ramadan on body weight, sum of skinfolds, caloric intake, physical activity, sleep habits, and athletic performance. Data are presented as mean ± Standard deviations. Statistical significance was set at $P < 0.05$.

Results

The effects of the Ramadan fast on anthropometric measurements and tests results are shown in Table 1. Following the Ramadan fast there was a very small but significant increase in the sum of skinfolds. No significant change was found in body weight. The Ramadan fast resulted in significantly reduced aerobic endurance (increased 3,000 m running time), reduced speed endurance (increased sum of 6 × 40 m run and performance decrement), and reduced vertical jump performance. The Ramadan fast had no significant effect on the sprint speed (40 m run) or agility (4 × 10 m shuttle run) performances.

Results of the vertical jump, the sum of 6 × 40 m run time and the 3,000 m run time before and after Ramadan are presented in Fig. 1. There was a significant reduction in the performance of all three tests after the Ramadan fast.

Changes in caloric intake, intense physical activity and sleep habits of the study participants before and during Ramadan are shown in Table 2. Intense physical activity was significantly reduced during the Ramadan fast. There was no significant change in sleeping hours before and during Ramadan. There was no significant change in total caloric intake, or in the relative consumption of carbohydrates, fat, and protein before and during Ramadan. However, there was a non-significant increase in fat consumption and a decrease in carbohydrate and protein intake during Ramadan.

Discussion

The main finding of the present study was that participation in the Ramadan fast reduces physical work capacity of adolescent soccer players. Naturally, the main possible factor when considering the reasons for this reduction is the change in eating habits during this month. However, one must keep in mind that the fasting during Ramadan is only partial. Abstention from food and fluid begins at sunrise and continues until sunset, but people are allowed to eat and drink during the night. Therefore, the total amount of energy intake during this month is not necessarily reduced when compared to non-fasting periods. Indeed, in the present study there was no significant difference in the daily total caloric intake during Ramadan and during a regular month (Table 2). Consistent with our findings, Beltaifa et al. (2002) reported that total daily energy intake did not differ significantly before, during and after Ramadan, despite the decrease in meal frequency of normal-weight adults during fasting. A cross-sectional study of 265 university students also showed that the amount of food intake did not change significantly during Ramadan compared to that of other months (Afifi 1997). Similar results were also reported by El Ati et al. (1995) when looking at the total daily energy intake of healthy Tunisian women. Moreover, Frost and Pirani (1987) showed that energy intake was significantly higher during Ramadan compared to the post-Ramadan period (3,680 kcal day^{-1} vs. 2,425 kcal day^{-1}), and body weight immediately after Ramadan was significantly higher than at the beginning of Ramadan (60.3 kg vs. 58.9 kg).

Since the total caloric intake during Ramadan was not found to be different than at other times, it is possible that, as far as athletic performance is concerned, the frequency and the timing of meals are equally, if not more, important than the total amount of energy consumption during this month. One should keep in mind that for every day during Ramadan there is a time span of about 13 h between the last meal (4:00 AM) and the practice session (5:00 PM). It is possible, therefore, that the long food and fluid deprivation will lead to dehydration and other metabolic and hormonal changes (e.g., low carbohydrate reserves) that could affect individual performance (El Ati et al. 1995; Ramadan 2002). In addition, an increase was reported in serum urea and uric acid, as well as in serum sodium, chloride, and protein during Ramadan (Ramadan and Barac-Nieto 2000; Roky et al. 2004; Sweileh et al. 1992). These findings may indicate a state of dehydration, catabolism and muscle damage in the fasting subjects. Thus, it was not surprising to find a significant reduction in speed endurance, aerobic capacity, and jump height of the subjects in the present study following Ramadan. In addition, it is possible that changes in the relative

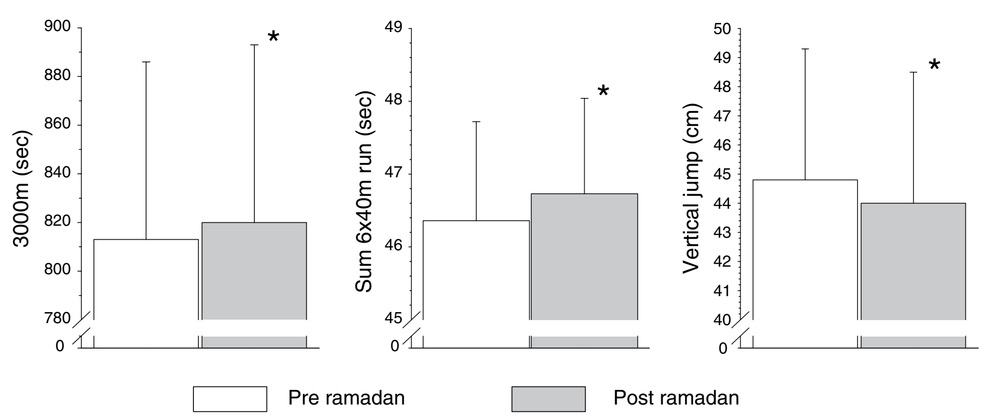

Fig. 1 Changes in aerobic endurance (*left panel*), anaerobic capacity (*middle panel*) and vertical jump (*right panel*) following the Ramadan fast

caloric consumption of carbohydrates, fat, and protein affected athletic performance. It is now well known that total carbohydrate intake, and the timing of its consumption (prior to, during, and post-exercise) affect athletic performance (Burke et al. 2001; Jeukendrup 2004; Lambert and Goedecke 2003). In the present study there was a decrease of 9% in carbohydrate consumption. Although not statistically significant, it is possible that this decrease led to reduced muscle glycogen stores and affected the participants performance capacity during the month of Ramadan.

The decrease in daily physical activity, reported in most of the studies (e.g., Afifi 1997; Leiper et al. 2003), is also an important factor determining performance during the Ramadan fast. In the present study there was a significant decrease in weekly intense physical activity (6.4 ± 0.2 h/week vs. 4.5 ± 0.1 h/week, $P < 0.005$). The coach adjusted the training program of the team to the special circumstances of this month. Accordingly, emphasis was given to a low intensity, technical, coordination, and tactical training, and high intensity training was reduced to a minimum. In addition, physical education classes at school were cancelled during the fasting month. Therefore, it is possible that the decrease in training intensity contributed to the reduction in the subjects' physical capacity by the end of Ramadan.

Sleep patterns may also influence athletic performance. In the present study there were no differences in the total daily sleeping time (Table 2). However, while in a regular month night sleep is continuous, during Ramadan night sleep is disrupted, and intermittent (wake-up before dawn to eat, and return to sleep). It is possible, therefore, that the disrupted sleep pattern resulted in lethargy and altered cognitive function that had a negative effect on performance of the participants.

Determination of the relative contribution of each of these factors (change in meal times and food habits, decreased intense physical activity, and disturbed sleep patterns) is almost impossible in a "real life" situation, since all occur simultaneously in a fasting individual during Ramadan.

The increase in the mean 3,000 m running time following the Ramadan fast indicates a decrease in the aerobic capacity of the subjects in the present study (Table 1 and Fig. 1). Previous studies did not find that Ramadan fasting has a negative effect on the maximal exercise capacity of sedentary adults. However, heart rate and ventilatory responses to sub-maximal exercise were reduced (Ramadan 2002; Ramadan and Barac-Nieto 2000). Sweileh et al. (1992) found a significant decrease in maximal aerobic capacity (VO_2 max) after the first week of Ramadan. However, VO_2 max levels returned to pre-Ramadan values in the last week of Ramadan. This phenomenon may indicate a physiological adaptation among the fasting subjects during the month of Ramadan. Indeed, Sweileh et al. also found a lower resting afternoon VO_2 among the fasting subjects. This suggests that in the period of Ramadan the body's metabolism slows down during the day, reflecting a drive to conserve energy stores. Fasting has also been associated with catecholamine inhibition and reduced venous return, causing a decrease in the sympathetic tone, which lead to a decrease in blood pressure, heart rate, and cardiac output (Stokholm et al. 1991; Suwaidi et al. 2006). These physiological changes may also influence physical work capacity and cause further deterioration in athletic ability. Gutierrez et al. (2001) found a significant and progressive decrease in the aerobic capacity (physical work capacity at 170 beats per minute—PWC170) of athletes who fasted for 72 h.

The findings regarding the anaerobic capacity of the subjects following Ramadan were somewhat confounding in the present study. While speed endurance (6×40 m run) and vertical jump ability were significantly decreased, sprinting speed (measured by 40 m run time) and agility (measured by 4×10 m run time) remained unchanged (Table 1 and Fig. 1).

The decrease in speed endurance was demonstrated by the increased sum of the six sprint times as well as by the performance decrement during this set of sprints. The present study showed a significant mean performance decrement of 9.5% at the end of the Ramadan fast compared to 9.0% before Ramadan. The sum of the six sprint times increased from 46.36 s before the beginning of the Ramadan fast to 46.73 s at the end of the month. This decrease in speed endurance may reflect decreased glycolytic capacity, as well as a slower replenishment of muscle creatine phosphate (CP) stores during the short recovery period between the sprints. Other studies, using a repeated sprint testing procedure, have found smaller mean performance decrements of 5–6% for adult football players (Dawson et al. 1993; Fitzsimons et al. 1993). It is possible that the higher speed endurance decrement seen in the present study also reflects the typical low glycolytic capacity of children and adolescents (Bar-Or 1983).

While the jumping ability of the subjects in the present study deteriorated following the Ramadan fast, the agility (4×10 m run) and the 40 m sprint run time remained unchanged. Consistent with our findings, other studies have found hand grip strength and reaction time to be unchanged during Ramadan (Gutierrez et al. 2001; Roky et al. 2000). The ability of the subjects to perform these activities mainly reflects their anaerobic power and muscle strength. Yet these activities may also be influenced by the subject's coordination, skill, and neuromuscular control. The results of these tests may also be influenced by the subject's diurnal alertness and ability to concentrate on the execution of these short highly technical drills. Although, as seen in the present study, nocturnal sleep, daytime alertness, and psychomotor performance were found to decrease during Ramadan (Roky et al. 2000, 2004), agility and sprint performance remained mainly unchanged. It is possible that the high skill control of the participants overcame any metabolic decrement, and they were able to maintain their agility and 40 m sprint time. It is also possible that the low intensity, coordination-focused type of training, emphasized by the coach during Ramadan, improved the subjects' specific skill during this period and contributed to their mechanical efficiency.

Finally, we did not find a change in body weight in the present study. While some studies have found a reduction in body weight (Hallak and Nomani 1988; Husain et al. 1987; Ramadan et al. 1999; Ziaee et al. 2006), others have failed to find a significant change in body weight during Ramadan (El Ati et al. 1995; Finch et al. 1998; Ramadan 2002). However, other studies even detected weight gain during this month (Frost and Pirani 1987; Siddiqui et al. 2005; Yucel et al. 2004). Differences in daily habits, occupation, and social and geographical environment can influence the energy balance and may contribute to the inconsistency of the findings in the different studies.

In summary, fasting during the Ramadan month causes a decrease in the physical work capacity of adolescent soccer players. This decrease is noted especially in activities that are supported by the aerobic energy system. The effect of Ramadan on short intensive exercise performance is less clear and is probably influenced by the technical control and motor skill of the subject. It seems that the timing of meals during the day, and the relative contribution of macro-nutrients (e.g., carbohydrates) rather than the total caloric intake, may serve as the main nutrient causes for the decrease in physical capacity. Decreased physical activity and disturbed sleeping patterns may also contribute to the significant decrease in athletic performance. The relative contribution of each of these factors remains unclear, and needs to be addressed in future studies. In light of the above, abstention from competitive participation should be considered in fasting athletes during Ramadan. However, since professional athletes are committed to regular appearances in different sport activities and competitions, special measures should be taken in order to maintain their performance level during Ramadan. This can be crucial mainly in endurance-type sports where reduction in physical capacity is most significant.

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