

Research article

## Influence of Ramadan fasting on anaerobic performance and recovery following short time high intensity exercise

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### Abstract

The aim of this study was to investigate the effects of Ramadan fasting on anaerobic power and capacity and the removal rate of lactate after short time high intensity exercise in power athletes. Ten male elite power athletes (2 wrestlers, 7 sprinters and 1 thrower, aged 20-24 yr, mean age  $22.30 \pm 1.25$  yr) participated in this study. The subjects were tested three times [3 days before the beginning of Ramadan (Pre-RF), the last 3 days of Ramadan (End-RF) and the last 3 days of the 4<sup>th</sup> week after the end of Ramadan (After-RF)]. Anaerobic power and capacity were measured by using the Wingate Anaerobic Test (WAnT) at Pre-RF, End-RF and After-RF. Capillary blood samples for lactate analyses and heart rate recordings were taken at rest, immediately after WAnT and throughout the recovery period. Repeated measures of ANOVA indicated that there were no significant changes in body weight, body mass index, fat free mass, percentage of body fat, daily sleeping time and daily caloric intake associated with Ramadan fasting. No significant changes were found in total body water either, but urinary density measured at End-RF was significantly higher than After-RF. Similarity among peak HR and peak LA values at Pre-RF, End-RF and After-RF demonstrated that cardiovascular and metabolic stress caused by WAnT was not affected by Ramadan fasting. In addition, no influence of Ramadan fasting on anaerobic power and capacity and removal rate of LA from blood following high intensity exercise was observed. The results of this study revealed that if strength-power training is performed regularly and daily food intake, body fluid balance and daily sleeping time are maintained as before Ramadan, Ramadan fasting will not have adverse effects on body composition, anaerobic power and capacity, and LA metabolism during and after high intensity exercise in power athletes.

**Key words:** Ramadan fasting, anaerobic power and capacity, lactate, passive recovery, power athletes.

### Introduction

Ramadan is the holiest month in the Islamic calendar. Ramadan fasting is one of the five pillars of Islam observed by over one billion Muslim adults worldwide. Since Hijra is a lunar calendar, Ramadan occurs at different times in the seasonal year over a 33-year cycle. During the month of Ramadan, Muslims abstain from eating, drinking, smoking, sexual relations and oral drug intake between sunrise and sunset. Food and fluid intake are mainly nocturnal and therefore usually, food frequency (Bahammam, 2005; Finch et al., 1998; Taoudi Benchek-

roun et al., 1999) and quantity (Husain et al., 1987), sleep duration at night (Margolis and Reed, 2004; Taoudi Benchekroun et al., 1999) and daily physical activity are reduced during the month of Ramadan (Ben Salama et al., 1993).

Previous studies showed that Ramadan fasting caused significant changes in body weight (Bigard, et al., 1998; Ziaee et al., 2006), basic hematologic parameters (Dewanti et al., 2006), blood glucose concentration (Larijani et al., 2003) and lipid profile (Adlouni et al., 1997; Adlouni et al., 1998; Afrasiabi et al., 2003; Aksungar et al., 2005; Ziaee et al., 2006) without any health problems. These metabolic changes varied due to eating habits, climate, population and geographical location. Decrease in resting metabolic rate (Sweileh et al., 1992), dehydration (Ramadan et al., 1999) and variation in hormone levels (Ben Salem et al., 2002; El-Migdadi et al., 2004; Sajid et al., 1991) the other changes were reported during Ramadan fasting.

Several studies showed significant changes in muscle metabolism during resting and long duration exercises (Knapik et al., 1988), and also decrease in exercise performance were reported (Loy et al., 1986; Maughan and Gleeson, 1988; Nieman et al., 1987; Schurch, 1993; Zinker et al., 1990) after 1 to 3.5 days fasting. Long duration intermittent fasting (Ramadan Fasting) is different from experimental fasting and there are very few studies relevant to its effects on exercise capacity. A study conducted on fighter pilots demonstrated that Ramadan fasting leads to an impairment in muscular performances (Bigard et al., 1998). On the other hand several studies reported that cardiorespiratory responses to exercise during Ramadan depend on the physical fitness and the activity level of the individual (Ramadan, 2002; Ramadan et al., 1999). In addition to this Ramadan fasting is associated with metabolic changes that enhance lipid utilization during exercise independent of the subject's physical activity level (Ramadan et al., 1999). Besides, these studies Sweileh et al. (1992) found a significant decrease in maximal oxygen consumption during the first week with a return to pre-fasting values during the last week of Ramadan in sedentary people. There is limited data on the effect of Ramadan fasting on physical performance of competitive athletes. According to our observations there is only one study about the impact of Ramadan on physical performance in professional athletes (Zerguini et al., 2007). In this recent study, Zerguini et al. (2007) reported

no remarkable change in sprint performance of professional soccer players during Ramadan. Therefore, there is a need for a study to investigate the effects of Ramadan fasting on short term high intensity exercise performance of competitive athletes. The aim of this study was to investigate the effects of Ramadan fasting on body composition, anaerobic power and lactate removal rate from blood after supramaximal leg exercise in regularly trained power athletes.

## Methods

### Subjects

Ten male elite power athletes (2 wrestlers, 7 sprinters and 1 thrower, aged 20-24 yr, mean age  $22.30 \pm 1.25$  yr) volunteered as subjects for the study. All the subjects currently participating in official championships had been training regularly in their respective sport activity more than 2 hours a day, 6 days a week for at least 4 years. Written informed consent was obtained from each subject after a detailed description of the purpose and procedures of the study. The study received ethical approval from the Ethical Committee of Hacettepe University, Ankara, Turkey.

### Study design

The study was conducted in Turkey during 2006 Ramadan period from September 23 to October 22. Subjects were tested 3 days before the beginning of Ramadan (Pre-RF), the last 3 days of Ramadan (End-RF) and the last 3 days of the 4<sup>th</sup> week after the end of Ramadan (After-RF). Tests were conducted in our laboratory at a constant environmental temperature and humidity (20–23°C and 50–60% respectively) and all measurements were taken at the same time of the day (between 3:00PM and 5:30PM). During the 24 hours before each test no intensive training was allowed. All subjects were at their preparatory training phase during the study. They maintained their training programme (intensity, duration and frequency) as before Ramadan.

### Body composition

Body height was measured to the nearest 0.1cm via a stadiometer (Holtain Ltd., UK). Body fat percentage (BF%), body weight (BW) ( $\pm 0.1$ kg), fat free mass (FFM) and total body water (TBW) were assessed by using foot to foot bioelectrical impedance analyser (Tanita TBF 401; Tanita Corp., Japan). Bioelectrical impedance measurements were performed in accordance with the manufacturer's specified procedures. Participants were asked to remove all clothing, jewellery and other accessories except a swimsuit for the measurement. Gender, height and physical activity classification were manually entered into the keypad interface. Subjects were measured while standing erect with bare feet on the analyser's footpads.

### Food intake

Food intake of each subject was recorded by using recall method (Rasanen et al., 1991; Valimaki et al., 1994) during each week of the test. The records were kept for the last 48 hours, including the last meal before the tests. Before food intake was recorded, subjects were informed

about Food Intake Analysis. Energy, macro food elements (carbohydrate, lipid and protein), micro food elements (vitamin, mineral, etc.) and water consumption were assessed with nutrition information system on the computer program (Garibagaoglu et al., 2005).

### Urinary density

Urinary density (UD) was assessed from 50 ml urine collected from each subject, 20-30 min before the tests. Density was measured to the nearest 0.001 unit by using specific gravity hand refractometer (Atago, Inc., USA).

### Wingate anaerobic test

Anaerobic power and capacity were assessed by using the Wingate Anaerobic Test (WAnT), which was performed on a computerized cycle ergometer (Monark 834E, Monark-Crescent AB, Varberg, Sweden). Before the test, feet were firmly strapped to the pedals, and the seat height and handlebars were adjusted for optimal comfort and pedalling efficiency. Before they started to warm up, subjects were informed about the test protocol. After a standardised 5 minutes warm up involving pedalling at 60-70 rpm interspersed with two all out sprints lasting four to five seconds, the subject rested on the cycle ergometer for five minutes (Inbar et al., 1996). During the rest period the subject was instructed to perform the test as fast and as hard as possible. Then the WAnT was initiated against minimal resistance. Following 3 to 4 seconds the predetermined test resistance (0.075 kg. body mass) was applied, and the computer was activated. Verbal encouragement was given to every subject to maintain as high a pedalling rate as possible throughout the 30s test duration, especially during the last 10-15s when the willpower was needed. The highest value during the 30s was defined as peak power (PP) or anaerobic power, and mean power (MP) output or anaerobic capacity was the average of all values obtained during the test. Anaerobic power and capacity were expressed in absolute (W) and relative ( $W \cdot kg^{-1}$ ) units. The difference between PP and the lowest value at the end was calculated relative to PP used as fatigue index (FI).

### Blood lactate and heart rate

Blood lactate (LA) concentration was analyzed as hemolyzed whole blood using a Yellow Springs Sports 1500 Lactate Analyzer (Yellow Springs Instruments, Yellow Springs, USA). Analyser was calibrated before every test for each subject, in accordance with the manufacturer's specified procedures (YSI, 2003). Blood samples were obtained by means of venipuncture performed on an earlobe at rest prior to warm up, immediately after WAnT (0 minute) and every 3 minutes until the end of recovery period (11-13 samples). Heart rate (HR) was also recorded every 5 seconds before warm up, during the test and recovery period using a heart rate monitor (Polar Vantage NV, Polar Electro Oy, Finland). During the passive recovery period subjects were resting in a relaxed sitting position.

Lactate removal rate from the blood following exercise was estimated from the half life of the peak lactate. The time required to remove half the amount of peak lactate was considered as the "Half Life" of lactate in the

**Table 1.** Changes in body composition, total body water, urinary density, daily sleeping time and daily calorie intake during the Ramadan fasting. Data are means ( $\pm$ SD).

	Pre-RF	End-RF	After-RF	F	p
<b>BW (kg)</b>	73.90 (8.99)	73.76 (9.68)	74.54 (9.10)	2.47	.113
<b>BMI</b>	24.25 (1.70)	24.15 (1.89)	24.18 (1.62)	.25	.780
<b>FFM (kg)</b>	66.83 (6.53)	67.00 (7.43)	67.85 (7.28)	2.08	.154
<b>BF (%)</b>	8.79 (2.45)	8.92 (2.98)	8.80 (2.35)	.02	.983
<b>TBW (L)</b>	48.94 (4.78)	49.04 (5.45)	49.67 (5.34)	2.03	.161
<b>UD</b>	1020.0 (4.76)	1023.1 (5.04)	1016.4 (4.53)	7.50	.004
<b>DST (h)</b>	8.32 (.82)	9.17(1.14)	8.32 (1.33)	2.44	.115
<b>DCI (kcal.day<sup>-1</sup>)</b>	3048.0 (655.6)	3177.3 (669.2)	3662.7 (744.3)	2.02	.162

Abbreviations: BW: Body Weight, BMI: Body Mass Index, FFM: Fat Free Mass, BF: Body Fat, TBW: Total Body Water, UD: Urinary Density, DST: Daily Sleeping Time, DCI: Daily Calorie Intake.

blood. Individual regression equation (time  $\times$  LA) was used to calculate LA half life from the peak lactate (Gupta et al., 1996). The equation was "y = a + bx" [y: time (min), a: intercept point of regression line, b: slope of the regression line, x: half life of LA (mmol.L<sup>-1</sup>)]. Time-LA relation was R<sup>2</sup> > 0.98 in individual regression equation.

### Statistical analysis

Descriptive statistics (mean $\pm$ SD) were calculated for all variables. Repeated measure ANOVA and Bonferroni tests were used to assess the difference between Pre-RF, End-RF and After-RF. Significance was accepted for all analysis at the level p < 0.05. All statistical analyses were performed with the statistical package for the social sciences (SPSS Inc., Chicago, IL, USA).

### Results

The changes on BW, body mass index (BMI), FFM, BF% and TBW, UD, daily sleeping time (DST) and daily caloric intake (DCI) at Pre-RF, End-RF and After-RF are presented in Table 1. Although BW and BMI were lower at End-RF than at Pre-RF and After-RF, the differences were not significant. No significant changes were assessed on FFM, BF% and TBW (Table 1).

DST was longer in End-RF compared with Pre-RF and After-RF, but it was not statistically significant. DCI tended to increase with time. However, there was no significant difference between Pre-RF, End-RF and After-RF. UD measured at End-RF was similar to Pre-RF, however, UD at After-RF was significantly lower than End-RF (p<0.01).

Absolute and relative PP, MP and fatigue index (FI) measured at Pre-RF, End-RF and After-RF are presented in Table 2. Absolute and relative PP measured at End-RF and After-RF were similar to each other, on the other hand both of the measurements of these phases were significantly higher (p < 0.05) than Pre-RF.

Mean scores of absolute and relative MP were significantly different between Pre-RF, End-RF and After-

RF according to repeated measures of ANOVA, however, after the follow up test, Bonferroni correction showed no significant difference between these phases. Moreover, no significant changes were found in FI calculated at Pre-RF, End-RF and After-RF.

LA and HR determined at resting and immediately after exercise and LA half life values during recovery at Pre-RF, End-RF and After-RF are presented in Table 3. Resting LA measured during End-RF was similar to Pre-RF and After-RF. Resting HR recorded at After-RF was significantly lower (p < 0.05) than Pre-RF. Peak LA and peak HR values determined after WAnT at Pre-RF, End-RF and After-RF were not significantly different. The time required to achieve peak lactate concentration were 6.90  $\pm$  1.45 (6-9min), 7.80  $\pm$  2.10 (6-12min) and 7.20  $\pm$  1.55 (6-9min) at Pre-RF, End-RF and After-RF respectively. Although the half life of lactate seemed to decrease, there was no significant difference between Pre-RF, End-RF and After-RF with respect to LA half life.

The changes in blood LA concentration after WAnT at 12, 18, 24 and 30<sup>th</sup> minutes of recovery are demonstrated in table 4. Blood LA concentration measured in various times of recovery at Pre-RF, End-RF and After-RF were not significantly different. Relationship between lactate concentration, heart rate and time throughout the measurement are shown in Figure 1 and 2 respectively.

### Discussion

The main results of this study revealed that if strength-power training is performed regularly and daily food intake, body fluid balance and daily sleeping time are maintained as before Ramadan, Ramadan fasting will not have adverse effects on body composition, anaerobic power and capacity, and LA metabolism during and after high intensity exercise in power athletes.

Fasting during the 30 days of Ramadan is abstinence from food and fluid from dawn to sunset. Remarkable changes were reported in the number and time of meals.

**Table 2.** Changes in power outputs during the Ramadan fasting. Data are means ( $\pm$ SD).

	Pre-RF	End-RF	After-RF	F	p
<b>PP (W)</b>	803.54 (113.10)	848.19 (116.90)	878.14 (69.13)	8.96	.002
<b>PP (W.kg<sup>-1</sup>)</b>	10.96 (1.15)	11.52 (.96)	11.87 (1.14)	8.05	.003
<b>MP (W)</b>	591.71 (86.58)	589.33 (80.15)	617.24 (66.16)	5.67	.012
<b>MP (W.kg<sup>-1</sup>)</b>	8.02 (.84)	8.01 (.69)	8.33 (.85)	4.12	.034
<b>FI (%)</b>	47.1(6.80)	52.33 (8.27)	51.0 (6.28)	3.14	.068

Abbreviations: PP: Peak Power, MP: Mean Power, FI: Fatigue Index.

**Table 3.** Changes in lactate and heart rate variables after high intensity exercise during the Ramadan fasting. Data are means ( $\pm$ SD).

	Pre-RF	End-RF	After-RF	F	p
LA <sub>resting</sub> (mmol·L <sup>-1</sup> )	1.10 (.19)	.98 (.29)	.98 (.26)	1.04	.374
LA <sub>peak</sub> (mmol·L <sup>-1</sup> )	14.25 (1.54)	13.94 (2.80)	13.98 (.71)	.11	.895
HR <sub>resting</sub> (bpm)	63.10 (8.91)	60.70 (11.56)	58.00 (11.14)	5.41	.014
HR <sub>peak</sub> (bpm)	177.30 (10.88)	178.10 (10.35)	177.90 (11.56)	.06	.945
LA Half-Life (min)	30.6 (3.53)	29.5 (4.19)	28.9 (4.59)	1.35	.283

Abbreviations: LA: Lactic Acid, HR: Heart Rate.

The number of meals decreased to two times each day, after sunset and just before dawn (Bahammam, 2005; Finch et al., 1998; Taoudi Benchekroun et al., 1999). Decrease in physical activity (Ben Salama et al., 1993) and changes in sleeping time were also reported in this month (Margolis and Reed, 2004; Taoudi Benchekroun et al., 1999). In the present study BW, BMI, FFM and BF% of regularly trained athletes measured at End-RF were not significantly different from Pre-RF, and After-RF (Table 1). The variability of BW and FFM were within below 1 kg throughout the study. The results dealing with the effects of Ramadan fasting on anthropometric variables were inconsistent in the previous studies conducted on sedentary subjects. According to Beltaifa et al. (2002), Ramadan (2002) and Ramadan and Barac-Nieto (2000), there was no significant change on anthropometric variables during the Ramadan. In contrast, Sweileh et al. (1992) and Ziaee et al. (2006) observed significant decrease in BW, BMI and BF%. Moreover Frost and Pirani (1987) reported that Ramadan fasting caused significant increase in BW. However the DCI was increased gradually by time, it was not statistically significant (Table 1). In contrast to the present study, several studies conducted on healthy sedentary subjects demonstrated that DCI had significantly increased during the Ramadan (Frost and Pirani, 1987; Gharbi et al., 2003). Whereas in the present study the difference was not significant, DST was higher in End-RF compared to Pre-RF, and After-RF (Table 1). The results of the previous studies in sedentary people were similar to the results of the current study. While sleeping and awake times of the healthy sedentary people had been changed, there was no significant change in the total daily sleeping time during Ramadan (Bahammam, 2005; Margolis and Reed, 2004; Taoudi Benchekroun et al., 1999). UD obtained at End-RF was similar with Pre-RF, but it was significantly higher than After-RF. Besides, TBW measured in Pre-RF, End-RF and After-RF were similar to each other. These results showed that power athletes' water retention mechanism might protect their total body water balance in this phase. The body water balance observed may be at least in part due to adaptation by the kidneys. The findings of the present study were consistent with the results of Ramadan et al. (1999) and Sweileh et al. (1992). Sweileh et al. (1992) which reported that dehydration existed during the first

week of Ramadan and returned to the pre-fasting levels during the last week. Similarly, Ramadan et al. (1999) noted significant increase in osmolarity in sedentary, but not in active subjects during Ramadan. This shows that body fluid balance was maintained in active subjects similar to the results in the present study.

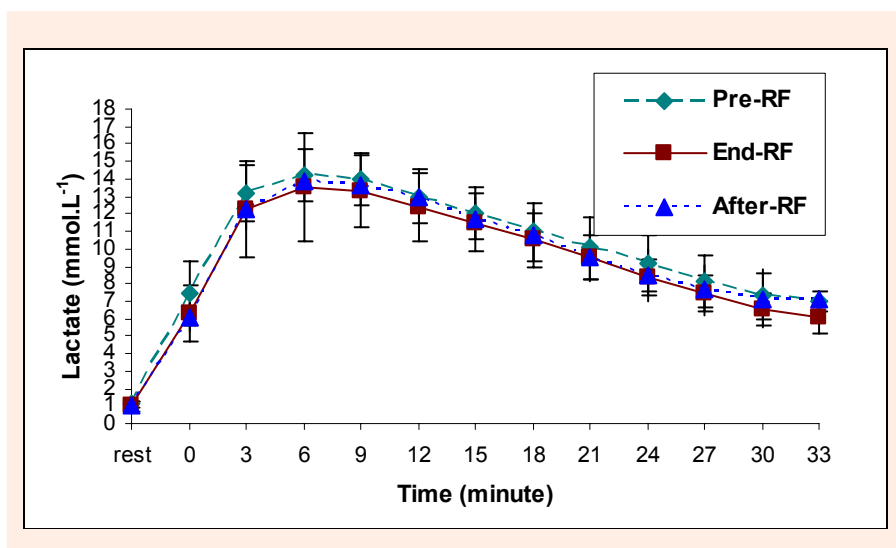
Absolute and relative PP and MP values determined in this study were found similar with the values of combat athletes (Kocak and Karli, 2003) and sprinters (Watson and Sargeant, 1986), but lower than speed skaters (Van Ingen Schenau et al., 1992). The results of the present study showed that in contrast to MP, significant increase was indicated in absolute and relative PP values during Ramadan (Table 2). Relative PP values measured at End-RF and After-RF were 4.9% and 7.7% higher than Pre-RF respectively. In addition a smaller improvement (2.9%) was also recorded in relative PP values from End-RF to After-RF. The regular strength-power training sessions maintained as before Ramadan might be the possible reason for the progressive increase in the PP values in this study. It appears that if strength-power training is performed regularly during Ramadan, long duration intermittent fasting (Ramadan Fasting) will not have detrimental effects on anaerobic performance. Previous studies dealing with the regular sprint and anaerobic training-induced adaptations in athletes and sedentary subjects have provided inconsistent results. Several studies indicated that the improvement of metabolic capacity of muscle caused by training was combined with the significant changes in short-term power output (Cadefau et al., 1990; Costill et al., 1979; Linossier, et al., 1993; MacDougall et al., 1998; Roberts, et al., 1982). However, in some other studies, even significant increase was observed in short-term power output, no remarkable differences were reported in creatine phosphate, glycogen stores and glycolytic enzyme activity (Barnett et al., 2004; Dawson et al., 1998).

LA values during Pre-RF, End-RF, and After-RF were similar (Table 1). This similarity in LA values under resting states may indicate that the subjects may have tested under similar metabolic and hormonal conditions. On the contrary, significant differences were observed in resting HR values (Table 3). In the literature, it is reported that resting HR values may exhibit wide range of variation due to the various factors (Lamberts et al., 2004;

**Table 4.** Changes in blood lactate concentration (mmol·L<sup>-1</sup>) at various times of passive recovery during Ramadan fasting. Data are means ( $\pm$ SD).

Recovery Time (min)	Pre-RF	End-RF	After-RF	F	p
12	13.0 (1.56)	12.4 (1.96)	12.9 (1.10)	.53	.599
18	10.9 (1.71)	10.5 (1.51)	10.8 (1.52)	.28	.761
24	9.2 (1.64)	8.4 (1.07)	8.5 (1.47)	1.22	.318
30	7.3 (1.28)	6.5 (1.00)	7.0 (1.21)	1.22	.317



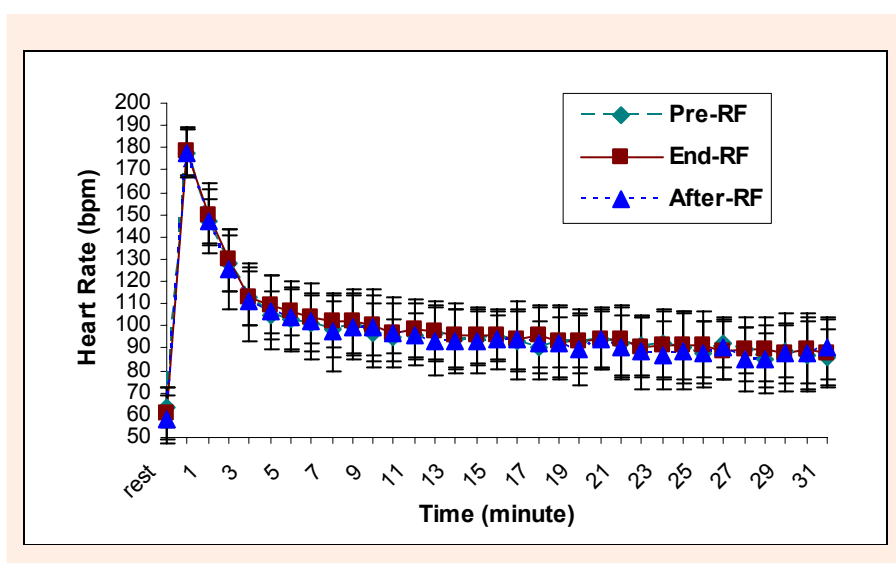


**Figure 1.** Lactate data for passive recovery during Ramadan fasting.

Lemmink et al., 2004). On the other hand, similarity among peak HR values at Pre-RF, End-RF and After-RF (Table 3) demonstrated that cardiovascular stress caused by supramaximal exercise was not affected by Ramadan fasting. Peak LA values measured following supramaximal exercise in the current study (Table 3) were similar with the values (10.6 – 14.7 mmol.L<sup>-1</sup>) of athletes and active subjects examined in other studies (Dotan et al., 2003; Hubner-Wozniak et al., 2004; Marsh et al., 1999; Sands et al., 2004; Weinstein et al., 1998). Peak LA value measured in End-RF was lower than Pre-RF and After-RF but the difference was not significant (Table 3). This result might indicate that long duration intermittent fasting (Ramadan Fasting) had no adverse effect on anaerobic metabolism and muscle glycogen stores during high intensity exercises in power athletes. To our knowledge, no report exists in the literature about the effects of long duration intermittent fasting (Ramadan Fasting) on muscle glycogen stores. However, Knapik et al. (1988) reported that the resting muscle glycogen level determined at the end of 3.5 days of fasting was not different from 12

hours of fasting.

To the best of our knowledge, no study has assessed the effects of long duration intermittent fasting (Ramadan Fasting) on removal rate of LA from the blood following supramaximal exercise. Half life of LA observed during passive recovery period at Pre-RF, End-RF and After-RF were 30.6, 29.5, 28.9 min respectively in the current study (Table 3). On the other hand, Gupta et al. (1996) reported that half life of LA of endurance athletes was 21.5 min during passive recovery period. It is known that removal rate of LA from blood is strongly related with the oxidative capacity of muscles (Thomas et al., 2004). Nevertheless, similar LA removal rates were reported in sprinters and endurance athletes during passive recovery. Therefore, it is suggested that the training type is not an effective factor on the removal rate of LA during passive recovery (Taoutaou et al., 1996). In the present study, neither half life of LA (Table 3) nor blood LA concentrations measured at 12<sup>th</sup>, 18<sup>th</sup>, 24<sup>th</sup> and 30<sup>th</sup> minutes of passive recovery were different at any point of observation (Table 4 and Figure 1). Although these results



**Figure 2.** Heart rate data for passive recovery during Ramadan fasting.

revealed that no influence of Ramadan fasting on removal rate of LA from blood following high intensity exercise was observed, the effects of long duration intermittent fasting on muscle glycogen stores and the metabolic fate of LA during recovery was not investigated in the current study. In the literature, there have been many studies about glycogen repletion and LA metabolism during active and passive recovery following aerobic or anaerobic exercises after 12-24 hours fasting in humans and animals (Astrand et al., 1986; Choi, et al., 1994; Fairchild et al., 2003; Maehlum and Hermansen, 1978; Raja et al., 2004). But long duration intermittent fasting (Ramadan Fasting) is different from experimental fasting and no study exists in the literature on this topic in humans. In the results of several studies, remarkable decrease (28% to 32%) was reported in muscle glycogen stores caused by short time high intensity exercises following experimental fasting (12-24 hours) in humans and animals (Choi et al., 1994; MacDougall et al., 1977; Raja et al., 2004). Moreover previous studies showed that both humans and various kinds of animals have the capacity to replete their stores of muscle glycogen rapidly even in the absence of food intake (Bräu et al., 1999; Bräu et al., 1997; Raja et al., 2004). Raja et al (2004) suggested that the regeneration rate of muscle glycogen stores during passive recovery from high intensity exercise in fasting animals was not limited by the amount of accumulated lactate. Although it was reported that the blood LA was an important endogenous carbon source for repletion of muscle glycogen stores in fasting condition (Bräu et al., 1999; Bräu et al., 1997; Raja et al 2004), the result of Raja et al. (2004) showed that the blood LA was not the only source for replenishment of muscle glycogen stores. The removal rate of accumulated lactate from blood following intense exercise has been reported to be slower during passive recovery in comparison to active recovery both in normal condition (Ahmaidi et al., 1996; Gupta et al., 1996; McAinch et al., 2004; Toubekis et al., 2005) and during fasting (Choi et al., 1994). On the contrary, Choi et al., (1994) and Nordheim and Vollestad (1990) suggested that the resynthesis of muscle glycogen was faster during passive recovery than active recovery in fasting individuals. These results indicated that during both normal and fasting conditions, the metabolic fate of lactate could vary depending on the recovery modes. Hence, future studies will be needed to compare the effects of different types of recovery modes on the removal rate of lactate from blood during long duration intermittent fasting (Ramadan Fasting).

## Conclusion

This study was conducted during the last 3 days of Ramadan fasting, and it can be assumed that metabolic adaptation was at its optimal state compared to earlier periods of Ramadan. Earlier periods of Ramadan may elicit different results compared to the results obtained. Therefore, there is also a need for further studies to compare the effects of different periods of Ramadan fasting. In conclusion, it appears that Ramadan fasting has no adverse effect on body composition, nor on power outputs of short time

high intensity exercise, provided that there is no change in daily caloric intake and no change in total sleeping hours. The results of this study also revealed that there was no influence of Ramadan fasting on LA metabolism during high intensity exercise and recovery phase, in regularly trained active power athletes.

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### Key points

- No significant changes were assessed on body composition, daily sleeping time and caloric intake, and body fluid balance in regularly trained power athletes during Ramadan fasting.
- Ramadan fasting has no adverse effect on power outputs of short time high intensity exercise.
- No influence of Ramadan fasting on LA metabolism during high intensity exercise and passive recovery in regularly trained power athletes.

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