

Effects of Ramadan Intermittent Fasting on Sports Performance and Training: A Review

**Anis Chaouachi, John B. Leiper, Nizar Souissi,
Aaron J. Coutts, and Karim Chamari**

The month-long diurnal Ramadan fast imposes a major challenge to Islamic athletes. Sporting events are programmed throughout the year, with the result that training and competition are often scheduled during Ramadan. The small numbers of well-controlled studies that have examined the effects of Ramadan on athletic performance suggest that few aspects of physical fitness are negatively affected, and only modest decrements are observed. Whereas subjective feelings of fatigue and other mood indicators are often cited as implying additional stress on the athlete throughout Ramadan, most studies show these measures may not be reflected in decreases in performance. The development and early implementation of sensible eating and sleeping strategies can greatly alleviate the disruptions to training and competitiveness, thus allowing the athlete to perform at a high level while undertaking the religious intermittent fast. Nevertheless, further research is required to understand the mechanisms and energy pathways that allow athletes to maintain their performance capacities during Ramadan, and which factors are responsible for the observed decrements in performance of some individuals.

Keywords: dehydration, fasting, fluid consumption, hydration, hypohydration, physical performance, Ramadan fasting, sleep and training

Ramadan is a fundamental rule of Islam and commands that healthy adult Muslims refrain from eating, drinking, smoking, and sexual relations from sunrise to sunset during the month of Ramadan. Because the Islamic calendar is lunar, Ramadan occurs at different times of the calendar year over a 33-year cycle. This variation results in the Ramadan intermittent fast (RIF) being undertaken in markedly different environmental conditions between years in the same country.¹ The duration of the fast depends on the geographical location and the season of the

Chaouachi is with the Research Unit "Evaluation, Sport, Health," National Centre of Medicine and Science in Sport, Tunis, Tunisia. Leiper is with the School of Sport and Exercise Sciences, Loughborough University, Loughborough, U.K. Souissi is with the Research Unit "Evaluation, Sport, Health," National Centre of Medicine and Science in Sport, Tunis, Tunisia. Coutts is with the School of Leisure, Sport & Tourism, University of Technology, Sydney, New South Wales, Australia. Chamari is with the Research Unit "Evaluation, Sport, Health," National Centre of Medicine and Science in Sport, Tunis, Tunisia.

year, and can be as long as 18 h a day in the summer of temperate regions.² Typically, two meals are eaten each day: one just before dawn (*sahour*) and one after sunset (*iftar*). Although there are no restrictions on the quantity or type of food that can be consumed during the night, several nutritional and behavioral changes are observed.^{3,4} These dietary changes can influence substrate availability and utilization^{5,6} and induce acute diurnal dehydration.^{1,7} The annual Ramadan fast is not obligatory for all adult Muslims, as there are several categories of healthy and ill people who are exempt or who can postpone the fast. These categories include travelers, pregnant women, the sick, and individuals for whom the fast could cause serious difficulties in themselves or others. This list does not specifically include competitive athletes for whom this is a serious issue, and this has become the subject of worldwide concern.

Food and fluid intake before, during, and after both training and competition has important implications for performance.⁸ The absence of fluid intake in the day may have a greater impact on performance than the absence of food, especially when training and competition take place in thermally stressful environments.⁷ Even mild dehydration may have adverse effects on a number of physiological and cognitive functions that are important components of performance.⁷ Collectively, these changes may cause perturbations that alter the physiological responses to exercise, which may have detrimental effects on sports performance.

A common difficulty for Muslim elite athletes is that the sporting calendar is not modified for religious observances and that sporting events are programmed throughout the annual calendar.⁹ For example, based on the current schedule, the 2012 Olympics in London will occur over Ramadan. Thus it is important to determine whether this religious fast has any untoward effects on performance.^{2,9-14} There is a general perception among athletes, coaches, and physicians that athletes undergoing RIF have difficulty in maintaining their training loads, body mass (BM), and physical work capacity.¹ This review will examine and summarize the current knowledge of the effects of RIF on training and performance. In addition, we formulate some practical recommendations for Muslim athletes and coaches supported by the evidence-based scientific literature from both controlled laboratory and field studies. The literature on the impact of RIF on training and performance was reviewed by using MEDLINE and SPORTDiscus database searches, and cross-referencing these articles using the search terms of hydration, dehydration, fluid consumption, hypohydration, sleep, training, physical performance, and RIF. There are five main factors that contribute to the explanation of the effect of Ramadan on exercise performance: energy restriction, sleep deprivation, circadian rhythm perturbation, dehydration, and reduction in the training load during Ramadan.

Dietary Intake

The Muslim community is established in almost every country and ethnic group across the globe. It is not surprising therefore that studies examining changes in diet and body composition caused by RIF have produced conflicting responses.^{1,15} Although daily lifestyle is markedly altered during Ramadan, it is not uniformly so, as geographical, socioeconomic, and cultural differences are prevalent. For example, Muslims typically eat only two meals per day during Ramadan, but many cultures have an additional meal a few hours after the *iftar* meal,¹⁶ whereas other

individuals prefer to miss *sahour* to have more time to sleep.¹⁷ The typical level of snacking can decrease during Ramadan, but may increase especially when family and friends meet to socialize.¹⁵

Dietary intake is therefore variable during RIF, but there is a trend for the majority of Muslims to eat foods that are specific to Ramadan. These foods tend to be higher in fats, animal protein, and sugars than the typical diet outside of Ramadan.^{1,15} However, poverty, loss of appetite, and/or cultural norms can reduce the energy intake during the RIF,¹ which might be manifested as a loss in BM and/or body fat.^{1,15}

Accurate dietary assessment in free-living individuals and groups is notoriously difficult to conduct.¹⁸ Many recall methods give highly variable estimates, whereas weighed diet records can misreport the usual diet by 10 to 30%. Even the duplicate portion method can underreport weighed diet records by at least 7%.¹⁸ Dietary assessment by recall and questionnaire can nevertheless give reasonable estimates for some groups.^{18,19} If energy intake is reported to be lower or higher over an extended period of time and BM changes follow in the same direction, then the dietary estimates would appear to be adequate.

A joint position statement on nutrition and athletic performance recommends that all physically active people consume a balanced diet containing sufficient energy to meet all of the training load and growth needs, with a mixture of foodstuffs that supply all of the macro- and micronutrients required.⁸ Performance benefits accrue when athletes ingest a daily diet that contains 6 to 10 g of carbohydrate per kg BM, 1.2 to 1.7 g of protein per kg BM, with a fat intake of between 20 to 35% of the total energy intake, and sufficient fluids to prevent a water deficit of more than 2 to 3% of BM.⁸ The timing of food and fluid intake is obviously also very important for athletic performance.^{8,19} The composition of the diet eaten during Ramadan in most studies suggests that physically active individuals consume more than adequate amounts of energy, with fat and protein levels increased while complex carbohydrate intake is decreased.^{1,6,14,19} Where emphasis is placed on eating a healthy balanced diet, athletes can usually be encouraged to eat a diet that meets the essential requirements of the “athletic diet,” at least in the second half of Ramadan.^{6,11,19} However, the timing of food and drink ingestion is not usually optimal for the Muslim athlete during Ramadan because of the daylight fast.

Most studies have demonstrated that no matter what diet is eaten through the RIF, more fat is used during submaximal exercise than out of Ramadan,^{5,20,21} but that carbohydrate oxidation is not compromised at high intensities.²¹ The increase in fat metabolism during RIF is a probable adaptation that is due to the raised concentrations of circulating lipids and low liver glycogen levels that normally occur following several hours of fasting.⁶ This metabolic milieu is likely to be present when Muslim athletes exercise during daylight hours in Ramadan.

Hydration

It is well established that hypohydration can reduce physical performance.⁷ A recent review of the literature concluded that, in warm-to-hot weather, dehydration by 2% or more of BM will impair the performance of aerobic exercise, and may also degrade mental/cognitive function.²² In addition, mild-to-moderate levels of hypohydration produce small but significant decrements in high-intensity exercise

and muscle power.²³ Although increased body water conservation occurs during RIF, there are also data to show that hydration is not chronically affected, at least in some populations, including athletes. Practicing Muslims certainly undergo diurnal dehydration during Ramadan, at a rate that is determined by the loss of body water minus the amount of metabolic water produced over this period.^{1,7} However, total body water content is chronically conserved during Ramadan in the few investigations that have measured this parameter.^{11,28,29} In most Ramadan studies, there are no direct measures of body water content and the conclusions are usually based on inappropriate measures of hydration status. Body mass alone cannot be used as an index of hydration status when energy balance may also be changing.

Recently, Shirreffs and Maughan⁷ assessed hydration status and fluid and electrolyte balance in fasting and nonfasting elite junior soccer players training in a warm environment during Ramadan. The results revealed no substantial change in total body water content over the period of Ramadan, although there may have been some expansion of the vascular space in both fasting and nonfasting groups. Mean sweat loss in a typical soccer training session was greater in the nonfasting than in the fasting players. The fasting players incurred a mean fluid deficit during training in excess of 2% of BM, with some individual values in excess of 3%. This level of dehydration induced by fluid restriction and exercise may have been sufficient to impair performance, especially in those individuals who were already hypohydrated before training began.⁷ Monitoring a subgroup of these players during this training session¹⁷ showed that heart rate was marginally higher in the fasting than in the nonfasting group, suggesting differences in preexercise and during-training hydration status. Furthermore, the level of dehydration elicited subjective feelings of a slightly decreased ability to concentrate, reduced alertness, and increased subjective sensations of fatigue.¹⁷ Dehydration may also contribute to an increased risk of injury as well as impaired match-play performance.⁷ Although the Ramadan practices do not appear to affect overall hydration status chronically, there is greater potential for some individuals to combine poor daily hydration with large fluid deficits over an exercise session.

Sensible dietary strategies that ensure adequate fluid intake, especially just before dawn, coupled with behavioral adaptations that minimize daytime fluid losses before training will help preserve hydration status and physical performance.^{17,28}

Circadian Rhythms

Most basic components of performance, such as body temperature, muscular strength, flexibility, and metabolic and psychomotor functions have rhythmic variations that follow a circadian pattern.¹² These variations partially explain why sports performances are generally improved by the end of the afternoon, around the peak of the circadian rhythm of body temperature.³² Nevertheless, the harmonious coexistence of distinct circadian rhythms cannot be assumed when the normal sleep–wake cycle is disrupted.³³ Factors such as the timing of the rest–activity cycle and meals can affect circadian rhythms.¹² Daytime fasting, modifications in sleep schedule, and psychological and social habits during Ramadan induce changes in the rhythmic pattern of a number of hormonal and nutrition-related biological variables.³ Ramadan can delay bedtime and shorten sleep, which can cause partial sleep deprivation.³⁴ Therefore, the propensity to participate in physical training and

Table 1 Estimated mean hydration levels during Ramadan

Population	Sample	Hypohydration Levels	Parameters Measured	Reference
Sedentary Kuwaitis	7	<1.5%	BM, serum osmolality, and sodium concentration	20
Sedentary Sudanese men	16	2.7% by 3rd week, but recovered by 4th week	BM, fluid intake, urinary vol., and electrolytes	24
Sedentary Pakistani men	46	No change	BM only	25
Sedentary men	10	<1.5% during 1st week, but recovered by end of Ramadan	BM, body fat, serum electrolytes, and protein	26
Sedentary Turkish women and men	37 women, 7 men	No change	BM, blood hematology, and biochemistry	26
Sedentary Malaysians	13	No change, but high urine osmolality in afternoon samples	Urine volume, osmolality, and solute excretion	27
Sedentary Indonesians	8	No change	TBW and BM	28
Physically active Gambian women	20	No change chronically, but up to 7.6% in the daytime	BM, body fat, urine volume, and osmolality	29
Physically active Kuwaitis	6	<1.4%	BM, serum osmolality, and sodium concentration	20
Physically active men	10	0.8%	BM and body fat (UWW)	21
Physically active Senegalese men	20	No change	BM only	31
Elite power athletes	10	No change	TBW, BM, and urine osmolality	11
Elite Tunisian judokas	15	<1%	BM and estimated changes in blood volume	6
Elite Tunisian rugby players	9	No change	BM and body fat	5
Middle Eastern junior soccer players	19	No change	BM only	2
Tunisian junior soccer players	55	2% exercise induced, chronically no change	BM, serum biochemistry, and urine SG	7
French middle-distance athletes	8	No change	BM and body fat	30

Note. BM = Body mass; TBW = Total body water; UWW = under water weighing.

the maximal capability to perform exercise can be impaired, even if the period of training is displaced voluntarily to the night.³

Numerous studies have shown that sleep loss produces a general decline in performance.³⁵ The trend is not the same for everyone or for all the components of performance. Mood, psychomotor and cognitive functions deteriorate more quickly than physical capabilities. The complexity, duration, and boredom produced by the task can also accelerate this decline.³⁵ Furthermore, sleep deprivation can reduce the amplitude of the diurnal fluctuation in performance;³³ this is due to a reduction in exercise capability at the time when the maximum values of performance are normally recorded. Thus, sleep deprivation modifies the rhythm of performance, reducing both the mean level of performance (mesor) and the peak-to-peak amplitude. There appears to be only one study that has examined the effect of Ramadan on diurnal variation in sport performance.¹² The authors reported that time-of-day effects on anaerobic power variables tended to disappear during Ramadan. Ramadan intermittent fasting impaired anaerobic performance in the afternoon and in the evening; however, morning responses for the Wingate and force-velocity tests were essentially unchanged. It appears that Ramadan might act directly on the circadian rhythm of anaerobic performance by (i) inducing a phase advance or delay in the rhythm or (ii) reducing the amplitude of the rhythm of anaerobic power development. Another possible explanation, for the decrease in performances in the afternoon and evening, is that Ramadan increases fatigue at these times of day. During a normal day, the subjective levels of fatigue can be higher in the afternoon than in the morning.¹² This increase may be enhanced during Ramadan, leading to a reduced capacity to maintain effort at the highest level.

Although future studies are required to describe the perturbation of circadian rhythms through Ramadan, it is important that sleep loss should be minimized. During Ramadan, the amount of sleep required is important; it is therefore expedient to allow spontaneous awakening to occur. It is also essential to establish a new sleep-wake cycle, with regular sleeping and eating schedules, well before any increase in training load or major competition.^{17,35} It may also be advisable to allow the athletes regular daytime naps.^{3,35}

Ramadan and Performance

The effect of short-term fasting on exercise capability has been widely investigated,^{36–44} with many studies concluding that fasting before exercise causes a decrement in performance. This effect has been explained, in part, by the extended periods of fasting employed (>24 to 55 h), dehydration,³⁷ prolonged exhaustive exercise testing,^{39,40} or very high-intensity levels of exercise.^{36,41} However, other investigators have failed to observe substantial performance decrements following shorter periods of fasting (11–24 h).^{44–47} The potential glycogen-sparing effect of fasting before exercise, attributable to increased free fatty acid availability, might explain the lack of decline in performance in short-term fasting.^{46,47} The long-duration, intermittent fasting of Ramadan is different from most experimental fasting investigations.

There are only a few studies that examined the effects of RIF on physical performance and, to date, the results have been inconclusive. The majority of these investigations have been conducted with sedentary or recreationally active

subjects. In this context, it is uncertain whether training load, periodization, and nutritional recommendations for elite athletes during Ramadan can be extrapolated from these limited results obtained in untrained individuals. Indeed, until 2007, no data were available on the impact of RIF in elite athletes, and many coaches and athletes still consider that Ramadan has a negative effect on sports performance.¹⁷ Any Ramadan-related decrement in athletic performance shown in recent studies has been shown to be small.^{2,9-11,14}

Even though the maximal heart rate (HR_{max}) reached during strenuous exercise is not substantially different during Ramadan, maximal oxygen uptake (VO_{2max}), submaximal oxygen uptake (VO_2), submaximal heart rate (HR), and exercise capacity at a given workload can be affected (Table 2). Sweileh et al,⁴⁸ reported that VO_2 may decrease significantly over the month of Ramadan and there may be a substantial reduction in VO_{2max} within the first week in sedentary subjects. However, the values were observed to return to prefasting values during the last week of Ramadan. At relatively low exercise intensities, there is a greater reliance on fat oxidation during the RIF.^{5,20} It is possible that this metabolic adaptation might explain some of the observed ventilatory changes, and carbohydrate metabolism does not seem to be compromised at high intensities.¹⁷ Nevertheless, whereas statistically significant reductions in aerobic performance have been detected in the early stages of the RIF, the decrements are usually small and tend to disappear in the second half of Ramadan.^{9,48}

Some studies have shown a reduction in anaerobic performance during Ramadan. A study conducted on fighter pilots⁴⁹ demonstrated that the RIF led to an impairment in muscular performance with maximum isometric strength (MVC) of elbow flexor muscles (right and left) decreasing by 10% to 12%. Muscular endurance at both 35% and 70% MVC were lower by the end of Ramadan in comparison with the control period (-28%, -22%, respectively). In addition, sprint performance can be affected by the RIF, with 3 × 150-m and 3 × 250-m sprint performance significantly impaired in comparison with pre-Ramadan values in Senegalese sprinters.⁵⁰ In another study, running performance in both 100-m and 800-m races were adversely affected by RIF in a group of young Tunisian athletes.⁵¹ Other investigators have also shown that whereas Wingate performance (peak power and mean power) and maximal power tests were essentially unaffected when tested in the morning during Ramadan, anaerobic power was reduced substantially compared with the control period, both in the afternoon and evening (17:00 and 21:00).¹²

In elite athletes, the effect of Ramadan on performance has only recently been examined.^{2,9-11,13,14} Unfortunately, the protocols used in these studies vary substantially, thus making it difficult to draw firm conclusions. Although many of these studies support the assumption that the metabolic challenges induced by RIF, combined with intense exercise training has little appreciable effect on the performance of experienced athletes, there are also results that have shown a detrimental effect on performance. Two studies, one involving Algerian professional soccer players¹⁴ and the other players in an Israeli youth soccer team,² found that the Ramadan fast was associated with decreases in some physical performance measures (Table 2). Nearly 70% of the professional players felt that their training and match performance were adversely affected during the fast, and more than half perceived that they ate less.¹⁴ These changes were suggested as the main reasons for the observed declines in performance. Other factors, such as environment, motiva-

Table 2 Mean aerobic performance effects measured during Ramadan

Population	Sample	Measured Parameters	References
Sedentary Kuwaiti men	18	<5% reduction in HR and ventilation responses during submaximal exercise; systolic pressure increase by 6%	54
Physically active Senegalese men	12	22% reduction in MAP; 3% lower HR and 20% lower systolic pressure at MAP	31
Young men of Senegalese army	17	3.7% reduction in mechanical work produced during 30 min of submaximal exercise	55
Physically active Senegalese men	12	22% decrease in endurance capacity; 19% lower systolic pressure at exhaustion	37
Algerian professional footballers	48	5% reduction in sprint speed; 9% reduction in dribbling speed; 7% reduction in agility; 16% reduction in endurance capacity; 22% increase in HR at end of endurance exercise	14
Middle Eastern junior footballers	19	<1% decrease in running aerobic capacity, endurance and performance; <2% reduction in jump performance	2

Note. HR = heart rate; MAP = maximal aerobic power.

tion, and changes in sleep patterns, were also cited as potential factors. However, these conclusions were based on the players' subjective estimation rather than on objective measures. In addition, this study provided no information on total energy and macronutrient intake, body composition changes, and training load of the players during the month of Ramadan. These factors limit the interpretation of the results reported in this study. Meckel et al² suggested that the decrease in performance of their youth players was due to the significant decrease in the weekly volume of intense physical activity from 6.4 ± 0.2 h/wk before Ramadan to 4.5 ± 0.1 h/wk during Ramadan. Once again, total water intake and body composition changes during RIF were not reported in this study.

A recent study examined the effect of the RIF on the aerobic and anaerobic performances of elite judo athletes maintaining high training loads.¹⁰ Ramadan intermittent fasting had little effect on performance during maximal aerobic and anaerobic tests in the judokas undertaking intensive physical training despite a 1.8% reduction in mean BM.¹⁰ Sprint performance was largely unchanged throughout the study, with no substantial differences detected between test sessions for the 30-m sprint times, or the 5-m or 10-m related split times. The estimated values for maximal aerobic velocity (vVO_{2max}), VO_{2max} and measured HR_{max} during the Multistage Fitness Test were also relatively unchanged throughout the study. The performance parameters in the single-effort jump tests (SJ and CMJ) did not alter during RIF. Nevertheless, the RIF elicited a small reduction in the 30-s repeated jump test at the end of Ramadan in comparison with the pre-Ramadan session.

A further study investigated the effects of Ramadan on anaerobic capacity and the removal rate of blood lactate after high-intensity exercise in an elite group of Turkish male power athletes (two wrestlers, seven sprinters, and one jumper).¹¹ This study showed significant increases in absolute and relative peak power during Ramadan, with no reduction in mean power, fatigue index, or change in lactate kinetics compared with the pre-Ramadan tests. Relative peak power values measured by the end and after Ramadan were 4.9% and 7.7% higher than before Ramadan, respectively. In addition, there was a smaller improvement (2.9%) in relative peak power values measured in the last week of Ramadan compared with those determined in the fourth week after Ramadan. It appears that RIF has no adverse effects on power outputs or lactate metabolism in short-term high-intensity exercise, provided there is no substantial change in daily energy intake or in total sleeping hours of these athletes.

A group of middle-distance runners were investigated before, and at days 7 and 21 of Ramadan.³⁰ In this study, training volume was unchanged. Maximum aerobic velocity, as determined by the Montreal Track Test Velocity method, decreased by <3% and <4% on the 5th and 21st day of RIF, respectively. The fast lasted approximately 13 h each day, and time spent sleeping was reduced by approximately 80 min by day 21, but had essentially returned to normal by the end of Ramadan. Whereas cortisol levels were unaffected by the RIF, circulating levels of adrenaline, noradrenaline, and interleukin-6 were approximately doubled, and melatonin concentrations were decreased. Subjective fatigue scores were slightly higher, with no other mood profile changes recorded. The authors speculated that the modest decrements in performance, and the increase in fatigue score may have been due to a lack of sleep or training load. However, these sleep and training measures were not assessed during the study.

In a controlled residential camp setting study, Kirkendall et al⁹ found that the RIF had little effect on objective tests of physical performance in a large sample ($n = 53$) of youth soccer players (mean age of 18 ± 1 y), in comparison with an age- and ability-matched control group ($n = 32$). In this study, the players' speed, power, agility, endurance, passing, and dribbling skills were not negatively affected by fasting.

In contrast with the studies that have failed to observe a detrimental effect of RIF on performance, both Meckel et al² and Zerguini et al¹⁴ reported that the soccer players in their studies reduced their training during Ramadan. Moreover, both groups of soccer players in these two studies were free living, whereas in other studies that have shown little change in performance,^{9,10} athletes stayed in a residential training camp. A training camp setting may provide a more physically rigorous, rigid, and healthier lifestyle than when free living.⁹ It is interesting to note that when athletes reside in a training camp during Ramadan^{9,10,17} they typically maintain their training and physical performance, and minimize the changes in their normal lifestyle. In contrast, athletes that are free living during Ramadan^{2,14} exhibit more substantial changes to training, lifestyle, and performance. Finally, in the studies that have reported no detrimental effect of RIF on performance, no major changes in body composition were reported, which could also explain the stability of the performance.

The small number of studies that have examined athletic performance and training intensity during Ramadan have shown that high levels of exercise activity can be maintained during the RIF.^{9–11,17} However, for some individuals and groups, the perturbations imposed by RIF significantly reduce their physical and mental abilities.^{2,14}

Training

The periodization of physical training is critical for optimizing performance in well-trained athletes. The placement of training can have a remarkable effect on performance when athletes undertake high training loads, or endure increased psychobiological stress.⁵² Unfortunately, there have been relatively few studies that have examined the different approaches to the periodization of training during the RIF. Table 3 shows a summary of the studies that have examined the performance changes in relation to training in highly trained athletes during Ramadan.

Most studies have reported that physical performance can be maintained when training duration, intensity, and loads are unchanged during the RIF compared with the pre-Ramadan period.^{10,11,17} For example, Chaouachi et al¹⁰ demonstrated that the physical performance of 15 elite judokas was mostly unaffected during Ramadan, despite maintaining their usual high training loads and reporting increased perceptual fatigue. Similarly, Karli et al¹¹ also demonstrated that when strength-power training regimes were maintained, and daily food intake, body fluid balance and daily sleeping time were preserved through Ramadan, that body composition, anaerobic power and capacity, and lactate metabolism were unaffected. These results show that high-level athletes can maintain performance during Ramadan if physical training, diet, and sleep are well-controlled.

Other research has shown that the responses to single training sessions are largely unaffected in fasting compared with nonfasting athletes during the RIF.¹⁷

Table 3 Summary of studies reporting changes in training variables, such as training duration and intensity of load, during Ramadan in fasting athletes compared with the before Ramadan levels

Sport	Level	Sample	Training Duration	Training Intensity	Training Frequency	Training Load	Reference
Judokas	Elite	15	NR	NR	NR	Maintained	6, 10, 56
Power athletes	Elite	11	Maintained	Maintained	Maintained	Maintained	11
Soccer	Elite	48	NR	NR	NR	NR	14
Soccer	Elite junior	87	NR	Maintained	NR	NR	17
Soccer	Junior	19	Reduced	Reduced	NR	Reduced	2
Soccer	Professional	10	NR	NR	NR	Reduced	53
Middle-distance runners	Well-trained	8	Maintained	NR	NR	NR	30

NR = not reported.

An observational study reported that soccer players following the RIF reported no substantial differences in perceived training intensity, or mean HR response to training during Ramadan despite having greater thirst, hunger, and fatigue than a nonfasting control group that completed similar training.¹⁷ These results, though limited, show that players perceive training difficulty and intensity similarly and have similar HR response to a training session than do nonfasting players. Unfortunately, however, the external loads completed by the players in this session were not measured and it is unclear whether the fasting players reduced their physical work during the session to adjust for the stressors of Ramadan. Future controlled longitudinal studies that continue through Ramadan are required to determine whether the RIF influences responses to the same training stimulus when training demands are matched.

There have been few reports of changes in training loads in high-level athletes who follow Ramadan (Table 3). Two studies have observed that soccer coaches reduce the training loads to adjust for the expected increased stress through the RIF.^{2,53} In a case report of a professional Tunisian soccer team, the mean weekly training load was reduced during Ramadan compared with the soccer competition periods before (20%) and following Ramadan (17%), respectively (Figure 1). In the study of Meckel et al.,² the daily intense physical activity of young soccer players was reduced by almost 2 h/wk during Ramadan. In this observational study, the coach adjusted the team's training program, giving greater emphasis to low-intensity, technical, coordination, and tactical training while reducing high-intensity training. In addition, physical education classes for these students were cancelled during the RIF. The authors suggested that the decrease in training intensity during the RIF reduced the 3000-m run time, 6 × 40-m repeated sprint, and vertical jump performance of these young footballers' physical performance (Table 2). There

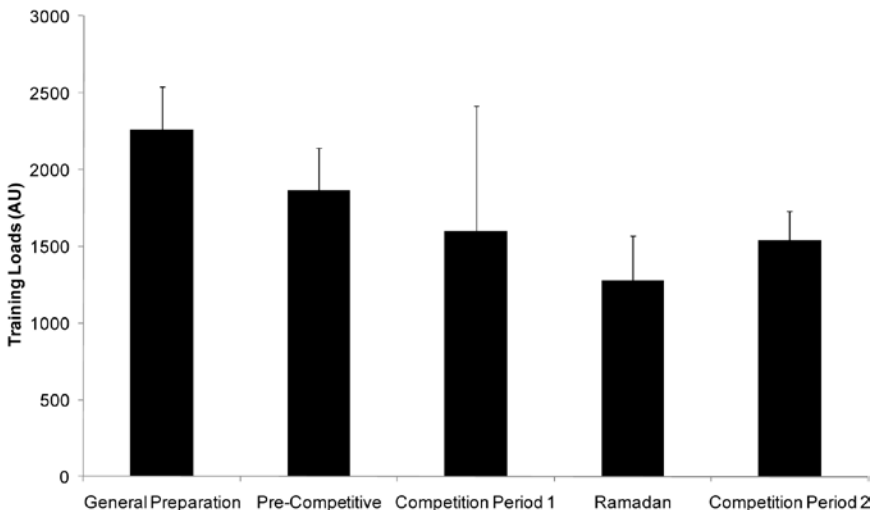


Figure 1 — Weekly training load (duration × session-RPE) in 10 professional Tunisian soccer players before and following Ramadan⁵³ (data shown as mean ± SD).

are no experimental studies that have directly examined the impact of different periodization or training strategies on physical performance during Ramadan with high-level athletes. However, in practice, coaches adjust training plans during this period to alleviate the increased fatigue, altered sleep, and diet changes that have been reported during the RIF. However, care must be taken when adopting such an approach because detraining may occur, particularly with high-level athletes.

There have been few studies that have accurately described the changes in the prescriptive training variables (ie, duration, intensity, frequency, and load) in high-level athletes during the RIF. However, it appears that most well-trained athletes accustomed to the RIF can cope well with the changes in behavior during Ramadan. Our knowledge of the effects of Ramadan on the performance of elite athletes remains limited. More research in this area is required to understand the mechanisms and energy pathways that allow athletes to maintain their performance capacities during Ramadan, and the factors responsible for the observed decrements in performance of some individuals. The ability of athletes to perform repeated-effort activities warrants further investigation, and for some team sports the use of sport-specific protocols might better mimic the real effort required for the sport. Interpreting performance results from laboratory or field tests is poor when considering, for example, the very specific effort made by a soccer player over more than 90 min of play varying in intensity and pattern. Nevertheless, coaches, athletes, and support staff can develop strategies that allow players to maintain physical performance throughout the month-long Ramadan fast.

Summary

Athletes should be encouraged to meet the normal energy and nutrient requirements of their training and competition. However, the timing of food and drink ingestion may not be optimal for the Muslim athlete during Ramadan because of the daylight fast.

Acute hypohydration will occur during daylight hours especially during bouts of strenuous physical activity in the heat. It is crucial that the athlete minimize the loss of body water during this period. Sensible dietary strategies that ensure adequate fluid intake especially just before dawn, coupled with behavioral adaptations that minimize daytime fluid losses before training will help preserve hydration status and physical performance.

Sleep deprivation and disruption to the normal circadian cycles can adversely affect physical performance. In the period before Ramadan, athletes should establish a new sleep-wake cycle, with regular sleeping and eating schedules, well before any increase in training load or major competition. Sleep loss should be minimized, and regular daytime naps may be required to sustain hard physical activity.

Athletes who maintain their energy and macronutrient intake, training load, body composition, and sleep are unlikely to suffer any substantial decrements in performance during the month-long Ramadan fast.

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