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Effects of Ramadan Fasting on Perceived Exercise Intensity During High-Intensity Interval Training in Elite Youth Soccer Players

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ABSTRACT

Ramadan fasting increases subjective feelings of fatigue and reduces self-motivation during exercise. Exercising in the Ramadan fasted state leads to a quality of training that is lower than normal due to a reduction in exercise intensity and/or physical efforts. This field investigation examined the impact of Ramadan fasting on perceived exercise intensity during high-intensity training sessions and its impact on maximal aerobic performance, in elite-level youth soccer players. The National Under-18 squad was organized into a fasting (FAS) and a non-fasting (control, CON) groups. During the Ramadan month, in addition to the normal soccer-specific training, both FAS and CON underwent six specific conditioning sessions consisting of high-intensity aerobic and anaerobic interval running. There were no significant differences between groups' post-exercise ratings of perceived exertion in all sessions. There were no significant differences between groups for Beep test performances at pre- and post-Ramadan. There was no adverse effect of fasting on perceived exercise intensity in Ramadan fasted players, and also no impact on their maximal aerobic performance post-Ramadan.

Key words: Fasting, Hydration, Oxygen Uptake, Ramadan, Ratings of Perceived Exertion

Reviewer: Jim Waterhouse (Liverpool John Moores University, UK)

INTRODUCTION

During the Islamic holy month of Ramadan, able-bodied Muslim men and women engage in the practice of fasting where individuals refrain from eating and drinking for the period between dawn to sunset for 30 consecutive days. In the Tropics, this implies a daily fasting duration of between ~12-14 h. Ramadan fasting is intermittent in nature, and there is no restriction to the amount of food or fluid that can be consumed during the permissible period. Since food and fluid are consumed after dusk and before dawn, the shift in feeding times affects the individuals' sleeping pattern and could lead to chronic sleep deprivation.

Muslim sportsmen continue to train during the Ramadan month and the impact of Ramadan fasting on exercise performance is mixed. Some studies showed that strength, anaerobic and high-intensity aerobic performance were adversely affected whilst other studies showed no change in exercise performance (for reviews, see [1, 2]). The lack of sleep, food and fluids were cited as possible factors that could compromise exercise performance during Ramadan [1, 2]. Another plausible but often overlooked, contributing factor is the insufficiency of training by the athletes over the Ramadan month [2, 3]. Indeed, many coaches believed that fasting Muslim athletes are not able to cope with normal training and tended to reduce the training volume (i.e., frequency, duration and/or intensity) during the Ramadan period [3-5]. Further, Muslims reported an increase in subjective feelings of fatigue, malaise, lethargy and moods that shift which can consciously or subconsciously result in their inability to sustain physical efforts, especially during high-intensity exercise [6-9]. Therefore it is plausible that 'detraining' as a consequence of an overall reduced exercise intensity and/or training quality, either through the deliberate lowering of training stimulus by the coach or reduced physical efforts on the part of the players leads to a decline in exercise capacity and/or performance, rather than the actual act of fasting *per se*.

Therefore the effect of Ramadan fasting on exercise intensity during training sessions on training subjects is not clear. Results of many studies show that athletes can physically cope well with high-intensity training loads leading to no change and even improvements in their physical or sporting performance [10-13]. In contrast, a significant reduction in daily intense physical activity from pre-Ramadan to during the Ramadan period was observed in well-trained soccer players that resulted in a poorer physical performance measures and capacity at the end of Ramadan month [5]. The effects of Ramadan fasting on training is further complicated by the findings of Chennaoui et al. [14], who recently reported a significant decrease in the maximal aerobic velocity of trained runners during the Ramadan period, even though there was no significant difference in the runners' training load prior to and during the Ramadan month. Several reasons can account for the disparate findings among the cited studies. Firstly, the use of training volume or duration to quantify training load in the studies [5, 10-12, 14] does not provide sufficient information about exercise intensity during training. Moreover, the absence of a detailed training description does not allow for an evaluation of the efficacy of the training programme and does not provide adequate information for the study to be replicated by other researchers [4, 5,10-14]. Secondly, the studies cited did not have a non-fasting control group to allow for a fair comparison of training results obtained [4, 5, 10-12, 14]. Without a control group for comparison it might be that the training characteristics for the non-Ramadan (i.e., control period) and Ramadan month were different, as is usually the case since coaches typically 'periodize' their training programme over the longer term [3, 15, 16]. Thus it cannot be ascertained from cited studies whether the decline or maintenance in exercise performances were because the athletes did not put equivalent efforts between the two training periods or that there was actual reduction in training quantity or quality. The latter is of critical importance since exercise intensity is

the key factor that influences training quality and the overall stimulus required to maintain performance during the challenging period of Ramadan fasting [3].

During an exercise session, coaches typically prescribe training by providing a set target, usually a quantifiable measure (e.g., distance, repetitions, duration, etc); and this is termed the external load [17]. However, what the coach demands of the athlete (external load) may not be what the athlete actual does during the training, i.e., the impact of external load may differ from the actual physical stress that the athlete is experiencing, which is termed internal load. It is plausible that different athletes perceive the same training stimulus differently due to differences in the level of fitness, training experience, level of skill, nutritional intake, etc. Moreover the interactions between external and internal perceived training load and/or intensity between Ramadan fasted and non-Ramadan fasted may be stark, given that athletes in the fasted state are considered to be in a less-than-optimal state when exercising. Apparently only one study had examined the athletes' ratings of perceived exertion (RPE) during training in the Ramadan month [18]. However in the cited study, RPE of all training sessions over the entire week were averaged and training was conducted on different players from different squads and at different times of day. There was a possibility of unequal efforts during training between the two groups of players as indicated by the significantly lower mean sweat lost in the fasting compared to the non-fasting group. All these factors could have confounded the results of Leiper et al. [18]. Hence, the effects of Ramadan fasting on the athletes' perceived exercise intensity require further investigation.

The aim of the present study was to describe the effects of Ramadan fasting on players, perceived exercise intensity during high-intensity exercise training, in elite youth soccer players. As exercising under the acute fasted state is likely to be more stressful than in the non-fasted state [16, 19-21], Muslim players could physically be overtaxed and this could lead to a poor adaptive response to the high-intensity training. Therefore, a secondary aim of the study was to determine the impact of such high-intensity sessions on fasted Muslim players' maximal aerobic performance over the Ramadan month.

METHODS

SUBJECTS

The National Under-18 squad comprised the country's most talented players in the age range, training as a group, and players had been playing competitively at the international level for at least three years. A total of 23 outfield players (goalkeepers were excluded because they engaged a totally different programme) were involved at the start of the study, but due to injuries and less than 100% attendance, the data of only 18 players were included for analysis. Except for the coaching staff, none of the players were informed of the real purpose of the study in order to avoid any form of bias. Players were informed that the tests and data collection were part of the squad's monitoring programme. In addition, the players' fasting status was determined only at the end of the Ramadan month via a personal interview with each subject. Based on this information, the players were then, retrospectively organized into the training and fasting (FAS; n = 10), and the training but not-fasting (or control, CON, n = 8) groups (Table 1). The FAS group consisted of all Muslim players who fasted throughout the Ramadan month and the CON group consisted of three non-Muslim players and five Muslim players who opted not to fast on training days and/or did not fast throughout the Ramadan month. All Muslim players who fasted in this study practiced the fast during Ramadan for at least the last six years. All players provided written informed consent and the study's procedures were approved by the Institutional Ethics Review Committee.

Table 1. Physical Characteristics of the Subjects in the Study (Results are mean ± SD)

	n	Age (y)	Stature (cm)	Body mass (kg)
FAS group	10	18.0 ± 0.7	173 ± 4	64.9 ± 7.1
CON group	8	17.9 ± 0.7	172 ± 5	62.7 ± 7.9

FAS = Muslim players who were fasting and training; CON = Muslim and non-Muslim players who were training but not fasting.

EXPERIMENTAL PROCEDURES

The study was conducted during the actual Ramadan month where the daily fast was from ~0530 h to ~1915 h, a total duration of ~13.5 hours. During the Ramadan month, both FAS and CON underwent an identical four-week training programme, with the soccer-specific and the high-intensity interval training sessions under the supervision of the squad's coaching staff and the principal investigator of the study, respectively. The criterion measure of the players' maximal aerobic performance, the 20-m multi-stage shuttle run (or Beep) test was conducted four days prior to, and five days after the completion of the Ramadan month (i.e., in the non-fasted state on both occasions).

The soccer-specific training was conducted four times per week. During the 90 min sessions, players performed soccer-specific training consisting of individual skills and drills, team set-pieces drills and tactics, and small-sided games. The high-intensity conditioning programme (see Table 2) was primarily modeled after those published in the soccer literature [22-26]. The basic premise of these sessions was to ensure that players exert high-to-maximal physical efforts so as to sustain a high level of training stimuli with the aim of either to improve or, at least, maintain the players' level of aerobic fitness over the Ramadan month. It was initially agreed that two sessions per week were to be conducted during the four weeks of Ramadan. However, due to two unanticipated friendly matches, only one session was

Table 2. Details of the Six High-Intensity Interval Training Sessions During the Four Weeks of Ramadan Fasting Month

Training session #	Description (repetitions x distance)	Intensity or pace (in minutes)	Recovery (duration and type)
1	2 reps x 800 m	3.0 min per 800 m	3.0 min, active
	6 reps x 400 m	1.33 min per 400 m	2.0 min, passive
2	6 reps x 600 m	2.0 min per 600 m	2.5 min, passive
3	4 reps x 30 m	all-out effort	2.0 min, passive
	6 reps x 20 m	all-out effort	2.0 min, passive
4	9 x 300 m	0.92 min per 300 m	2.5 min, passive
5	10 x 200 m	0.50 min per 200 m	2.5 min, passive
6	6 reps x 30 m	all-out effort	2.0 min, passive
	8 reps x 15 m	all-out effort	2.0 min, passive

All sessions were either hard running or sprinting. Training sessions 1, 2, 4 and 5 were conducted on a running track with players wearing sport shoes. Training sessions 3 and 6 were conducted on the field with players wearing soccer boots. Active recovery = jogging pace between ~4.0 - 8.0 $km \cdot h^{-1}$; Passive recovery = light lumbering, stretching and walking. All training sessions lasted between 30-50 min, including 5 min of warming-up and cooling- down.

conducted in the last two weeks of Ramadan month, for a total of six sessions. Both of the friendly matches were conducted in the evening time after the break of the day's fast.

For all (both soccer-specific and conditioning) sessions, both FAS and CON players performed the exercises together as a squad. All sessions were conducted between 1730 h to 1800 h, about ~1.5 to 1.0 hours prior to the breaking of the day's fast. The temperature and relative humidity during these sessions were 27-32° C and 59-66%. FAS players performed their sessions in the fasted state for all sessions while the CON players were allowed to drink (only water) ad libitum during training. At end of each training session, both groups were provided with the same catered food and fluid (i.e., dinner meal). The meal provided an estimated ~2.0 g·kg body mass^{-1} carbohydrate and ~0.3 g·kg bodymass^{-1} protein per day. Both groups consumed their dinner ad libitum at about the same time (i.e., immediately after the breaking of the day's fast).

SESSION RATINGS OF PERCEIVED EXERTION DURING TRAINING IN THE RAMADAN MONTH

To compare the perceived exercise intensity between FAS and CON groups during the high-intensity running sessions during Ramadan, Borg's 10-point category-ratio ratings of perceived exertion (RPE) scale was used (Fig 1). This RPE scale is a reliable and valid method of quantifying aerobic-anaerobic nexus exercise intensities [17]. When compared to heart rate and blood lactate concentration, the method is shown to be a good indicator of global measure of exercise intensity during high-intensity, and non-steady state running [17]. The scale is easy to understand, simple to use and is an effective way of quantifying the perception of physical exertion during a training session with a large group of subjects. The main advantage of using the session RPE to quantify exercise intensity is that RPE represents the player's own perception of effort or encountered internal stress relative to the challenge of physical training (or external load prescribed by the coach), which includes both the physical and psychological stress of exercise itself [17]. In short, the internal load accounts for the individual differences. This allows for an appropriate comparative evaluation between FAS and CON players' perceived exercise intensity against the same prescribed external exercise load that both groups are performing.

Rating	Descriptor
0	rest
1	very, very easy
2	easy
3	moderate
4	somewhat hard
5	hard
6	
7	very hard
8	
9	
10	maximal

Figure 1. Borg's Categorical Ratio Ratings of Perceived Exertion (RPE) Scale

The session RPE was administered 20 min after the end of the session. The players were simply asked "How was your workout?". We emphasized to the players throughout the study that the RPE value represents a single global rating of intensity for the entire training session using whatever cues that the players felt were appropriate. All players were familiarized with the use of the RPE scale prior to the commencement of the study. We did not multiply the session RPE value with training duration to calculate the training load value, because our sole purpose was to compare the exercise intensity perception between FAS and CON players for each of the six sessions assessed rather than to quantify the load over the entire programme in both groups.

20-m MULTI-STAGE SHUTTLE RUN (BEEP) TEST

The Beep test was used to assess the impact of training during the Ramadan month on players' maximal aerobic performance. All players were familiarized to the Beep test as the test was part of the squad's monitoring tool. The test was conducted as previously described [27]. In brief, after a standardized warm-up, in groups of 6-8, subjects ran back and forth between two lines, spaced 20-m apart, in time to a progressively increasing "beeping" sounds (20-m shuttle run test, compact disc, Australian Sports Commission, Canberra). The test was terminated when the subject could not follow the set pace of the "beeps" on two successive shuttles, or stopped voluntarily. The total number of completed shuttles was used as the player's criterion measure of maximal aerobic performance.

STATISTICAL ANALYSIS

The Statistical Package for Social Sciences ver. 15 for Windows (SPSS Inc., Chicago, IL) was used for all statistical analyses. Comparison between FAS and CON groups in their post-exercise RPE at each of the six training time-points were analyzed with an independent t-test. The total number of shuttles was analyzed using 2 x 2 one way analysis of variance (ANOVA) with one repeated factor (time: pre- and post-Ramadan month) and one between-group factor (FAS vs. CON). An independent t-test follow-up procedure was used to determine significant F values where appropriate. The level of statistical significance was set at $p < 0.05$.

RESULTS

All results are reported as mean (± SD). Both FAS and CON subjects were similar in their basic physical characteristics (Table 1). Comparison between FAS and CON subjects' in their post-exercise RPE for all the six training sessions showed no significant differences between groups (all $p > 0.05$; Figure 2). Also, there was no significant main effect for the total number of completed shuttles between FAS and CON either for main group ($F_{1,2} = 0.387$; $p > 0.05$), main time ($F_{1,2} = 0.366$; $p > 0.05$), or interaction effects ($F_{1,16} = 0.103$; $p > 0.05$) (Table 3).

Table 3. Performance in the Bleep Test at Pre- and Post-Ramadan Month for Players who were Fasting and Training (FAS group, n = 10) and Players who were Training but not Fasting (CON group, n = 8)
(Results are mean ± SD)

	Total Number of Shuttles Completed		**Maximum Heart Rate During Test (b·min^{-1})**	
	Pre	**Post**	**Pre**	**Post**
FAS group	114 ± 8	115 ± 9	198 ± 6	197 ± 6
CON group	111 ± 12	112 ± 14	200 ± 3	198 ± 5

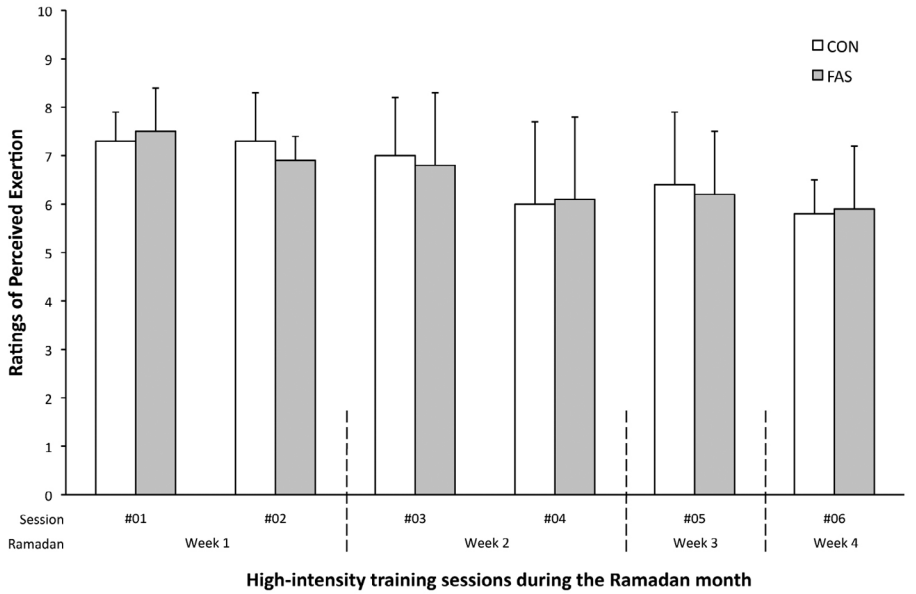

Figure 2. Mean Post-Exercise Ratings of Perceived Exertion (RPE) at the End of Each of the Six High-Intensity Interval Training Sessions Conducted During the Ramadan Month, in the Fasting (FAS, *n* = 10) and Non-Fasting (CON, *N* = 8) Groups
(Results are Mean ± SD)

DISCUSSION

Generally, the international sporting communities do not take into account the Ramadan fast in the scheduling of international competitions and Muslim athletes have to compete and/or train during the Ramadan month. The National Under-18 soccer squad was training for 10 months in preparation for a major competition, scheduled for early November. Ramadan was from late September to late October. Given the previous observations that Muslim athletes tended to lower their physical efforts during exercise in the Ramadan fasted state and that training intensity is the key to maintaining fitness and/or prevention of detraining [2, 3], the squad's coach was thus concerned about the impact that Ramadan fasting would have had on the fitness levels of Muslim players who opted to fast. Therefore the purpose of the present study was to determine if the chronic intermittent daily fasting has an influence on perceived exercise intensity and hence the consequent physical efforts during training sessions and its subsequent impact on maximal aerobic performance over the Ramadan period. The major finding of the present study is that FAS players were able to cope well with the high-intensity training sessions over the Ramadan month, as reflected by the similar exertion ratings with the CON group. FAS players were able to maintain maximal aerobic performance at the end of Ramadan month.

Zerguini et al. [9] reported that more than 70% of professional soccer players felt that their training quality was adversely influenced by Ramadan fasting, albeit it was unclear as to what aspects of the players' "training quality" was affected. Results of the present study are at odds with this observation [9] but clearly supported the findings of others [10-13], in particular that of Kirkendall et al. [13]. The latter study involved adolescent trained soccer

players, subjects of similar characteristics to the present study. The results showed that while fasting players reported that they were feeling more tired and less ready to train during Ramadan, the perceived effort during training in the Ramadan fasted state were similar to that before Ramadan and, were also not significantly different from the non-fasting players [18]. At the end of the study, the players' physical performance capabilities (speed, agility, power, speed endurance and aerobic endurance) were either maintained and/or showed progressive improvements [13], which was similar, albeit for the endurance measure, to the present study. It is noteworthy that players from Kirkendall et al. [13] were residing in an ideal environment with their food and fluid intake, sleep, and training programme rigorously controlled. On the other hand, the players in the present study were free-living athletes who were at the peak of physical fitness and were preparing for a major competition. Taken together, these two studies provide good evidence that perceived exercise intensity was unaffected in Ramadan fasted athletes, insofar as they were well-trained and highly motivated individuals and that training sessions were well-supervised.

In the present investigation, FAS players would have gone without food or fluid for at least ~11 hours prior to starting their training sessions during the Ramadan month. Thus, compared to CON players, they would be in a less than optimal hydrated state and possibly possessed lower levels of endogenous glycogen stores at the start of training sessions during Ramadan [2, 28, 29]. It is not clear from the present study's design how the FAS players were able to physiologically cope with the acute demands of each training session. Muscle glycogen was not measured in the present study, but it is highly unlikely that the performance in the exercise sessions was limited by endogenous muscle glycogen. This view is supported by studies indicating that ~24 hours of fasting duration did not totally deplete the body's muscle glycogen [30, 31], and subjects who fasted for less than 24 hours were clearly able to sustain their exercise intensity reasonably well without undue fatigue [32]. For example, no significant differences were observed in subjects' psychosomatic sensation, physiologic, and metabolic responses during 90 min of running at 70% $\dot{V}O_2$max intensity when performed either in the fasted (i.e., no food and fluid for ~12 hours) or non-fasted state [33]. In another study, running time to exhaustion at 70% $\dot{V}O_2$max was similar in both fasted (~21 hours) and fed state (102 ± 8 and 106 ± 8 min, $p > 0.05$) [34]. Again, there were no significant differences between the two conditions in their oxygen uptake, heart rate and blood lactate during exercise [34]. Although these data were non-Ramadan specific investigations, they do indicate that exercising in the acute fasted state did not appear to have adverse effects on the subjects' exercise responses and performances [35]. In regard to hydration, the fasted players in the present study were hypohydrated at the start of exercise, although a previous study with a similar fasting duration indicated that the extent of the levels of hypohydration appeared to be moderate only [28, 36], particularly if players had drunk plenty of fluids the night before and the morning of the fast [37]. Although dehydration is a physiological concern during exercise, the training sessions were of relatively short duration (< 50 min). Further, all sessions were conducted in the late afternoon when the ambient temperatures were at the lowest during that period of the daytime. All these conditions are likely to attenuate the negative impact of hypohydration on exercise performance within the fasted players in the present study [38].

Since RPE is reported to be elevated in athletes who were overtrained [39], a significantly higher overall perceived exercise intensity in the FAS as compared to the CON group was thus expected. But this was not the case in the present study. All the Muslim players in this study were accustomed to Ramadan fasting and have certainly experienced fasting and training at the same time previously. It is thus likely that these fasted players have adopted

various coping strategies to try to reduce the impact and/or stress of Ramadan fasting and training [1, 21, 40]. These strategies would have included self-behavioral modifications such as increasing intake of calories and fluids during the nocturnal period, consuming the *sahur* meal (i.e., the last main meal before the start of the day's fast) as late as permissible, taking short naps in the daytime to make-up for the lost sleep hours, reducing other non-essential physical activities to conserve energy acutely, adopting a task-oriented and positive attitude towards training, etc. The extent of such behavioral strategies and adjustments during Ramadan fasting are not known, but would most certainly have positive effects and influence on the athletes' exercise performance during Ramadan. Additionally, the present investigators deliberately implemented several training and organizational strategies to try to minimize the impact of Ramadan fasting on exercise. For example, there was no segregation between groups and both the FAS and CON players exercised together so that there was 'peer-pressure' and/or encouragement among players. Also, verbal encouragement was provided as much as possible to all players, targeted split-times for the aerobic interval runs were cued through loudspeakers to help players with their pacing throughout the runs and players were encouraged to focus on the quality of their physical efforts. In addition, the duration of sessions were kept within the hour to attenuate the influence of endogenous glycogen levels and dehydration on performance, and that sessions were deliberately conducted as close as possible to the breaking of the day's fast so that there was added 'psychological' motivation for the fasted players to put in the extra physical effort since they would be able to consume food and fluid soon after the end of training (i.e., catered dinner meals). These practical strategies are easily implemented by the coaching staff to ensure the 'best' possible exercise responses from the Ramadan fasted athletes.

LIMITATIONS

The present investigation has several limitations. The overall food and fluid intake as well as the sleeping times throughout the study were not assessed, but previous studies have indicated that subjects from modern societies (as the case of the present study) either increased or maintained their overall caloric intake throughout the Ramadan month [28]. A previous study also indicated that while fasted individuals may experience shortened sleeping hours, their daytime sleepiness was not adversely affected [41]. We also did not assess the players' perceived exercise intensity during their conventional soccer training sessions. Nonetheless, the intensity of these sessions is very much dependant on the coaches' training objectives and style. Also, players from different outfield positions participate in different set-plays, drills and/or skills that were clearly specific to the individual players' needs. Thus the intensity of these sessions was likely to be different among players. The six conditioning sessions, on the other hand, were tightly controlled by the primary investigator, who ensured that all players gave a maximum effort during training. Lastly, we did not measure other variables such as heart rate, blood lactate, actual running speed, etc., during these sessions. Such measures would have allowed a more direct and thorough comparison of the actual quality of exercise performances of the two groups during training. Notwithstanding these limitations, the results of this field study have high external validity and implications for athletes who are training and fasting at the same time during Ramadan.

CONCLUSION

The present study indicated that Ramadan fasting had no adverse impact on perceived exercise intensity during high-intensity interval training sessions. The capacity to sustain exercise intensity and/or efforts, at least in part, contributed to the fasted players' ability to

maintain their maximal aerobic performance through Ramadan month. A practical implication of the present study is that training to preserve maximal aerobic performance are feasible during the Ramadan fasting month provided that the appropriate exercise stimuli is imposed during training.

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