








Aspetar Clinical Guideline: Ramadan Fasting and Exercise for Healthy Individuals

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During the Islamic holy month of Ramadan, healthy adult Muslims observe fasting as an integral part of their religious practice. This dawn to dusk daily fasting regimen for over 29-30 days involves strict adherence to various lifestyle aspects, including nutrition, hydration, and sleep patterns, which can potentially influence physical performance. It is often observed that Ramadan fasting may deter athletes from training and participating in competitions, and it can also discourage the general community from engaging in physical exercise. This situation can place practicing Muslim athletes at a competitive disadvantage. Therefore, the objective of this clinical guideline was to offer practical recommendations, supported by consensus from an expert panel, for healthy athletes and their support teams on how to effectively adapt their behavioural, social, and psychological strategies to cope with the changes and constraints imposed by Ramadan fasting. The scope of these recommendations extends beyond merely prescribing appropriate exercise routines during the month of Ramadan, but also encompassing considerations like scheduling, intensity, duration, exercise type, and training load. Additionally, the recommendations address various aspects of lifestyle, including nutrition, hydration, and sleep, while also delving into psychosocial and cognitive facets related to Ramadan fasting. It is important to emphasize that these recommendations are intended for healthy individuals. Patients with chronic illnesses should consult their healthcare providers to ensure that they can safely practice Ramadan fasting.

Keywords: Athlete Performance; Chronobiology; Exercise; Expert Panel Consensus; Health and Fitness; Hydration; Lifestyle Recommendations; Nutrition; Sleep

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INTRODUCTION

The observance of Ramadan fasting will have an impact on several routine lifestyle variables, notably nutrition, hydration and sleep patterns. It can potentially reduce alertness, motivation, physical, and psychomotor performances (1-15). Therefore, rather than focusing on single alterations/perturbations, these variables should

be adjusted and coped with, utilizing a holistic approach, given the fact that these variables are strictly inter-related. Moreover, the approach should not be “one-size-fits-it-all”, but should consider the variability among athletes and individuals and their specific needs (eg biological, psychological, cognitive-behavioral), as well

as their social and cultural environment (16). Consequently, fasting athletes and general community Muslim individuals might have to face particularly challenging situations when they train, compete and exercise during the Ramadan month, no matter whether they are residing in a predominantly Muslim or in a non-Muslim majority country (3-6, 17-19).

Healthy adult Muslims, who observe Ramadan, are following strict religious rules, which concern not only the spirituality, but also life pattern. Amongst the constraints, fasting consists of completely refraining from eating and drinking from dawn to sunset. The last meal during nighttime, before the start of the day's fast is called "Sahur", while the evening meal consumed just after sunset is called "Iftar" (ie the breaking the day's fast). The daily fasting duration is based on the daylight hours, from dawn till dusk. As Ramadan is based on the lunar cycle, it shifts over the seasons on a 33 years' calendar. Therefore, Ramadan can take place at any season, and, therefore, the fasting daytime duration can vary accordingly with longer fasting durations during summer. Lastly, at any time point, the geographical situation will influence the daylight, the higher the latitude the longer the fasting duration (20).

The public opinion is that the observance of Ramadan fasting affects an athlete's ability to train and compete optimally, and, hinders the general community to exercise. This places devout Muslim athletes at a competitive disadvantage. Therefore, the aim of this clinical guideline was to offer an overview of practical and scientifically sound recommendations based on expert panel consensus, scholarly literature and experts' opinion. This clinical guideline was intended to be used by healthy athletes, and their support staff to: *i*) guide them on how to adopt appropriate behavioral, social and psychological strategies; and *ii*) cope with the changes and constraints as a result of Ramadan fasting.

2. METHODS

Editorial Approach

This clinical guideline document has been developed and issued by Aspetar, through a process, which aligns with international best practice in guideline development and localization. The editorial methodology used to develop this clinical guide involved several critical stages as described in Figure 1.

The guideline will be reviewed on a regular basis and updated to incorporate comments and feedback from all stakeholders. The recommendations for this clinical guideline are a result of collective decisions by the

"Ramadan Fasting and Exercise for Healthy Individuals" Aspetar Guideline Development Group (GDG) with input, if required, by the chairperson of the Aspetar Clinical Guideline and Pathway Committee. Where no agreement is reached on a specific recommendation, the majority vote would then prevail. This was not necessary for this guideline.

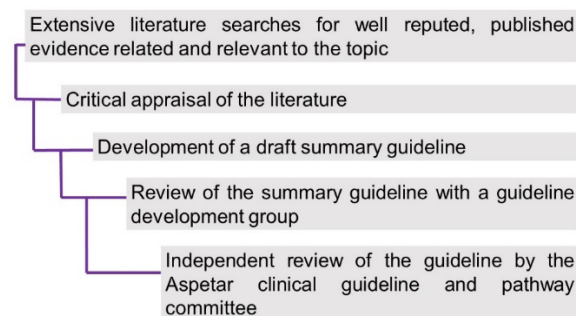


Figure 1. Editorial methodology applied in the development of the clinical guide

Sources of Evidence

To the best of the authors' knowledge, this is the first guideline that treats the issue of Ramadan fasting and exercise for healthy individuals. We searched PubMed, ScienceDirect, Web of Science and SPORTDiscus databases. The following combination of key-words was applied: (exercise OR sport) AND (Ramadan OR fasting). Only papers in English and French languages were retained. The reference lists of the selected papers were screened for relevant papers.

Evidence Grading and Recommendations

Recommendations made within this guideline are supported by evidence from the medical literature and where possible the most authoritative sources have been used in the development of this guideline. To provide an overview of the level of evidence for each recommendation made in this clinical guideline, a hierarchy of evidence was used to classify them (Boxes 1 and 2). Where the recommendations of international guidelines have been adopted, the evidence grading is assigned to the underlying evidence used by the international guideline. Where more than one source has been cited, the evidence grading relates to the highest level of evidence cited (Box 1).

In order to give additional insight into the reasoning underlying certain recommendations and the strength of recommendation, a recommendation grading has been used, where recommendations are made (Box 2).

Box 1. Levels of scientific evidence

Level (L)	Details
L1	Meta-analyses (specifically, meta-analyses of randomized controlled trials) Randomized controlled trials Systematic reviews (specifically, systematic reviews of randomized controlled trials)
L2	Observational studies, examples include: <ul style="list-style-type: none"> ○ Cohort studies with statistical adjustment for potential confounders ○ Cohort studies without adjustment ○ Case series with historical or literature controls ○ Uncontrolled case series Statements in published articles or textbooks
L3	Expert opinion Unpublished data, examples include: <ul style="list-style-type: none"> ○ Large database analyses ○ Written protocols or outcomes reports from large practices

Box 2. Recommendation (R) grades

Grade (G)	Abbreviation	Details
A1	RGA1	Evidence demonstrates at least moderate certainty of at least moderate net benefit
A2	RGA2	Evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care
B	RGB	Evidence is insufficient, conflicting, or poor and demonstrates an incomplete assessment of net benefit vs. harm; additional research is recommended
C1	RGC1	Evidence demonstrates a lack of net benefit; additional research is recommended
C2	RGC2	Evidence demonstrates potential harm that outweighs benefit; additional research is recommended
Recommendation of the guideline development group	R-GDG	Recommended best practice on the basis of the clinical experience of the Guideline Development Group members

Scope of the Clinical Guideline

Population

The population covered by the guideline are healthy athletes of all categories practicing Ramadan and healthy individuals from the public who are not exempted from fasting during Ramadan.

Setting

The setting are athletes in Clubs and Federations and community (eg outpatient clinic, ward).

Target Audience

The target audience are clubs and federations physicians and medical staff members, athletes, coaches and sports managers.

Clinical Issues

Patients with specific pathologies are not included and should consult their physician for any exercise-related questions, including exercising during Ramadan (see section 3.2.2 of the clinical guideline).

Responsibilities of Healthcare Professionals

This clinical guideline has been issued by Aspetar to define how appropriate and optimal care should be provided in Aspetar. It is based upon a comprehensive assessment of the evidence available as well as its applicability to the national context of Qatar and specific context of Aspetar. Healthcare professionals are expected to take this guidance into account when exercising their

clinical judgement in the care of patients presenting to them. It should be emphasized that the guidance does not override individual professional responsibility to take decisions which are appropriate to the circumstances of the patient concerned. Such decisions should be made in consultation with the patient, their guardians, or caregivers and should consider the individual's risks and benefits of any intervention that is contemplated in the patient's care.

RESULTS AND DISCUSSION

The primary aim of this clinical guideline was to define the appropriate management of healthy, adolescent and adult Muslim athletes, who are concurrently fasting and exercising during the month of Ramadan. The objective was to enhance the prescription of appropriate exercise guidelines during the holy month of Ramadan. The second aim was to follow-up the healthy individuals from the general community. It is intended that the clinical guideline will be used primarily by physicians, physiotherapists, nurses and health educators to provide appropriate advice to athletes, coaches and general community individuals.

Ramadan Fasting and Exercise for Healthy Individuals

For healthy athletes, recommendations regarding Ramadan fasting and physical exercise are presented in Table 1, and those concerning lifestyle aspects (eg

nutrition, hydration, body cooling, mouth rinsing, and sleep) are outlined in Table 2.

Time of Day of Training Sessions

Training times during Ramadan undoubtedly represents a crucial variable, which can be manipulated and adapted to the daylight fasting regimen (20, 21). According to the sport and/or training session, coaches can adapt the guideline recommendations to suit the needs of their athletes (20). Regarding time of day training, four options are possible, whenever the coaching staff can adapt training to Ramadan:

Performing training sessions before *Iftar*

The coach can organize training activities 1-2 hours before *Iftar* and end activities just before to *Iftar* time. This will enable the athletes to replenish their nutrients and fluids immediately post-training [L3, R-GDG]. Incidentally, this is also the period, albeit in the non-fasting condition, in which the levels of strength-induced hormonal secretion and arousal are at their peak. As such, this time of day does not impose significant sleep perturbations.

Table 1. Key Recommendations: Ramadan Fasting and Physical Exercise in Healthy Athletes

Factor	Key recommendations
Important considerations	Athletes should decide to continue sports training (and competition) during Ramadan Coaching and support teams assist (but are not the sole responsible parties) to adapt sports training to the needs of the fasting athlete Athletes should take the responsibility to optimize their Ramadan fasting environment and implement the necessary life style changes, and coping strategies
Training sessions: time of day	
1-2 h before <i>Iftar</i> (first meal to break the fast - sunset time)	Advantages: athletes will be able to replenish nutrients/fluids very soon post-training, no sleep perturbation This pre- <i>iftar</i> session will not affect the night sleep <i>We advise light-to moderate technical-tactical sessions:</i> low-to-moderate cardiovascular load or resistance training sessions of relatively short duration <i>Intense sessions:</i> intensive cardiovascular or neuromuscular (eg plyometrics) training sessions should be adapted (10-30% lower volume) compared to before Ramadan
~3 h after <i>Iftar</i>	<i>Advantage:</i> best option to maintain an acceptable hydration and nutritional status throughout the training Avoid high intensity and/or long duration training sessions because they have a negative impact on the sleep-wake cycle/sleep quality resulting in sleep deprivation <i>Disadvantage:</i> usually, different from the times of training and competitions (in many sports)
2-3 h after <i>Sahur</i> (last meal before starting the fast - dawn time)	It is not recommended to train in the morning time (2-3 h after <i>Sahur</i>) <i>Disadvantage:</i> recovery post-session will be impacted by the absence of food/fluid intake until sunset time If training is performed at this time of day, the athlete will have to recover post-session, in complete rest in a cool environment
Training session: organization, program and environment	
Frequency	<i>For elite athletes who exercise twice a day:</i> ✓ 1 st session training (pre- <i>Iftar</i>): a preferably non-physically exhausting exercise session ✓ 2 nd session training (post- <i>Iftar</i>): physically demanding exercise sessions are possible <i>For elite athletes who exercise only once a day:</i> ✓ Train preferably post- <i>iftar</i> , with the possibility to perform training sessions pre- <i>iftar</i> for non-physically exhausting exercise sessions
Intensity	Progressive loading approach: increase the exercise stimulus/intensity and loading variation throughout the month: ✓ 1 st week: light to moderate training sessions ✓ 2 nd to 4 th weeks: progressively increase the intensity High intensity physical training sessions (eg repeated sprint ability training sessions, or high-intensity intermittent training sessions) should be performed post- <i>Iftar</i> (if possible)
Duration	Pre- <i>Iftar</i> training sessions: no longer than 60 to 75 min Post- <i>Iftar</i> training sessions: 60 to 75 min
Type of exercise	<i>Training program:</i> incorporate strength or resistance sessions (once or twice a week depending on the athlete specialty) Balance training objectives to preserve psychomotor performance and minimize the risk of hypoglycemia/injuries Do not decrease the training load too steeply; otherwise, a detraining effect would take place, negatively influencing sporting performance Closely monitor athletes to rate their perceived physical and mental condition, and readiness to train Dynamically adapt/adjust training programs to each athlete's needs/status
Training environment	Ideal training environment during the day: cool and "preferably" not with direct sun exposure for too long (eg indoors) If not possible: train in a shaded place to prevent excessive sweating

All recommendations are level 3 and recommendation of the guideline development group.

Table 2. Key recommendations: Ramadan fasting and lifestyle aspects in healthy athletes

Factor	Key recommendations
Nutrition	Closely monitor type, amount and timing of meals Monitor nutritional-related parameters (eg lean/fat mass) during fasting <i>Sahur</i> : eat high glycemic index foods, and if fasting duration > 12 h: consume <i>Sahur</i> just before dawn and not earlier <i>Iftar</i> : eat both low and high glycemic index foods Supplements: to be taken after consultation by a physician and/or experts in the nutritional field General daily dietary intake guidelines: ✓ Carbohydrates: 6-10 g/kg of body mass ✓ Proteins: 1.2-1.7 g/kg of body mass ✓ Lipids intake: 20-35% of the total energy intake
Hydration	Hydrate well between <i>Iftar</i> and <i>Sahur</i> (ie ~200 ml every 30 min) Add osmotically active agents (eg sodium salts) Avoid coffee and tea General hydration guideline: consume enough fluids (3.0-4.0 L per day) to prevent a deficit > 2% of body mass (depending on sport' specialty and environmental conditions)
Body-cooling and mouth-rinsing	Cooling strategies (eg ice baths, cold towels, plunge pools, ice vests, appropriate clothing): before and during exercise in hot (and humid) environmental conditions Mouth-rinsing could lead to some relief and help endurance performance, but importantly, consider the religious consequences of potentially swallowing some of the liquid during mouth rinsing procedure
Sleep	Adopt an optimal sleep behavior and avoid sleep deficit and/or chronic sleep deprivation Daytime naps of ~30-40 min could be used to complement "night sleep" Self-adjustments to the sleeping schedule: going to sleep earlier or later for morning- and evening- chronotype athletes, respectively Manage sleep patterns with non-pharmaceutical approaches (eg sleep diaries/registries, psychometric tools) Avoid pharmaceutical strategies
Weight categories' sports and injury risk	Weight categories sports athletes: it is recommended to approach the competition target body weight way ahead of Ramadan. Injury risk reduction: optimize variables that have been associated with the occurrence of injuries: poor (i) sleep, (ii) nutrition, and/or (iii) hydration

All recommendations are level 3 and recommendation of the guideline development group.

Although some studies reported reduced performance, athletes would still be able to perform extra physical effort and tap into their reserves because psychologically, they know that they will be ending their fast and replenishing themselves very soon after training [L3, R-GDG]. For this time of day, it is recommended to perform light-to moderate technical-tactical sessions with low-to-moderate cardiovascular load, or, resistance training sessions of relatively short duration [L3, R-GDG]. For intense sessions, this period is also optimal to realize maximal exercises with 10-30% lower volume (due to dehydration of the fasting) than before Ramadan. The athletes will have the possibility to drink and eat after one hour of the end of the session [L3, R-GDG].

Performing training sessions at night

This time seems to be the best option for athletes because nutrition and hydration is not compromised before, during and after training. [L3, R-GDG]. It is recommended to perform high intensity and/or long duration training sessions at this time of the day (ie starting ~3 hours after *Iftar* (sunset dinner, breaking the fast meal) usually consumed just after sunset prayer; [L3, R-GDG]). However, it may negatively impact on the sleep-wake cycle and sleep quality resulting in sleep deprivation which may impact the athlete's physical and

psychomotor performance. Another major limitation for this time-of-day training is the difference between the times of training and occurrence of competitions [L3, R-GDG]. Usually, international competition times do not consider Ramadan fasting and athletes should compete during the daytime. This will impose considerable impact on the athlete, as they are not adapted to practice exercise at this time of day (See sleep section below 3.1.8).

Performing training sessions after *sahur*

Usually performing training sessions after *sahur* [ie 2-3 hours after *Sahur* (last meal before the start the day's fast) usually consumed just before dawn] is not recommended because of the long post-training period that will take place between this training session and *Iftar* time [L3, R-GDG]. This will impose additional stress on the athletes' body, with recovery processes impacted by the absence of food and fluid intake. If scheduled anyway, it is advised that this session entails low-intensity exercises focusing and addressing specific skills, tactics and techniques, rather than activities that require high-level and prolonged sustaining of physical efforts [L3, R-GDG]. In such case, it would be necessary that the athletes take complete rest in a cool environment [L3, R-GDG]. Indeed, if the athletes remain in hot and/or

humid environments, this will increase the physiological stress on their bodies.

Case of multiple training sessions a day

The athletes could train before and after *Iftar* as described above [L3, R-GDG].

Training Organization: Principle of Frequency, Intensity, Time and Type for Optimal Training

Coaches and sports managers should modulate training sessions considering physiological and metabolic perturbations induced by the responses to training in the Ramadan fasting state, which are usually more intense in the initial first few days of Ramadan fasting (20).

It is important to note that the scholarly literature reports contradicting results about the effects of Ramadan fasting on physical performance (need reference here). As mentioned previously, some studies reported a clear negative effect of Ramadan fasting, others reported no or minimal effect (5, 12, 14, 21). Indeed, when maintaining high training loads during Ramadan, elite judoists were able to maintain several physical performance measures despite the appearance of excess fatigue and a slight increase in the inflammatory markers (22). On the other hand, a tapering approach (decreasing training duration while maintaining training intensity (13) brought positive results with improvements of muscle power and strength in young soccer players (23). Nevertheless, this decrease in training duration over the entire month could still impact the total training load and thus potentially the training stimuli, which may result in detraining and negatively impacting performance (13).

A study that examined the effects of Ramadan fasting on distance covered over varying running velocities using a global positioning system during a 90-min football (soccer) match showed that the overall physical performance was negatively impacted in sub-elite football players³. This study is of particular relevance as it has monitored the players' training load prior to Ramadan and when compared with the training load in Ramadan, showed a clear and significant decrease in training load during the Ramadan month (24), and hence a possible decrease in overall physical stimuli. Thus, one cannot exclude the potential of detraining effect that could explain the totality, or at least part, of the decrease in the players' match performance in the Ramadan fasting state reported in the study. Indeed, Aloui et al. (9) showed a clear negative effect of Ramadan fasting on repeated sprint ability in young athletes. Therefore, if the athletes wish to perform maximal performance repeated sprint ability training sessions, they should avoid *pre-Iftar* time of the day and rather

consider performing their high-intensity training session in a fed-state, ie at night after *Iftar* [L3, R-GDG].

Unfortunately, the findings are limited because most studies have been conducted using amateur players, without considering their training state and without investigating whether the reduction in performance could be related to training session modifications during Ramadan fasting. Indeed, when Ramadan fasting is observed in the summer, the test sessions before Ramadan were performed at the end of the sports season (eg May or June); however, during Ramadan, the test sessions were performed after a period of training (eg July or August). Interestingly, studies conducted in physically active men (who maintain their training routines) did not report any significant Ramadan fasting effects. In summary, the effects of Ramadan on athletes' training and performances during competitions are conflicting, depending on a multitude of variables (for examples, time of the year when Ramadan occurs, duration of the daily fasting, harsh environmental conditions, athletes training level, variety of training prescription, amongst others).

Training frequency

Elite athletes commonly exercise twice a day, but this could be both physically and mentally demanding during Ramadan. Nonetheless, coaches could change their first *pre-Iftar* training session to a non-physical exercise session, ie a technical and/or tactical-emphasis session, [L3, R-GDG]. Indeed, the coach can simply use this daytime session to educate, relax and prepare athletes for the second physically demanding evening training session, *post-Iftar* (20) [L3, R-GDG].

Training intensity

A progressive loading approach should be adopted, gradually increasing the exercise resistance or stimuli and loading variation throughout the Ramadan month to facilitate athletes' adaptation to training in the fasted state (23, 25) [L3, R-GDG]. Coaches and athletes should also be aware that the individual's exercise heart rate, blood lactate and ratings of perceived exertion have been shown to be higher when exercising during the Ramadan fasting state compared to the same exercise during the non-fasting state (26, 27).

Throughout the month of Ramadan, there should be some form of periodization of the four weeks of training sessions. For example, it is not advisable to have zero high-intensity training sessions in the Ramadan month, which will clearly lead to detraining (especially with elite athletes who are used to exercising at high intensity) [L3, R-GDG]. On the other hand, one cannot have all training sessions to consist of high-intensity efforts throughout

the Ramadan month [L3, R-GDG]. In fact, high intensity training is not ideal, especially during the first week of Ramadan, because the same intensity of exercise before Ramadan will be perceived as a higher level of exertion with corresponding higher heart rates and metabolic challenge when performed during Ramadan. Training sessions during the first week should be light to moderate, which can then be progressively increase in intensity as one proceeds into the Ramadan month [L3, R-GDG].

Training duration

The duration of *pre-Iftar* training sessions should not be longer than 60 to 75 minutes (including warm-up and cool-down phases) [L3, R-GDG]. The rationale is to avoid hypoglycemia due to the excessive depletion of the fasting individual's muscle glycogen stores, which could lead to a poorer physical performance, particularly late during the training session and at the same time possibly increase the risk of musculoskeletal injuries.

Type of exercise

The training program, besides resting periods, should incorporate strength or resistance sessions (for instance, once or twice a week) [L3, R-GDG]. This is to counteract, or mitigate the potential total protein loss/reduction (as a result of possibly lowered calorie intake and/or decreased training stimuli) and help preserve the integrity and functioning of the muscle mass (28).

All these recommendations would allow athletes to gradually adapt to fasting and exercising conditions during Ramadan [L3, R-GDG]. Pre-Ramadan eventual training adaptations are discussed in section 3.1.9. There is a need to balance the athlete's training objectives, preserve his/her psychomotor performance and minimize the risk of hypoglycemia and injuries. Indeed, if the training load is decreased too steeply, this can lead to detraining condition (due to the reduced training volumes and loads as described above) (20).

Coaches and supporting staff should closely monitor athletes (by using reliable and validated psychometric tools, such as the Borg's ratings of perceived exertion, or a visual analogue scale) to rate perceived physical, mental conditions and readiness to train, eventually, dynamically, adapt and adjust the training program accordingly [L3, R-GDG].

Training environment

Unfavorable environmental conditions such as high humidity and/or heat represent an additional challenge for the Ramadan fasting athlete, imposing an additional burden of physiological stress resulting in increased body temperature and significant sweat loss. Thus, the training environment during the day in the Ramadan fasted state

should be cool and preferably indoors [L3, R-GDG]. If not possible, training should be held in a shaded place to avoid excessive sweat loss [L3, R-GDG]. The latter could potentially compromise the individual's thermoregulatory responses to exercise, which may lead to excessive hyperthermia. Otherwise, this would potentially lead to poorer and inadequate physical and psychomotor performances (29).

Living in a Muslim majority country could help the athletes easily share religious practices with their family and/or peers, while training pattern is adapted to Ramadan. A major challenge for these Muslim athletes would be the forced shift or perturbation of their sleep-wake cycle, which is crucial for recovery and training-induced adaptations. Indeed, in these countries, there is a shift of most social activities from day to night and this would impose considerable impact on sleep hygiene. Additionally, the call to perform late prayers (*Taraweeh*) could further shift and/or altered the normal sleep of the athlete.

Conversely, in non-Muslim majority countries, it is difficult to enjoy fasting and adapting to non-appropriate feeding and sleeping times can be really challenging for the fasting athletes living in such countries (20). Perhaps, in this case, sleep fragmentation could be more frequent (to have a *Sahur* meal and to be able to fully support the daytime fasting, see section 3.1.8) [L3, R-GDG]. The coach and team are not the sole parties responsible to adapt to the needs of a Ramadan fasting athlete. In fact, the athletes need to choose their priorities if they are to continue to engage in their chosen athletic pursuit. The athletes must accept responsibility and take the initiative to modulate the challenges of their Ramadan fasting environment. In case an athlete is fasting while being part of an environment where the training and competition schedule is not adapted to Ramadan, he/she should take their decision on the best way to cope with the challenges according to the advices given in next sections (3.1.5 to 3.1.10). In any case, it falls directly upon the Muslim athletes to adapt and make the best of the situation and implement the necessary life habits' changes to optimize their coping strategies to the situation.

Nutrition

Ensuring an adequate overall nutritional level is fundamental during the month of Ramadan (30). The type, the amount and the time-of-day of ingested food should be closely monitored to maximize the athlete's physiological and psychomotor performances [L3, R-GDG]. Despite the reduced frequency of meals, the total caloric uptake over the 24-h period can be relatively

easily preserved (11), when consuming balanced amounts of carbohydrates, proteins and fats. It is advisable to eat high glycemic index foods during the *Sahur* meal (start of the day's fast) in order to guarantee or even increase the bioavailability of carbohydrates and carbohydrate oxidation rates during the training session performed later during the day (30) [L3, R-GDG]. Both low and high glycemic index nutrients can be eaten when breaking the day's fast (*Iftar*) [L3, R-GDG], in that they properly modulate the insulin response and provide athletes with adequate muscle glycogen stores for the evening training sessions (31). It is fundamental to regularly monitor nutritional-related parameters during the fast (including body composition – lean/fat mass, and if necessary, blood glucose concentration). Sports supplements should be taken only after consultation by physicians and experts in the nutritional field [L3, R-GDG].

Hydration

Athletes are recommended to hydrate themselves well between *Iftar* and *Sahur*, possibly with frequent small amounts of drinks (~200 ml every 30 minutes) and eventually adding osmotically active agents such as sodium salts, to promote greater fluid retention and attenuate excessive urine loss [L3, R-GDG]. Fluids such as coffee and tea should be avoided, as they are activators of fluid excretion (32) [L3, R-GDG]. Maximal and/or optimal hydration status should be targeted by *Sahur* time. When the fasting duration is especially long (eg > 12 hours), *Sahur* should be consumed just before dawn and not earlier [L3, R-GDG]. We recommend that the athletes should wake up at this important time to ingest some foods and fluids [L3, R-GDG]. This is the last opportunity for the athlete to ingest nutrients before the prolonged fast. If feasible, hydration-related variables, such as urine frequency and color and, if possible, sweat loss, should be closely monitored. Many studies have reported that levels of hypohydration $\geq 2\%$ of body mass negatively impacted physical performance but the majority of these studies were limited by the fact that abstaining from ingesting fluids cannot be blinded to the subjects in the studies. As such there was no evidence for the actual real cause of the physical performance decrement in dehydrated individuals. However, Funnell et al. (32) recently investigated the effect of inducing a hypohydration in individuals who were blinded to their hydration status (hydration being ensured by nasogastric tubes). The aforementioned study is the first to show a negative effect of hypohydration (> 3% body mass) on physical performance and the result reinforces the advice given of ensuring adequate hydration pattern (ie

avoidance of hypohydration) in athletes during Ramadan fasting (the primary target would be to keep hypohydration < 2% body mass).

General dietary intake and hydration guidelines per day between sunset and dawn [L3, R-GDG]:

- 6 to 10 grams of carbohydrates per kg of body mass
- 1.2 to 1.7 grams of proteins per kg of body mass
- Lipids intake of 20 to 35% of the total energy intake
- Enough fluids to prevent a deficit of more than 2% of body mass. For individuals who are planning to exercise, they should ingest a minimum of 3.0-4.0 L of fluid during the period between *Iftar* and *Sahur*. We obtain this value, assuming that a non-exercising average person throughout the day should optimally ingest a mean of 2 to 3 liters of fluid a day (based on world health organization recommendations). Then Muslim athletes who are planning to fast and exercise should surely have to consume more than the average non-exercising individuals because of their sweat loss during the exercise in the day (and/or at night) [L3, R-GDG].

Body-cooling and Mouth-rinsing Strategies

To maintain a thermoregulatory homeostasis, cooling strategies such ice baths, cold towels, plunge pools, ice vests, and appropriate clothing could be used before and during exercise (3, 18) [L3, R-GDG]. Mouth-rinsing (fluids with or without carbohydrates) could lead to some relief, although evidence for this strategy has been conflicting (33-35). Indeed, if mouth-rinsing has led to performance enhancement during exercise of prolonged duration (34), it did not show any similar positive effects during all-out repeated sprints performed after three days of Ramadan fasting in trained adults (36). Of religious interest is to note that Ramadan fasting individuals who are engaging in mouth-rinsing during exercise should take into consideration the findings of the latest study, showing that when mouth-rinsing in-between all-out maximal sprint efforts, there is (i) a slight risk of inadvertently swallowing some of the gurgled liquid and (ii) accurate weighing of the fluid used for mouth-rinsing and thereafter expectorated, showed that a small quantity remains in the subject's mouth. Whether this residue is subsequently evaporated by hyperventilation and/or swallowed by the exercising individuals, is currently unknown. These considerations could have important religious consequences and should be clearly explained to the fasting Muslim athletes before considering any mouth-rinsing procedures.

Sleep

Regardless of Ramadan, sleep is an important prerequisite for optimal sport performance and recovery and plays a vital role in exercise's training-induced adaptation outcomes and injury prevention. Hence, athletes should avoid sleep deficit and/or chronic sleep deprivation that may typically accompany the lifestyle changes occurring during Ramadan fasting [L3, R-GDG]. Scientific evidence has shown that during the month of Ramadan, sleep tends to decrease both from a quantitative standpoint (by approximately 60 minutes in football players and by 88 minutes in middle-distance athletes) and from a subjective point of view (in terms of sleep quality) (6, 19). Thus, in general, Ramadan fasting leads to around ~60 minutes of sleep loss per day throughout the Ramadan period. On the other hand, however, it has been reported that Muslim athletes tend to indulge in much longer daytime napping during Ramadan than out of Ramadan (18, 37). Daytime naps of about ~30-40 minutes could be a useful strategy to help make up for the loss of nocturnal sleep and preserve alertness and adequate neuro-behavioral responses to stimuli (38).

Athletes could also make self-adjustments to the new sleeping schedule during Ramadan, and this should be done gradually considering the athlete's chronotype: for instance, going to sleep earlier or later could be another helpful technique for morning- and evening-chronotype athletes, respectively [L3, R-GDG]. Athlete sleep patterns should be carefully managed, using non-pharmaceutical approaches such as sleep diaries/registries and psychometric tools (assessing sleepiness or alertness) [L3, R-GDG]. Pharmaceutical strategies should only be used in exceptional circumstances and must be managed by a physician [L3, R-GDG]. Finally, coaches and sports managers should instruct and educate athletes regarding the importance and benefits of an adequate sleep level and its impact on psychomotor performance (39). The acquired knowledge will hopefully increase the chance that the athlete voluntarily adopts an optimal sleep behavior during the month of Ramadan [L3, R-GDG].

Psycho-social and Cognitive Impact of Ramadan Fasting

Athletes experience various levels of stress during Ramadan caused by disruption and/or alteration of their biological clock. In soccer players, this has been shown to impact mood and to lead to an increase in both physical and mental fatigue (13). Interestingly, after only three days of fasting, similar to Ramadan fasting, an individual's simple and multiple-choice reaction time were negatively impacted (40). It should be noted that the latter study investigated cognitive functions under valid

ecological conditions (ie with the participants performing the cognitive assessment in-between exercise sprint efforts); whilst other studies designs with such evaluations have had performed separately [assessing the cognitive function after exercise (ie in a resting state) have shown no effect] (*need a reference here*). Thus, the findings of the Cherif et al. (40) study suggest that decision-making behaviors during exercise/competitions conditions may be adversely affected in Ramadan fasting. In that regard, it is important to consider the ecological validity of the study designs to inform real world practitioners (athletes and coaches). From a psychological perspective, Farooq et al. (41), have shown that elite footballers had strong negative beliefs and attitudes toward Ramadan fasting regarding their exercise and mental performance capacity. This could be due to the potential nocebo effect of observing Ramadan fasting during exercise, as previously suggested by Aziz et al. (42, 43). Indeed, the latter work showed that the decrement in physical performance between the non-fasting condition and exercising in the Ramadan fasting condition occurred very early during exercise, and this strongly suggested that this early observation of "fatigue" in the Ramadan fasting state was potentially due to a nocebo effect (ie a negative belief that Ramadan fasting is obviously having a deleterious effect on physical performance). Interestingly, these authors mentioned that this decrease in performance could also be due to the nocebo effect and/or poor pacing strategy in the Ramadan fasting athletes (42, 43).

The social support network around the athlete as well as the strength of the athlete's spiritual beliefs and the so-called "religious intelligence", and could be the critical moderating variables in coping with stressors experienced during Ramadan fasting. Mental preparation courses could be attended by Muslim athletes' prior to the commencing of Ramadan fasting, in order to learn proactive coping skills (3, 18, 44). Coaches and managers are encouraged to consider preparing for Ramadan with training-rehearsal with athletes who are planning to train and compete in the fasting-state before the commencement of Ramadan (20) [L3, R-GDG]. This rehearsal could help dampen the potential negative perceptions and/or improve the pacing strategies of fasting Muslim athletes during exercise training. In that regard, it seems that experienced athletes, ie individuals having fasted for multiple Ramadan-months in their lives, seemed to possess better coping strategies than beginners (45). Indeed, young boys performing the religious fast for the first time in their lives showed a clear

reduced physical performance compared to their performance out of Ramadan periods (46-48).

Other potential ways of counteracting decrements in physical performance during Ramadan may also be considered, such as listening to music during pre-exercise warm-up which has been shown to help maintain their exercise performance, by distracting the fasted athletes from the “challenges” of Ramadan fasting (49) [L3, R-GDG]. There are other promising strategies, such as listening to Holy Qur’an (50) [L3, R-GDG], but despite its potential effect on fasting believers, no direct study has been conducted as yet to determine its ergogenic effectiveness.

Ramadan, Weight Categories’ Sports, and Injury Risk

For weight categories sports athletes, fasting during Ramadan further adds as a challenge during training and competition (51). Such athletes are encouraged to approach their competition target body weight way ahead before Ramadan because tempting to lose weight in addition to training and observing the Ramadan fasting could result in extreme challenges [L3, R-GDG]. In addition, Ramadan is accompanied with biological alterations showing an increase in markers of muscle injury (52). This could explain the slight but significant increase in overuse injuries observed in Tunisian football players during Ramadan (24). Nevertheless, Chamari et al. (24) study’s findings have not been replicated by a later Middle-East’s study which has shown that Ramadan was not accompanied with any change in injury rates in several teams in Qatar’s premier league (53). However, it should be mentioned that training and matches were played during the afternoons and evenings in the study of Chamari et al. (24), with a marked difference of conditions in the study of Eirale et al. (53) where all training sessions and matches were all held at night, ie in the non-Ramadan fasted state. Despite the controversial results, currently there is no strong evidence for the effects of Ramadan fasting on injuries in athletes; nonetheless emphasis should now be placed in implementing injury prevention strategies during Ramadan. The advice for coaches and fasting Muslim athletes would be to optimize their sleep, nutrition, and hydration since these key factors would not only reduce their risks of injury during exercise, but also potentially maximize their performance when training and competing in the Ramadan fasting state [L3, R-GDG].

For General Community

Table 3 presents some recommendations regarding physical activity and exercise for the general population.

Table 3. Key recommendations: Ramadan fasting and exercise in general community

Factor	Key recommendations
Healthy population	Similar guideline as for athletes Number of sessions and exercise intensity: lower than that of an elite trained Muslim athlete Untrained individuals: train <i>post-Iftar</i> <i>Recommendations:</i> ✓ One exercise session/day for six days/week ✓ 150 min/week of moderate intensity activity or 75 min/week of vigorous activity
Unhealthy population	Make sure to exercise safely during Ramadan in consultation with your physician

All recommendations are level 3 and recommendation of the guideline development group.

Healthy Population

For healthy untrained individuals from the community who are not exempted (eg pregnant women), the guidelines for athletes apply, but the number of sessions and exercise intensity would obviously be lower than that of an elite training Muslim athlete [L3, R-GDG]. Untrained individuals should ideally train in the evenings, *post-Iftar* when they are in a fed state [L3, R-GDG]. One exercise session a day for six days a week is recommended, with a minimum of 150 minutes a week of moderate intensity activity or 75 minutes of vigorous activity a week according to the world health organization recommendations (54) [L3, R-GDG].

Unhealthy Population: Persons with Acute or Chronic Disease

Athletes and those in the general community with chronic disease, should consult their physician for a comprehensive health assessment to determine whether fasting is recommended, and subsequently make necessary adjustments to the medication dosages, and also determine the appropriate time to take their medications between *Iftar* and *Sahur* [L1, RGA2]. Their doctor can also determine if they need long-acting or short acting medication that can be taken at night, once or twice a day, without affecting their religious fast [L1, RGA2].

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CONSENT FOR PUBLICATION

Not applicable

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AUTHORS' CONTRIBUTIONS

KC, ARA, TMJ, OS, KK, NLB, AC, HC, HBS: conception and design.

KC, ARA, TMJ, OS, KK, NLB, AC, HC, HBS: analysis and interpretation of the data.

KC, ARA, TMJ, OS, KK, NLB, AC, HC, HBS: drafting of the paper.

KC, ARA, TMJ, OS, KK, NLB, AC, HC, HBS: revising it critically for intellectual content.

All authors gave their final approval to the version that will be published.

DECLARATION

The English, Arabic, and French versions of this clinical guideline are available on the Aspetar website (<https://www.aspetar.com/en/professionals/aspetar-clinical-guidelines/ramadan-fasting-and-exercise-for-healthy-individuals>).

The Arabic version of this clinical guideline was published in "Moroccan health journal" (https://tawassol.ma/majala/features-articles/ramadan/550-rmm_n32_37.html).

The French version of this clinical guideline was published in "La Tunisie Medicale" (<https://latunisiemedicale.com/index.php/tunismed/article/view/4363>).

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