

ASPETAR CLINICAL GUIDELINE: RAMADAN FASTING AND EXERCISE FOR HEALTHY INDIVIDUALS

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Aspetar Clinical Guideline: Ramadan Fasting and Exercise for Healthy Individuals

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Abbreviations:

The abbreviations used in this guideline are as follows:

RF: Ramadan-fasting

WHO: World health organization

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1 Information About this Guideline:

1.1 Objectives and Purpose of the Guideline

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

1.2 Scope of the Guideline

- **Population:** the population covered by the guideline are healthy athletes of all categories practicing Ramadan and healthy individuals from the general public who are not exempted from fasting during Ramadan.
- **Setting:** athletes in Clubs and Federations and community (e.g. outpatient clinic, ward)
- **Target audience:** 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 2.4.2 of the document).

1.3 Editorial Approach

This guideline document has been developed and issued by Aspetar, through a process which aligns with international best practice in guideline development and localization. The guideline will be reviewed on a regular basis and updated to incorporate comments and feedback from all stakeholders.

The editorial methodology, used to develop this guideline, has involved the following critical steps:

- Extensive literature searches for well reputed, published evidence related and relevant to the topic
- Critical appraisal of the literature
- Development of a draft summary guideline
- Review of the summary guideline with a Guideline Development Group
- Independent review of the guideline by the Aspetar Clinical Guideline and Pathway Committee

The recommendations for this guideline are a result of collective decisions by the "Ramadan Fasting and Exercise for Healthy Individuals" Aspetar Guideline Development Group 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.

1.4 Sources of Evidence

To the best of the authors' knowledge, this is the first guideline that treats the issue of Ramadan fasting (RF) 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.

1.5 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 insight into the evidence basis for each recommendation, the following evidence hierarchy has been used to grade the level of authoritativeness of the evidence used, where recommendations have been made within this guideline. 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:

Level 1 (L1):

- Meta-analyses (specifically, meta-analyses of randomized controlled trials).
- Randomized controlled trials.
- Systematic reviews (specifically, systematic reviews of randomized controlled trials).

Level 2 (L2):

- Observational studies, examples include:
 - 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.

Level 3 (L3):

- Expert opinion.
- Unpublished data, examples include:
 - Large database analyses.
 - Written protocols or outcomes reports from large practices.

In order to give additional insight into the reasoning underlying certain recommendations and the strength of recommendation, the following recommendation grading has been used, where recommendations are made:

- Recommendation **Grade A1** (RGA1): evidence demonstrates at least moderate certainty of at least moderate net benefit.
- Recommendation **Grade 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.
- Recommendation **Grade B** (RGB): evidence is insufficient, conflicting, or poor and demonstrates an incomplete assessment of net benefit vs. harm; additional research is recommended.
- Recommendation **Grade C1** (RGC1): evidence demonstrates a lack of net benefit; additional research is recommended.
- Recommendation **Grade 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.

1.6. Guideline Development Group Members

The following table lists members of the Guideline Development Group (GDG) nominated by Aspetar Clinical Guidelines and Pathway Committee (ACGPC). The GDG members have reviewed and provided feedback on the draft guideline relating to the topic.

Karim Chamari (PhD) (lead)	Physiologist, Sport Scientist	Aspetar
Tajdine Moumen Jamai (MD)	Sport Medicine Physician	Aspetar
Omar Al Sayrafi (MD)	Sports Medicine Physician	Aspetar
Karim Khalladi (MSc)	Sport and Clinical Psychologist	Aspetar
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Nicola Luigi Bragazzi (MD, PhD)	Physician, Epidemiologist and Biostatistician	Laboratory for industrial and applied mathematics (LIAM), Department of Mathematics and Statistics, York University, Toronto, Ontario, Canada
Anis Chaouachi (PhD)	Physiologist, Sport Scientist	Tunisian Research Laboratory "Sports Performance Optimization", National Center of Medicine and Science in Sports (CNMSS), Tunis, Tunisia, and AUT University, Sports Performance Research Institute New Zealand, Auckland, New Zealand.
Hamdi Chtourou (PhD)	Physiologist, Sport Scientist	Activité Physique, Sport et Santé, UR18JS01, Observatoire National du Sport, Tunis, Tunisie - and Institut Supérieur du Sport et de l'éducation physique de Sfax, Université de Sfax, Sfax, Tunisia
Helmi Ben Saad (MD, PhD)	Physician	University of Sousse, Farhat HACHED Hospital, Heart Failure Research Laboratory (LR12SP09), Sousse, Tunisia

1.7 Aspetar Clinical Guidelines and Pathways Committee Members

The following table lists members of the Aspetar Clinical Guidelines and Pathways Committee (ACGPC), appointed by the Aspetar Director General. The ACGPC members have reviewed and provided their feedback and approval of the guideline document. Each member has completed a declaration of conflicts of interest, which has been reviewed and retained by the Aspetar Department of Medical Education.

MEMBERS	TITLE	ORGANIZATION/DEPARTMENT
Paul Dijkstra (chair)	Sports Medicine Physician/ Director of Medical Education	Aspetar - Medical education
Sofie Eline Nelis (deputy chair)	Lead Medical Education Specialist	ASPETAR - Medical education
Khalid Hassoun	NSMP Director of Medical Services	ASPETAR - NSMP
Celeste Geertsema	Sports Medicine Physician	ASPETAR - Sports Medicine Department
Michael Saretsky	Senior Physiotherapist	ASPETAR - Rehabilitation Department
Vasileios Korakakis	Senior Physiotherapist	ASPETAR - Rehabilitation Department
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Syed Sajid Ahmed	Head of Quality Management	ASPETAR - Planning and Performance Department

1.8 Responsibilities of Healthcare Professionals

This 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.

2 Ramadan Fasting and Exercise for Healthy Individuals

2.1 Key Recommendations

The observance of RF will have an impact on several variables, notably nutrition, hydration and sleep patterns. It can potentially reduce alertness, motivation, physical, and psychomotor performances¹⁻¹⁵. 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 (biological, psychological, cognitive-behavioral), as well as their social and cultural environment¹⁶. Consequently, fasting athletes and general community 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}. Box 1 presents the key recommendations related to RF and exercise.

Box 1. Key recommendations: Ramadan fasting (RF) and exercise.

Factor	Key recommendations
Healthy athletes	
Important considerations	<ul style="list-style-type: none"> 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 RF environment and implement the necessary life style changes, and coping strategies.
Training sessions: time of day	
1-2 h before Iftar (first meal to break the fast - sunset time)	<ul style="list-style-type: none"> Advantages: athletes will be able to replenish nutrients/fluids very soon posttraining, no sleep perturbation. This pre-iftar session will not affect the night sleep. We advise light-to moderate technical-tactical sessions: low-to-moderate cardiovascular load or resistance training sessions of relatively short duration. Intense sessions: intensive cardiovascular or neuromuscular (e.g. plyometrics) training sessions should be adapted (10-30% lower volume) compared to before Ramadan.

~3 h after Iftar	<ul style="list-style-type: none"> Advantage: 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. Disadvantage: usually, different from the times of training and competitions (in many sports).
2-3 h after Sahur (last meal before starting the fast - dawn time)	<ul style="list-style-type: none"> It is not recommended to train in the morning time (2-3 h after Sahur). Disadvantage: 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 postsession, in complete rest in a cool environment.
Training session: organization, program and environment	
Frequency	<ul style="list-style-type: none"> For elite athletes who exercise twice a day: <ul style="list-style-type: none"> ✓ 1st session training (pre-Iftar): a preferably non-physically exhausting exercise session. ✓ 2nd session training (post-Iftar): physically demanding exercise sessions are possible. For elite athletes who exercise only once a day: <ul style="list-style-type: none"> ✓ Train preferably post-iftar, with the possibility to perform training sessions preiftar for non-physically exhausting exercise sessions.
Intensity	<ul style="list-style-type: none"> Progressive loading approach: increase the exercise stimulus/intensity and loading variation throughout the month: <ul style="list-style-type: none"> ✓ 1st week: light to moderate training sessions. ✓ 2nd to 4th weeks: progressively increase the intensity. High intensity physical training sessions (e.g. repeated sprint ability training sessions, or high-intensity intermittent training sessions) should be performed post-iftar (if possible).
Duration	<ul style="list-style-type: none"> Pre-Iftar training sessions: no longer than 60 to 75 min. Post-Iftar training sessions: 60 to 75 min.
Type of exercise	<ul style="list-style-type: none"> Training program: 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	<ul style="list-style-type: none"> Ideal training environment during the day: cool and "preferably" not with direct sun exposure for too long (e.g. indoors). If not possible: train in a shaded place to prevent excessive sweating.
Nutrition, hydration, body-cooling and mouth-rinsing, sleep	
Nutrition	<ul style="list-style-type: none"> Closely monitor type, amount and timing of meals. Monitor nutritional-related parameters (e.g. lean/fat mass) during fasting. Sahur: eat high glycemic index foods. Iftar: 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: <ul style="list-style-type: none"> ✓ 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	<ul style="list-style-type: none"> Hydrate well between Iftar and Sahur (i.e. ~200 ml every 30 min). Add osmotically active agents (e.g. sodium salts). Avoid coffee and tea. If fasting duration > 12 h: consume Sahur just before dawn and not earlier. 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	<ul style="list-style-type: none"> Cooling strategies (e.g. 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	<ul style="list-style-type: none"> 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 (e.g. sleep diaries/registries, psychometric tools). Avoid pharmaceutical strategies.
Weight categories' sports and injury risk	<ul style="list-style-type: none"> 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

General community	
Healthy population	<ul style="list-style-type: none"> • Similar guideline as for athletes. • Number of sessions and exercise intensity: lower than that of an elite trained Muslim athlete. • Untrained individuals: train post-Iftar. • Recommendations: <ul style="list-style-type: none"> ✓ One exercise session/day for six days/week. ✓ 150 min/week of moderate intensity activity or 75 min/week of vigorous activity.
Unhealthy population	<ul style="list-style-type: none"> • Make sure to exercise safely during Ramadan in consultation with your physician.
All recommendations are Level 3 and Recommendation of the Guideline Development Group (R-GDG).	

2.2 Background

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 starting the fast is called "Sahur", while the evening meal consumed just after sunset is called "Iftar" (breaking the fast). 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 impact on the daylight, the higher the latitude the longer the fasting duration²⁰.

The public opinion is that RF hinders an athlete's ability to train and compete, and, hinders the general community to exercise. This places devout Muslim athletes at a competitive disadvantage. Therefore, the aim of this guideline is to offer an overview of practical and scientifically sound recommendations based on expert panel consensus, scholarly literature and experts' opinion.

This guideline is intended to be used by healthy athletes, and their support staff:

- (i) To guide them on how to adopt appropriate behavioral, social and psychological strategies; and
- (ii) To cope with the changes and constraints as a result of RF.

2.3 Healthy Athletes

2.3.1 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 athletes²⁰.

Regarding time of day training, four options are possible, whenever the coaching staff can adapt training to Ramadan:

2.3.1.1 Performing Training Sessions Before Iftar (1-2 hours before Iftar)

The Coach can organize training activities 1-2 hours before Iftar and end activities prior 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, and better prepares an athlete for competition. Although some studies reported reduced performance, athletes could still perform extra effort and tap into their reserves because, they will be ending their fast and replenishing themselves within one hour 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].

2.3.1.2 Performing Training Sessions at Night [starting ~3 hours after Iftar (sunset dinner, breaking the fast meal) usually consumed just after sunset prayer]

This time seems to be the best option for athletes to maintain an acceptable hydration and nutritional status throughout the training [L3, R-GDG]. It is recommended to perform high intensity and/or long duration training sessions at this time of the day [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 is the difference between the times of training and competitions [L3, R-GDG]. Usually, international competition times do not consider RF 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 2.3.8).

2.3.1.3 Performing Training Sessions After Sahur [2-3 hours after Sahur (last meal before starting the fast-ing day) usually consumed just before dawn prayer]

Usually this 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 a 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.

2.3.1.4 Case of Multiple Training Sessions a Day

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

2.3.2 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 RF state, which are usually more intense in the initial first few days of RF²⁰.

It is important to note that the scholarly literature reports contradicting results about the effects of RF on physical performance. As mentioned previously, some studies reported a clear negative effect of RF, 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 fatigue and a slight increase in the inflammatory markers²². On the other hand, a tapering approach (decreasing training duration while maintaining training intensity¹³) brought positive results with improvements of muscle power and strength in young soccer players²³. Nevertheless, this decrease in training duration could still impact the total training load and thus potentially the training stimuli, which may result in detraining and negatively impacting performance¹³.

A recent study that examined the effects of RF 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 players⁷. This study is of particular relevance as it has monitored the players' training load prior to Ramadan, showing a clear and significant decrease in training load during the Ramadan month²⁵, and hence a possible decrease in overall physical stimuli. Thus, one cannot exclude the potential detraining effect that could explain the totality or at least part of the decrease in the players' match performance played in the RF state reported by that study. Indeed, Aloui et al.⁹ showed a clear negative effect of RF 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, i.e. at night after Iftar [L3, R-GDG].

On the other hand, most studies have been conducted among amateur players, without considering their training state and without investigating whether the reduction in performance could be related to training session modifications during RF. Indeed, when RF is observed in the summer, the test sessions before Ramadan were performed at the end of the sports season (e.g. May or June); however, during Ramadan, the test sessions were performed after a period of training (e.g. July or August). Studies conducted in physically active men (who maintain their training routines) did not report, indeed, any significant RF effects. In summary, the effects of Ramadan on athletes' training and performances during competitions, has given conflicting results, depending on a multitude of variables (Ramadan time of the year, daily fasting duration, environmental conditions, athletes level, training features, amongst others).

2.3.2.1 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, i.e. a technical and/or tactical-emphasis session, [L3, R-GDG]. The coach can use this session to educate, relax and prepare athletes for the second physically demanding evening training session, post-Iftar²⁰ [L3, R-GDG].

2.3.2.2 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 fasting state^{23,24} [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 RF state compared to exercising during the non-fasting state^{25,26}.

Throughout the month of Ramadan, there should be some form of periodization of the four weeks of training sessions. On the one hand, one cannot have zero high-intensity training sessions in the Ramadan month, which will 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 being of high-intensity throughout the Ramadan month [L3, R-GDG]. In fact, high intensity training is not ideal during 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 and progressively increase in intensity as one proceeds into the Ramadan month [L3, R-GDG].

2.3.2.3 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 late during the training session and possibly increase the risk of musculoskeletal injuries.

2.3.3 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 mass²⁷.

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 2.3.9. 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].

2.3.4 Training Environment

Unfavorable environmental conditions such as high humidity and/or heat represent an additional challenge for the RF athlete, imposing an additional burden of physiological stress resulting in 14 increased body temperature and significant sweat loss. Thus, the training environment during the day (the RF 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 performances²⁸.

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. On the other hand, a major limitation for these athletes would be the forced shift or perturbation of the sleep-wake cycle, which is crucial for recovery and training 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. Likewise, late prayers (Taraweeh) could shift the normal sleep of the athlete.

Conversely, in non-Muslim majority countries, it is difficult to enjoy fasting and adapting to nonappropriate feeding and sleeping times can be really challenging for the fasting athletes living in such countries²⁰. 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 2.3.8) [L3, R-GDG]. The coach and team are not the sole parties responsible to adapt to the needs of a RF 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 assume their responsibility to modulate the challenges of their RF environment. In case an athlete is fasting while being part of an environment where the training and competition schedule is not adapted to Ramadan, they should take their decision on the best way to cope with the challenges according to the advices given in next sections (2.3.5 to 2.3.10). In any case, it is the responsibility of the athletes to adapt to the situation and implement the necessary life habits' changes to optimize their coping strategies to the situation.

2.3.5 Nutrition

Ensuring an adequate overall nutritional level is fundamental during the month of Ramadan²⁹. 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 preserved³¹, 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 day³⁰ [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 sessions³¹. 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].

2.3.6 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 excretion³² [L3, R-GDG]. Maximal and/or optimal hydration status should be targeted by Sahur time. When the fasting duration is especially long (e.g. > 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.³³ 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 (i.e. avoidance of hypohydration) in athletes during RF (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 (WHO) recommendations). Then Muslim athletes who are planning to fast and exercise should surely have to consume more than the average nonexercising individuals because of their sweat loss during the exercise in the day (and/or at night) [L3, R-GDG].

2.3.7 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 conflicting³⁴⁻³⁶. Indeed, if mouth-rinsing has led to performance enhancement during exercise of prolonged duration³⁵, it did not show any similar positive effects during all-out repeated sprints performed after three days of RF in trained adults³⁷. Of religious interest is to note that RF 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 allout 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.

2.3.8 Sleep

Regardless of Ramadan, sleep is an important pre-requisite for optimal sport performance and recovery and plays a vital role in exercise's 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 RF [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, RF 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^{18,39}. 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 stimuli⁴⁰.

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 nonpharmaceutical 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 performance⁴¹. 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].

2.3.9 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 fatigue¹³. Interestingly, after only three days of fasting, similar to Ramadan fasting, an individual's simple and multiple-choice reaction time will be negatively impacted⁴². The latter study investigated cognitive functions under valid ecological conditions (i.e. with the participants performing the cognitive assessment in-between exercise sprint efforts). Other study designs with such evaluations performed separately [assessing the cognitive function after exercise (i.e. in a resting state) have shown no effect]. Thus, the findings of the Cherif et al.⁴² study suggest that decision-making behaviors during exercise/competitions conditions may be adversely affected in RF. In that regard, it is important to consider the ecological validity of the study designs to inform real world actors (athletes and coaches). From a psychological prospective, Farooq et al.⁴³, have shown that elite footballers had strong negative beliefs and attitudes toward RF regarding their exercise and mental performance capacity. This could be due to the potential nocebo effect of observing RF during exercise, as previously suggested by Aziz et al.^{44,45}. Indeed, the latter researches show that the comparison between the non-fasting condition and exercising in the RF condition led to a rather surprisingly low physical performance very early during exercise, and strongly suggested that this early observation of "fatigue" in the RF state was potentially due to a nocebo effect (negative belief that RF 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 RF athletes^{44,45}.

The social support network around the athlete as well as the strength of the athlete's spiritual beliefs and the so-called "religious intelligence", could be moderating variables in coping with stressors experienced during RF. Mental preparation courses could be attended by Muslim athletes' prior to the commencing of RF, in order to learn proactive coping skills^{3,18,46}. 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 Ramadan²⁰ [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, i.e., individuals having fasted for multiple Ramadan-months in their lives, have better coping strategies than beginners⁴⁷. 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 periods⁴⁸⁻⁵⁰.

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 RF⁵¹ [L3, R-GDG]. There are other promising strategies, such as listening to Holy Qur'an⁵² [L3, R-GDG], but despite its potential effect on fasting believers, no study has been conducted yet.

2.3.10 Ramadan, Weight Categories' Sports, and Injury Risk

For weight categories sports athletes, fasting during Ramadan is a challenge⁵³. 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 RF could result in extreme challenges [L3, R-GDG]. In addition, Ramadan is accompanied with biological alterations showing an increase in markers of muscle injury⁵⁴. This could explain the slight but significant increase in overuse injuries observed in Tunisian football players during Ramadan⁵⁵. Nevertheless, Chamari et al.⁵⁵ 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 league⁵⁶. However, in the mentioned studies, training and matches were played during the afternoons and evenings in the study of Chamari et al.⁵⁵, with a marked difference of conditions in the study of Eirale et al.⁵⁶ they were all held at night. Despite the controversial results, and no strong evidence for the effects of RF on injuries in athletes, emphasis should be placed on implementing injury prevention strategies during Ramadan. The advice for coaches and fasting 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 RF state [L3, R-GDG].

2.4 For General Community

2.4.1 Healthy Population

For healthy untrained individuals from the community who are not exempted (e.g. 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 WHO recommendations⁵⁷ [L3, R-GDG].

2.4.2 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].

The present guidelines are for healthy individuals. Patients with chronic disease should decide on safe exercise during Ramadan in consultation with their physician [L1, RGA2].

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