THE NUTRITION X-CHANGE

7 RAMADAN & SPORTS PERFORMANCE

A DETAILED LOOK INTO THE EFFECT OF RAMADAN FASTING ON ATHLETIC PERFORMANCE AND HOW MUSLIM ATHLETES CAN MINIMISE PHYSIOLOGICAL IMPACT

BY MOHAMED SAAD, ANDREAS M. KASPER & GRAEME L. CLOSE

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Practical Implications

- Ramadan is a period of fasting within the Muslim faith which occurs during the ninth month of the Islamic calendar. During this time 2 main meals per day are consumed, one prior to sunrise known as the Suhoor and one to break the fast after sunset known as the Iftar. Between these 2 meals no foods or liquids can be consumed even if the athletes are involved in strenuous exercise or competitive elite sport.

- The literature base is somewhat complicated given that 'Ramadan fasting' and 'intermittent fasting' are often discussed interchangeably although the 2 are quite different.

- The literature suggests that there may actually be some health advantages during Ramadan, and providing that nutrition support is provided, an athletic body composition can be maintained. However, some aspects of performance, particularly repeated high-intensity efforts could be impaired, especially if careful consideration is not given to the feeding strategies.

- It is important to remember that Ramadan fasting does not always result in caloric deficits and there are suggestion of unwanted gains in body fat due to an abundance of energy dense food and drinks, despite the majority of calories being consumed in 2 meals.

- From a sport nutrition perspective, the key considerations include maintaining energy balance, consumption of an athletic specific quantity and distribution of macronutrients and maintaining euhydration (or at least preventing severe hypohydration).

- Specific competition strategies may help such as mouth rinsing of cold water, carbohydrate, caffeine and menthol although this requires consultation with the sport nutritionist alongside guidance from religious authorities.

- Through the application of fundamental sport nutrition knowledge, and considering the Total, Type and Timing of nutrition intake it is possible to minimize the performance decrements that may be associated with fasting and achieve the approximate sport specific nutrition requirements of elite athletes during training and competition.

Background

Ramadan is a period of fasting within the Muslim faith, known as sawn, and is one of the five core pillars of the religion. The month of Ramadan, where it is said that 'the reward for good deeds are multiplied', remembers the time where the holy Qur'an was revealed to the prophet Mohammed. During this period, Muslims not only abstain from food and drinks on a daily basis (from dawn to sunset), but also refrain from smoking and sexual practices. This religious period occurs during the ninth month of the Islamic calendar, a calendar consisting of 12 lunar months, therefore changing within the Gregorian ('New Style') calendar each year. For example, in the year 2000 in the UK, Ramadan occurred during the winter compared with this year where Ramadan is based in the spring. Given that the fast lasts from dawn to dusk, dependent upon the geographical location, fasting can last between 10-21+ hours per day (Figure 1). The first meal after sunset is called the Iftar and is the breaking of the daily fast, whilst the final meal prior to beginning the daily fast is called the Suhoor and is consumed directly prior to sunrise (Figure 1). It is common during this month that practicing Muslims also sleep less and have a poorer quality of sleep due to staying awake longer, as they eat later and family gatherings

usually occur late at night. It is unsurprising that athletes following Ramadan may fluctuate in total mass and body composition during this time as not only is sleep compromised, but foods consumed are often deep fried and contain high sugar content, something not conducive to an athletic physique or physical performance.

roughly 3 hours post-Iftar. Although not permitted by Islamic law ('Fatwa') unless athletes are travelling to compete (there are specific exceptions to fasting for travel), some athletes may choose to break the fast during periods of competition and make this up away from competition such as in the days following Ramadan. During the London 2012 Olympic games

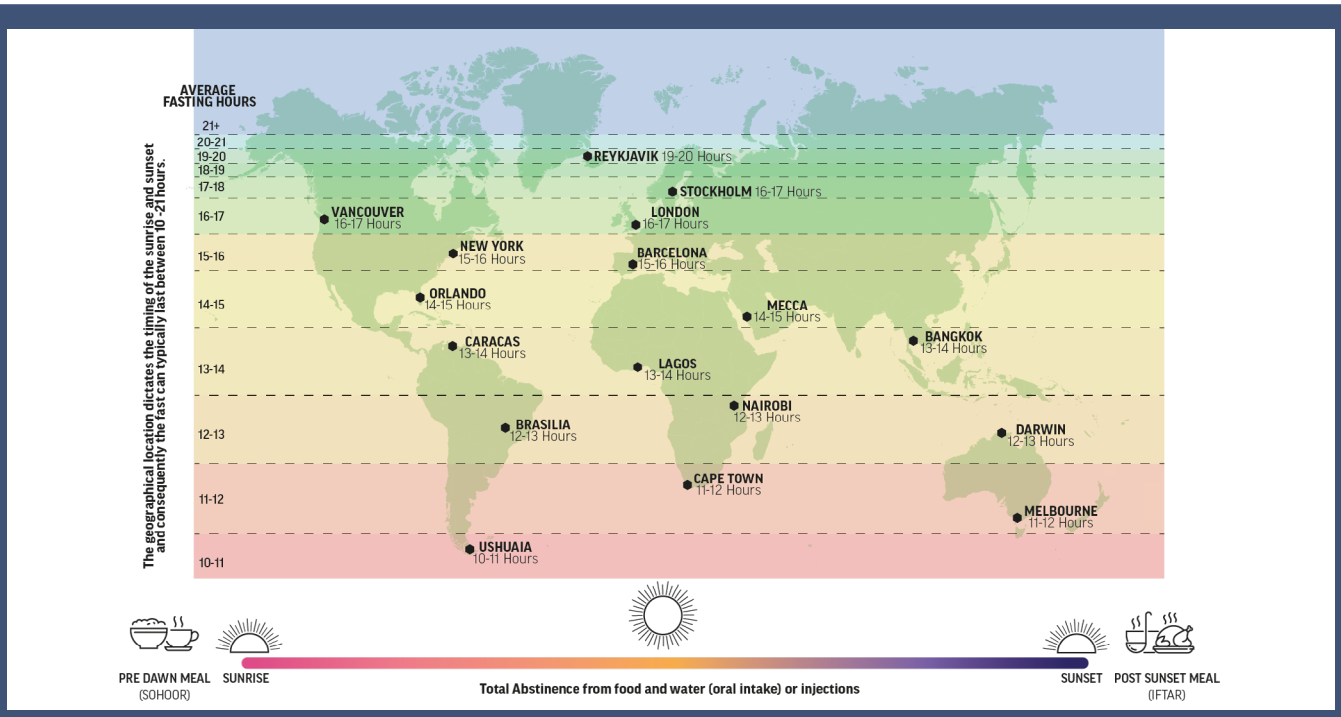

Figure 1. Illustration how the geographical location dictates the length of the fast during Ramadan due to the differing time of sunrise and sunset. Note that Melbourne, for example, would require a 11-12 hour fast compared with London which may require a 16-17 hour fast hence some athletes choosing to switch training bases during this time.

Approximately 26% of the world's population identify as Muslim accounting for 1.9 billion people across the globe. Whilst 20% of the worlds Muslims live in the Middle East and North Africa, there are more than 50 countries that are considered to be Muslim majority. Many Muslim athletes will continue to train and compete as normal during Ramadan given that the international sporting calendar does not take this into consideration (Maughan et al., 2010). For example, the London 2012 Olympic games occurred during Ramadan, as did the 2014 FIFA world cup in Brazil, whilst in most years, the English Football League Seasons includes Ramadan. Although it is uncommon in the UK to see sports teams alter their training schedules to facilitate Ramadan, some individual athletes will change the timing of their training schedule around the feeding opportunities, and some even move their training base to other countries such as Australia (shorter fasting period, see Figure 1) to help facilitate their training and recovery. In some countries such as Bahrain, although competition still occurs, events may take place

it was widely reported that the British Rower Mohamed Sbihi, after consultations with Muslim scholars in Morocco, chose to donate 60 meals to the homeless for every day of fasting he missed. Where athletes do fast during Ramadan, evidence suggests that providing they can restructure their nutrition to accommodate the specific training schedule, it is unlikely that they will suffer significant decrements to performance and an athletic body composition can be maintained. This nutrition x-change will look at the effects of Ramadan on health, performance and competition and explore the specific nutrition and hydration support required during this special period.

Effects of fasting on general health and body mass

It is somewhat difficult to interpret the literature on fasting and health in the context of Ramadan given that Ramadan fasting and intermittent fasting are often used interchangeably. Although these two fasts are similar in that there are prolonged periods with no caloric intake, there are many major differences

which make comparisons unwise including, but not limited to the training status of the participants, the specific foods consumed, the addition of a lack of sleep during Ramadan and the fact that often in Ramadan there is not a daily calorie deficit due to the high energy content of the main meals. It is also crucial to acknowledge the spiritual and emotional aspect of Ramadan and the effects this may have on the overall health of the athlete.

It is becoming increasingly documented that there may be health benefits to periods of intermittently fasting (reviewed further in Horne et al., 2015 and Jane et al., 2015), usually lasting between 8-12 hours. These fasting periods can result in an overall caloric restriction with the benefits even correlating with an increased life expectancy (Wilcox et al., 2014). The health benefits of intermittent fasting have been associated with positive changes in hormonal responses, oxidative stress and inflammation (Desgorces et al., 2016; Mattson et al., 2017; Michelsen et al., 2013). In addition, cancer studies have demonstrated a potential beneficial effect of fasting on malignant cell growth through alterations in growth factors and metabolite level creating environments where there a reduction in the capability of cancer cells to adapt and survive (Nencioni et al., 2018). Specifically to Ramadan, Mindikoglu et al., (2020) reported that Ramadan fasting for >14 hrs for 30 consecutive days resulted in an upregulation of key proteins involved in metabolism, immune function, and debilitating disease, in the absence of any total caloric restriction, suggesting that the benefits of fasting may be present regardless of energy balance, however further research is required before drawing any definitive conclusions. Overall, the balance of evidence suggests that from a general health perspective, there are no major health issues with following Ramadan and there may even be health advantages.

The literature on the effects of body composition in athletes during Ramadan is particularly limited with a recent meta-analysis only finding 12 research studies totaling 183 athletes meeting the inclusion criteria (Aloui et al., 2019). It is important to remember that although caloric restriction and fasting have both independently been evidenced to positively influence body composition and weight (Correia et al., 2021), during Ramadan, although there are periods of caloric restriction (between the Suhoor and Iftar), this does not necessarily equate to an overall daily negative energy balance, often dictated by social and cultural factors. It is therefore important to distinguish studies on intermittent fasting for weight loss from studies on body mass during Ramadan. Research on body composition during Ramadan have actually shown that body fat may decrease, maintain or even increase dependent upon the actual diet consumed during this time (Haouari et al., 2008; Kul et al., 2014; Sadeghirad et al., 2014). In the meta-analysis by Aloui et al., (2019) it was concluded that body fat percentage was generally lower during Ramadan. There was, however, no meaningful change in lean body mass although this was only assessed in 5 studies and therefore it could be suggested that this needs to be explored in more detail in future studies. Interestingly, 2 studies assessed total body water, which was unchanged during Ramadan. In another meta-analysis, focused upon youth athletes <19 years of age, Trabelsi et al., (2020) reported that dietary intake including total energy intake, carbohydrate, protein and water remained essentially unchanged compared with the athlete's habitual diet, and consequently there were no changes in body fat or lean body mass. Taken together, in terms of body composition, the balance of evidence suggests that athletes during Ramadan are able to maintain lean mass, and in some situations, can actually use this time to reduce body fat percentage, provided they are offered the correct dietary and training advice and support.

Sleep considerations

In Ramadan, many Muslims choose to change their sleep routine, with an extra mid-day nap occurring during the afternoon prior to awakening for Iftar in an attempt to compensate for a shortened nighttime sleep. Following this mid-day nap, it is common that they will then remain awake until the early hours of the morning, with many not sleeping until after the morning Suhoor, (especially if the Suhoor occurs in the early hours of the morning) and then napping throughout the day. In a systematic review and meta-analysis that reviewed the association between Ramadan and sleep, in 245 athletes from 13 separate studies, there was an overall decrease in the Total Sleep Time (TST) during Ramadan, with sleep quality also deteriorating especially towards the end of Ramadan (Trabelsi, 2019). However, as with much of the other literature on Ramadan, study number is relatively low and it is therefore difficult to draw definitive conclusions, except that during

Ramadan sleep quantity and quality may be reduced. The authors have observed in their individual practice a number of athletes reporting poor sleep and awakening and encourage athletes to prioritise and promote sleep prior to midnight (post-Iftar) and awaken for Suhoor, with regular napping throughout the day. Either way, athlete support personnel should appreciate that their athletes may be sleep compromised and take this into consideration when designing and running training sessions.

Effects of Ramadan fasting on performance and competition

Given the fundamental role that pre-, during and post- nutrition plays in athletic performance, it would appear logical that prolonged periods of fasting would have major detrimental effects on both training and competitive performance. However, research tends to suggest that performance can largely be maintained during Ramadan, via careful consideration of the training loads, time of training and nutrition in the permitted non-fasting periods. It is crucial that training loads are carefully managed, given that there are suggestions of increased overuse injuries in soccer players during both fasting athletes during and non-fasting athletes following Ramadan (Chamari et al., 2012). In terms of actual performance, research has indicated that if there is a small performance impairment, this tends to be focused on the initial days of Ramadan with this subsiding by the end of the month. One potential strategy may therefore be for athletes to consider beginning to gradually adapt their sleeping and dietary habits prior to commencing Ramadan, especially if there is an important performance in the first few days of fasting. In a recent systematic review and meta-analysis by Abaïdia et al., (2020), mean and peak power during both bike based (Wingate) and running based (repeated sprint test) exercise were decreased during Ramadan fasting, especially when exercise was performed in the afternoon. It could therefore be argued that such activities may best be performed shortly after the Iftar to attenuate these small losses in peak power. In the same systematic review, other markers of performance (strength, jump height, fatigue index and total work) were not significantly affected by Ramadan fasting, with trivial to small effects reported. It must, however, be stated that small effects may still be meaningful, especially when it comes to competition, and therefore although training may not be noticeably different, there are potential for small impairments in maximum competitive performance. These data presented in the meta-analysis of Abaïdia et al., (2020) are however equivocal, with another systematic review (Correia et al., 2020) reporting that aerobic capacity was reduced during Ramadan fasting. Unfortunately, despite meta-analyses, the extant data on performance during Ramadan is limited and therefore should be, at best, described as equivocal. It is likely that the discrepancies in the findings are due to the varied methodologies and differences in the way individuals observe Ramadan, including their Geographical location. It is also unclear in most of the literature if diet is controlled sufficiently with qualified support from a sport nutritionist, with limited details provided on the carbohydrate intakes in the habitual diet in the non-fasting periods. In addition, the participants are varied (a wide range of physical characteristics) and it is unclear if the athletes are in energy balance, surplus or deficiency. Nevertheless, in certain situations, performance may be negatively affected by fasting and/or low energy availability, and therefore it is crucial that athletes following Ramadan receive individual diet coaching as well as comprehension from their physical coaches of the logistics of this period allowing training to be managed and adapted appropriately. One simple adaption to training could be to move the more extensive and intensive training sessions to around the Iftar to allow these to be fueled correctly with training during the day reserved for technical or tactical lower intensity efforts (Figure 2).

Nutrition considerations during Ramadan

It has been suggested that perhaps there has been too much focus on establishing if there are performance consequences of Ramadan at the expense of research into the best ways to optimize performance during this time (Chaouachi et al., 2012). As an example, it is well known that exercise in extreme environmental conditions can have negative consequences (Girard et al., 2015), but rather than state 'do not do exercise in the heat', research has established the ideal practices to attenuate any potential disturbances to training and performance. Unfortunately, to date, there are limited research studies on high performing athletes during Ramadan, and therefore

much of the sport nutrition advice comes from applied experience combined with extrapolation of fundamental sport nutrition research and studies on intermittent fasting. In terms of sports nutrition, it is important to consider the 3 Ts, these being the Total, Type and Timing of nutrition intake. It is clear that all 3 of the Ts can have profound effects on adaptations to athletic training / performance and in terms of Ramadan, whilst Total and Type can easily be managed, perhaps it is the Timing that needs extra consideration.

Total amount of energy and Type of macro nutrient intake

Research suggests that athletes are able to maintain energy balance during Ramadan, and at times can even over consume due to an abundance of high energy foods being available, particularly at the Iftar (Shephard, 2012). Therefore, from an energy availability perspective, and a desire to maintain sufficient calorie intake to preserve total body mass with careful planning of the total training load, combined with specialist nutrition advice around the Suhoor and Iftar, total energy intake should not be a problem.

The specific macronutrient intake, however, may require more careful consideration. For example, if athletes are trying to maintain a high training load, or if Ramadan falls during a competition schedule, it may be desirable for athletes to consume 6-10g per kg body mass of carbohydrate (Burke et al., 2011). This would normally be achieved spread throughout a 14 hour feeding window, however, during Ramadan this will need to be achieved predominantly during the Iftar with some contribution during the Suhoor. There may be benefits from the deliberate switch to some high GI and low residue carbohydrate sources to help with gastro-intestinal discomfort (de Oliveira et al., 2914; Pfeiffer et al., 2012) as well as liquid carbohydrates if energy demands are very high to achieve the total requirements. Either way, it is crucial that nutritionists make some attempt to quantify the total carbohydrate intake at this time to ensure muscle and liver glycogen stores are fully loaded prior to exercise, something that is especially important given the inability to utilize exogenous carbohydrate during exercise itself (providing the performance is not taking place after sunset).

Many athletes strive to achieve ~1.6 g per kg body mass per day of dietary protein to maximize muscle protein synthesis and promote muscle growth and repair (Witard et al., 2019). For smaller endurance athletes weighing approximately 50kg this would be easily achieve in the 2 main meals, however, this may present a challenge for larger athletes such as rugby players who may be greater than 110 kg (Morehen et al., 2015). Specific consideration should be given to larger athletes when it comes to total protein intake and the careful use of batch-tested protein shakes may be a strategy worth exploring, including slow releasing casein shakes which could provide a slower but more sustained supply of amino acids throughout the fasting period (Tang et al., 2009). However, of more concern when it comes to dietary protein intake could be the timing which will be covered in the next section.

Timing of energy macro-nutrient intake

The timing of nutrition intake has received considerable attention over the last decade becoming a cornerstone of fundamental sport nutrition (Kerksick et al., 2017). For example, it is now well established that there is a maximum anabolic to protein intake in a meal and therefore rather than prescribing 1.6g/kg per day of protein, it may be wiser to suggest 4 x 0.4g/kg protein feeds spread evenly throughout the day (Areta et al., 2013). Similarly, whilst carbohydrate intake is usually prescribed again on a daily g/kg basis there is solid evidence that when it comes to muscle glycogen resynthesis there is an increased ability to restore glycogen when carbohydrate is fed in the first hour after exercise (Ivy et al., 1985). Indeed, we demonstrated in rugby players that simply delaying the carbohydrate re-feed following a simulated game by as little as one hour affected the muscle glycogen concentrations 48 hours later (Bradley et al., 2017). This therefore presents a major challenge to the sport nutritionist, and indeed the athletes themselves during Ramadan.

One potential solution to this challenge can be addressed through careful consideration of the training schedule. It would appear logical that during the day training should be reserved for technical and tactical aspects of sports performance with the higher intensity efforts and gym based resistance training

performed closer to or even following the Iftar to allow appropriate sport nutrition to be consumed. Indeed, when it comes to protein and resistance training, whilst a handful of studies show some benefits of protein pre resistance training (Tipton et al., 2007), it is unquestionable that post resistance training protein feeding results in the most favorable anabolic environment for muscle growth and repair (Moore, 2019; Phillips, 2014). A theoretical feeding and training structure can be seen in Figure 2 which allows protein to be distributed throughout the day including immediately post training (achieving 4 x 0.4g/kg), carbohydrates to be provided before and after 'high intensity' sessions (achieving 6-8g/kg), and slow releasing proteins pre-bed and pre-fast to give a more sustained supply of amino acids to facilitate recovery. This structure would of course need fine tuning in collaboration with the athlete and all of the individuals involved in supporting the athletes training needs. The nutritionist should also be aware of cultural food choices that can be utilized to aid the athlete, for example, dates are a low GI carbohydrate source popular during Ramadan which may be especially useful for helping to achieve daily carbohydrate targets.

Performance specific nutritional considerations

Whilst training can be adapted to minimize the potential disruption of a prolonged fast, competition schedules are normally fixed and do not offer the same degree of flexibility. It is therefore essential that strategies are taken to minimize the disturbances and potential solutions are developed. Given that exogenous carbohydrates cannot be consumed it is crucial that muscle and liver glycogen are fully loaded. Research suggests that this requires 6-12 g/kg in the days leading up to the event (Mata et al., 2019). As highlighted above, this is entirely possible, although it would require careful planning and dietary approaches. It will also be crucial to ensure that athletes are fully hydrated prior to competition given that fluids cannot be consumed during the day. This could involve urine osmolality being checked prior to sunrise with appropriate rehydration strategies implemented should the athlete present even marginally dehydrated (Maughan, 2003).

There are numerous supplements that have been proven to assist performance including creatine (Tarnopolsky, 2010), beta alanine (Hobson et al., 2012) and dietary nitrates (Jones et al., 2018). Fortunately, all of these supplements need to be loaded for maximum benefit and as such can be taken daily

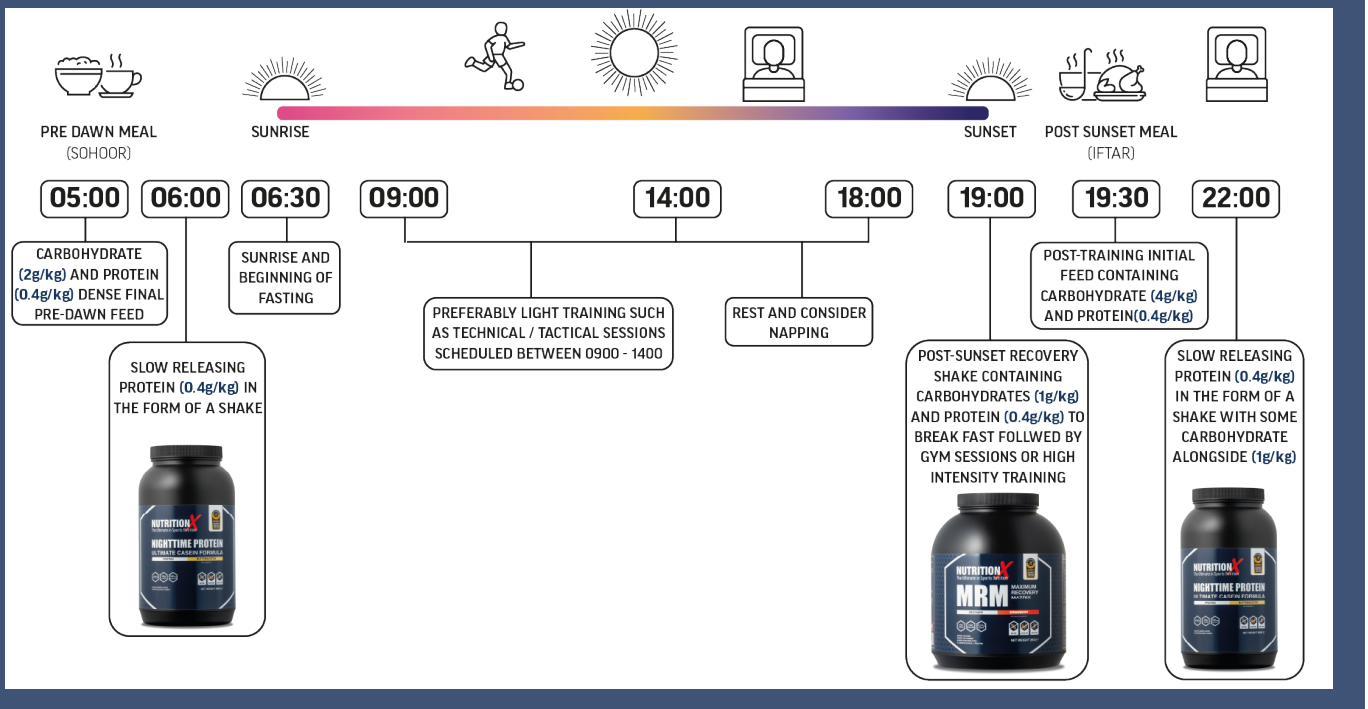

Figure 2. Proposed timeline of training and nutrition intake for an athlete during Ramadan allowing them to achieve their sport specific nutrition needs taking into account the 3 Ts of nutrition, Timing, Type and Total.

prior to sunrise or after sunset. It would be wise for athletes following Ramadan to continue on such supplement strategies which may require their clubs to provide them with these to be taken at home as opposed to the common practice of supplements being consumed at the training ground. Whilst exogenous carbohydrate in the form of drinks and gels (Newell et al., 2018), and supplemental caffeine (Tarnopolsky, 2010) are 2 proven ergogenic aids, these need to be taken around exercise for maximum benefit which of course is not possible if competition is during sunlight hours. However, there is emerging research on the sensory effects of both of these products with suggestions that they may enhance performance without the need for ingestion simply through mouth rinsing (Kasper et al., 2016). Indeed, this has proven advantageous in Ramadan fasting situations (Pak et al., 2020). If competition is scheduled in hot climates it may also be useful to consider a menthol mouth wash which has again been shown to be beneficial without the need for ingestion (Flood et al., 2017; Stevens et al., 2016). However, it should be stressed that all of these mouth rinse strategies may require specific advice for the athletes from Muslim scholars to ensure this is line with religious law.

Hydration considerations

Long hours of fasting can result in the loss of total body water content. It has been suggested that 12 hours of fasting for a non-active adult will result in a loss of 800 ml of body water, which for a 70 kg adult would equate to an approximate loss of 1% of body weight. Whilst this small drop in body mass is unlikely to decrease sports performance (Maughan, 2012), athletes may have increased thermoregulatory demands through exercise, especially if they are training in warm climates, that may result in performance impairments through dehydration. Most countries around the world fast for more than 12 hours (see Figure 1) and given that Ramadan can fall during the summer months, a time when the temperature and humidity are high, dehydration may be a particular problem during and after exercise. Whilst it is unlikely that mild dehydration associated with Ramadan will negatively effect short term exercise, i.e. under one hour, (Maughan, 2012) this may not be the case during longer duration events especially if these events take place in high ambient conditions. It therefore seems logical that athletes during Ramadan should make increased efforts to ensure that exercise is commenced euhydrated and that rehydration occurs as soon as it is feasibly possible. It is important to note that this is really only a problem when exercise is performed prior to the Iftar meal since when exercise is after the Iftar the athlete will have the opportunity to consume fluids before and during the actual event. It may also be an option to utilize cold mouth washes during exercise to help prevent feelings of thirst, however, this again will require discussion with religious authorities.

There is no reason why even the most substantial fluid losses cannot be corrected daily and as such progressive fluid deficits should not occur over the month. When it comes to rehydration, it is important to remember that rehydration should not only be focused upon restoration of fluids but also must consider the specific electrolytes that will be lost especially sodium given that sweat sodium concentration may vary between 10-80 mmol/L. This may involve the addition of electrolytes to fluids especially if athletes have performed prolonged exercise in the heat prior to the Iftar meal. Drinking sufficient fluids from Iftar until Suhoor is crucial, while taking into consideration the need for additional electrolytes. It would be advisable to choose drinks that score favorably on the beverage hydration index (Maughan 2016) to help with fluid retention. It should also be noted that it would be unwise to attempt to hyperhydrate by drinking copious amounts of water at the Suhoor meal as this can lead to prompt diuresis and ultimately could contribute to further dehydration. Since 2018, Glycerol supplementation is no longer prohibited by WADA and therefore it may be an option to consider adding 1g/kg body mass of glycerol to increase plasma and tissue osmolality thus attenuating diuresis and assisting with hyperhydration (McCubbin et al., 2020), however, this strategy requires careful planning with a sport nutritionist and practicing prior to the event. Ultimately, with carefully planned hydration and rehydration strategies, and appropriately timed exercise, many of the potential adverse effects of dehydration can be avoided during Ramadan, perhaps with the exception of prolonged exercise during the day especially in warm ambient conditions.

Table 1. Five common nutritional mistakes made during Ramadan and suggested strategies

Mistake	Rationale	Solution
Drinking inconsistent amounts of fluid between Iftar and Suhoor, followed by a large amount of fluid before dawn (Suhoor time).	The body may not be able to efficiently store the water consumed and may even increase urine output in the acute period following.	Best practice may be to consume 2000-3000 ml, non excessively, over the non-fasting periods (Iftar and Suhoor meal times) and ensure that any loss of body mass has been corrected. Also, in the Suhoor it may be possible to add 1g/kg glycerol, to increase plasma and tissue osmolality and reduce the diuresis.
Eating salty food during the Suhoor meal.	Sodium may be beneficial for fluid retention, however consuming excess amounts of salt prior to dawn may result in increased thirst sensation throughout the day.	Try to choose non processed foods that may be high in sodium and consider adding less table salt to meals.
Drinking high energy calories on light training days.	Excess caloric intake, including through fluids such as carbohydrate dense fruit juices, may lead to weight gain and accumulation of fat mass during this month.	Consider the training demands of the day and if high carbohydrate intakes are not required focus on water as the main fluid option.
Eating excessive food during the Iftar meal.	Consuming large amounts of food during the first meal after long periods of fasting can lead to indigestion and may effect sleep.	Consider consuming smaller easily digestible meals as this may help.
Missing the Suhoor	Missing Suhoor meal may lead to lower energy and increased hunger the next day.	Having Suhoor containing slow digestion macronutrients will lead to better energy levels the next day, and more controlled hunger. A slow release casein shake may also help.

Practitioner observations

As a nutritionist working in Bahrain and throughout the UAE with predominantly Muslim athletes, it has been necessary to develop strategies to assist athletes during Ramadan given that many of the practical considerations cannot be found in journal articles and textbooks. Table 1 summarizes 5 of the most common nutritional mistakes observed by the lead author that have been made by athletes during Ramadan along with the potential solution.

Conclusion

Ramadan is a religious period of fasting within the Muslim faith which lasts for a lunar month of the Islamic calendar. During this period there are 2 main meals consumed, the Iftar or breaking of the fast after sunset, and the Suhoor or final meal before sunrise. Despite this practice being observed by the entirety of the Muslim faith, including athletes, the current available evidence related to sports performance is complex and equivocal at best, with studies often performed on untrained individuals and inclusion of general fasting regimes without

any reporting of energy intake or dietary control. Whilst meta-analyses often find 'trivial' / 'negligible' results of Ramadan fasting on strength and fitness outcomes, it must be considered that within highly trained populations, 'trivial' / 'negligible' changes may be the difference between winning and losing performance and therefore specific advice must be provided to athletes during Ramadan to help to optimize their nutritional strategies. In addition, the majority of the literature has tended to focus upon the potential detrimental effects of Ramadan fasting and future studies must now focus upon the best nutritional strategies to assist athletes in overcoming the potential barriers to performance. From a sport nutrition perspective, the key considerations include maintenance of euhydration (or at least prevention of severe hypohydration) and the application of fundamental sport nutrition knowledge; this includes the Total, Type and Timing of nutrient intake to maintain energy balance, consuming an athletic specific quantity and distribution of macronutrients to support training and adaption taking into consideration the specific circumstances of the individual athlete.

Author bios

Mohamed Saad

is acknowledged as one of the leading sports nutritionists in the Middle East holding a master's degree in sports and exercise nutrition from Middlesex university in London, United Kingdom. He is working with wide range of Olympic, professional and amateur athletes in different sports from different countries around the world to improve their performance and enhance their body composition. He has accomplished many gold medals and world champions titles with his athletes globally. Mohamed has worked as the head nutritionist for Bahrain triathlon national team, Bahrain football national team, and currently working as the head nutritionist for Bahrain Mixed Martial Arts national team (ranked as number one MMA national team in the world). Mohamed has been recognized as an expert in weight cutting in weight categories sports, as he has been appointed by His Highness Shaikh Khaled bin Hamad Alkhalifa as the nutritionist and weight-cut specialist for his globally renown team "KHK MMA" since 2016.

Andreas Kasper

has worked at the highest level of elite professional sport since 2014 and is currently a performance nutritionist working within the Premier League. He has previously worked with a number of Championship Football Clubs with extensive experience of working within different performance teams and with international players. Alongside the roles within football, Andreas' team sport expertise extends to rugby, where he has worked with both the national England Rugby Union (RFU) and League (RFL) sides with pathway and senior sides, respectively. Andreas is currently completing his PhD in Cellular and Molecular Physiology at Liverpool John Moores University.

Professor Graeme Close PhD, rSEN, fBASES, fECSS

Graeme is a professor of Human Physiology at Liverpool John Moores University where he combines his academic research (>125 research papers to date) with nutrition and physiology consultancy to some of the world's leading sporting organizations. He is currently the expert nutrition consultant to England Rugby, the Head of Performance Nutrition to The European Tour Golf and European Ryder Cup Team and consults to several Premier League Football clubs and players. Graeme is currently the Deputy Chair of the Sport and Exercise Nutrition Register (SENr) and is a fellow of both The European College of Sport Science and The British Association Of Sport and Exercise Sciences. Graeme is a scientific advisor to nutrition X and editor in chief of the Nutrition X-change.

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