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REVIEW ARTICLE

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Chrononutrition in the context of Ramadan: Potential implications

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Abstract

Every year, healthy adult Muslims practice dawn to sunset fasting for a whole lunar month. No food or fluid is allowed for the fasting time window. After sunset, eating is allowed. The dramatic change in the timing of meals is accompanied by changes in sleeping hours and thus alterations in circadian rhythms. Hormonal mechanisms mainly determined by the latter also change. These include shifts in cortisol and melatonin. Food-dependent hormones such as Ghrelin and leptin also show changes. A well-established principle of chrononutrition is that the timing of eating may be as or more important than the content of food. Ramadan fasting (RF) is distinct from other forms of intermittent fasting, although there are also some similarities with time restricted eating (TRE). Both have been shown to have health benefits. Here, we examine existing literature to understand and learn from this very commonly practiced form of fasting and its relationships to circadian rhythms and homoeostatic mechanisms.

KEYWORDS

chrononutrition, diabetes, energy expenditure, fasting, neurohormonal regulation, Ramadan

1 | INTRODUCTION

Over the last 15 years, there has been increased recognition of how chronobiology impacts health and disease. In mammalian tissues and organs, circadian rhythmicity is driven by local oscillators, systemic factors and central circadian pacemaker light-dark cycles.[1] Clock genes are now recognised for their indisputable role in coordinating nearly all biological and physiological processes of the body,[2] including cyclical patterns of sleeping and eating and energy metabolism.[3] Studies in rodents have shown that time restricted eating has direct effects on the central nervous system and peripheral organ clocks; in rats, a breakfast skipping model was shown to lead to weight gain and alteration in circadian oscillation of the hepatic clock and lipid metabolism-related genes.[4,5] In humans, ingested calories are utilised more efficiently in the morning than in the evening and this is manifested through improved weight loss even under iso-energetic calorie intake, a clear indication of the importance of meal timings over and above the content of meals.[6] Skipping breakfast is associated with lower physical activity thermogenesis.[7]

Studies on the epidemiology of temporal eating patterns in humans, along with evidence from human intervention studies investigating morning versus evening energy intake, metabolic effects and emerging chrononutrition interventions such as intermittent fasting (IF) are increasing in number. IF has been gaining popularity over the past few years. It is practiced for health benefits and in particular for weight loss, although randomised trials show no evidence that IF is more efficacious for weight loss compared to controls.[8,9] IF comes in different forms. More common IF regimens include alternate day fasting, time restricted eating (TRE-also referred to as time restricted fasting or TRF, especially when referring to animal studies) and whole day fasting[10–12] (Figure 1).

Recent studies suggest that chrononutrition may have therapeutic applications for individuals who are either with or are at-risk of metabolic disease and thus may convey health benefits within the general population.[13] In particular, the time of eating has important effects on cardiometabolic risk.[14]

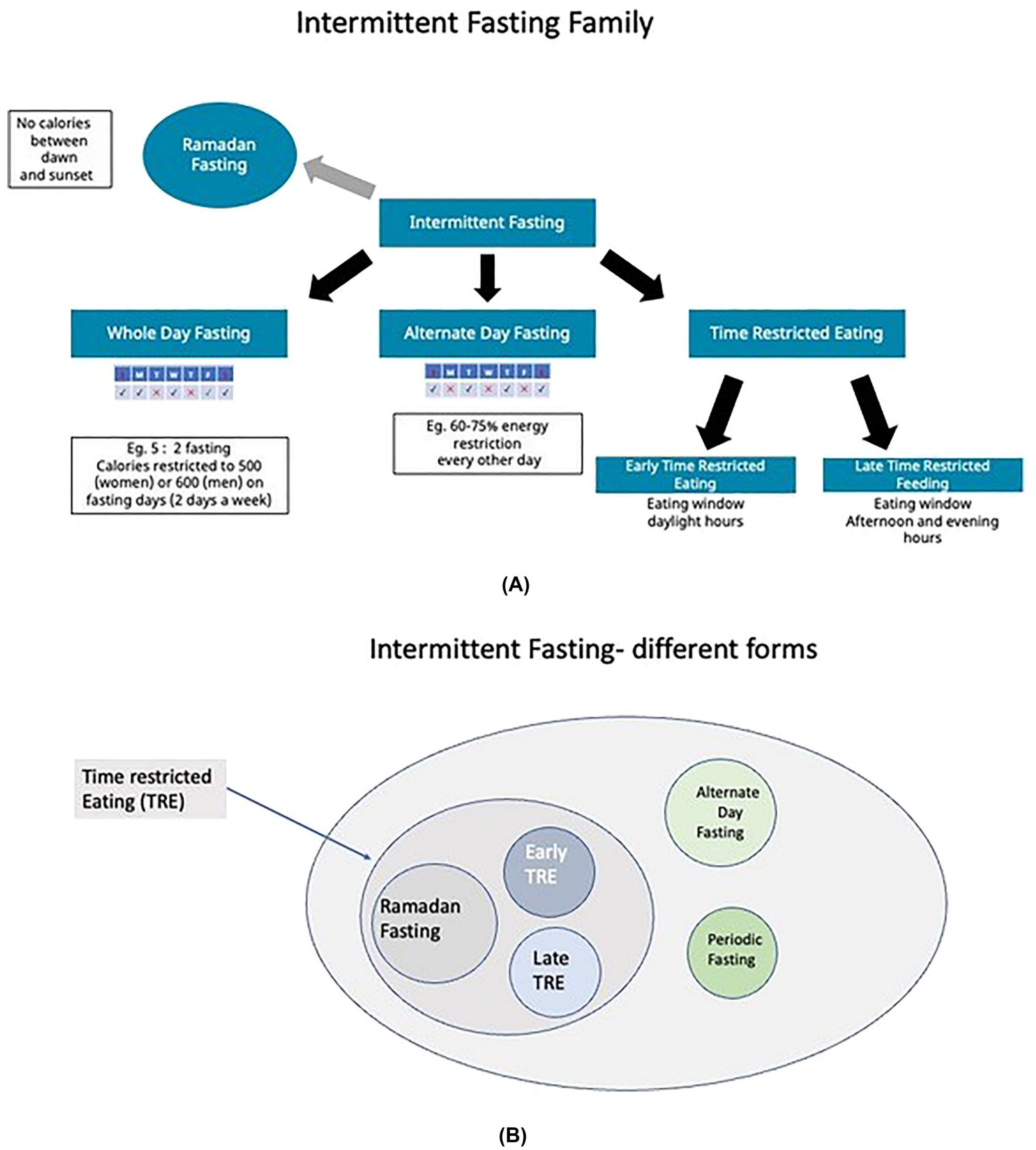

FIGURE 1 Intermittent fasting family. Fasting takes many forms; whole day, alternate day, time restricted Eating (early and late), periodic and Ramadan fasting (PANEL A); some forms last hours while other forms last days. Ramadan is being accepted as a form of intermittent fasting (PANEL B), a unique one though owing to its absolute food and drink abstinence between sunrise (*Suhoor*) and sunset (*Iftar*), daily, for 29-30 consecutive days every year.

2 | RAMADAN AS A FORM OF INTERMITTENT FASTING: WHERE DOES RAMADAN STAND?

Fasting is the willing abstinence or reduction from some or all food, drink, or both, for a period of time. This makes fasting distinct from starvation when food restriction occurs unwillingly. Globally, fasting is practiced in different settings and can take different forms including absolute fasting, dry fasting and wet fasting.

Fasting is also practiced in religious and spiritual contexts in Islam, Christianity, Judaism, Buddhism and Hinduism.[15] In particular, Ramadan fasting (RF) has an important impact on the 1.8 billion community of Muslims, many of whom fast for a month annually, whether they are healthy or suffer from health conditions that involve circadian rhythm, such as chronic metabolic diseases, insulin resistance, diabetes, hypothyroidism, or cardiometabolic disease.[16] RF represents a dramatic change from normal diurnal eating to nocturnal patterns, and as such, is an interesting model of exploring chrononutrition concepts. Some aspects have been investigated in some detail, while others remain less so, if at all. In this review, we explore chrononutrition in the context of RF, and highlight current knowledge and what needs further investigation; Figure 2.

RF is a unique type of dry time-restricted intermittent fasting.[15,17] Like early time restricted eating (TRE), in RF food is allowed in the evenings, and also overnight; Figure 2. There is a time window for complete food restriction, which includes abstinence from drinking as well as eating. Importantly, eating and fasting time windows follow night and day time, respectively, with sunset and dawn marking the time windows quite strictly.

RF entails various changes from "normal" life, including major circadian disruption and a major change in eating pattern. Unlike early TRE, where the time window for eating is generally around 8 h, the RF eating time window can vary with season (shorter in summer) and latitude (much shorter in higher latitudes in summer). This can have important chrononutritional consequences.

Different forms of IF including RF have been shown to have definitive effects on health.[10] These are often positive and in the case of RF include a modest loss of weight of around 1–1.5 kg on average as demonstrated in several studies including meta-analyses.[18,19] These have also shown major inter-individual variability in the direction and magnitude of the weight change, thought to be determined by individual, social and cultural factors. It is also important to note that in most individuals this weight reverts to its pre-Ramadan levels in a matter of few weeks post-Ramadan.[20,21]

3 | CHRONONUTRITION: CIRCADIAN RHYTHMS AND NUTRITION

3.1 | Circadian rhythms

Circadian rhythm is the internal process that regulates sleep-wake cycles in the body and repeats every 24 h. Recent studies support

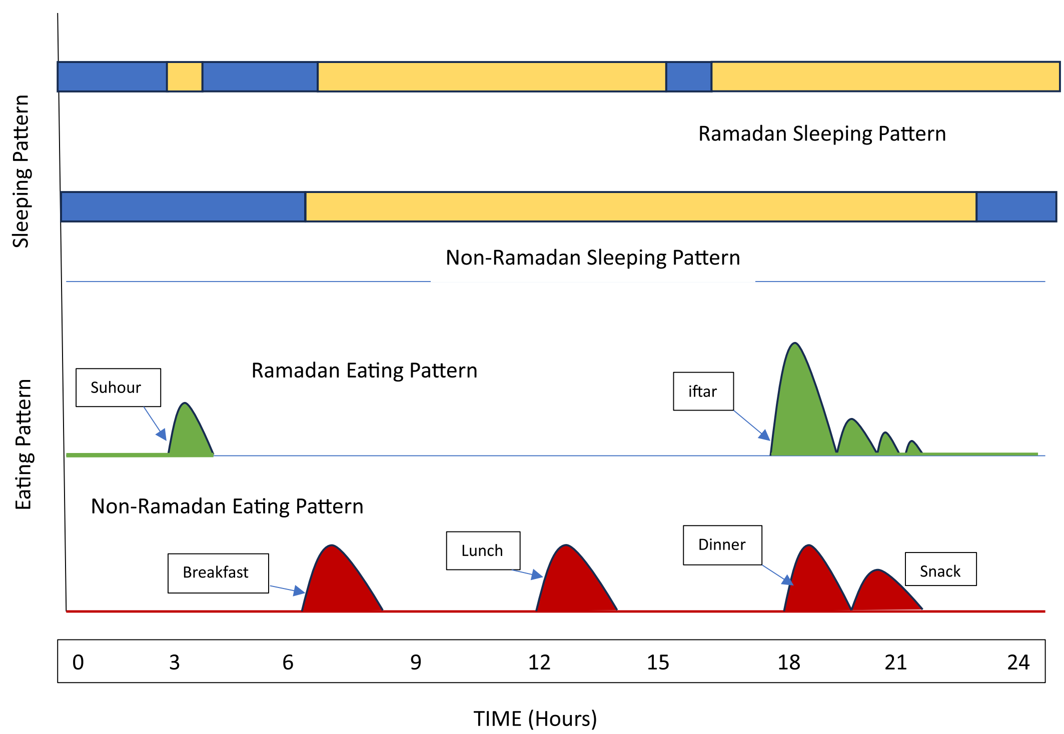

FIGURE 2 Differences in trends of sleeping and feeding patterns on Ramadan fasting (RF) and non-Ramadan (NR) days. During Ramadan, sleep and feeding changes occur in various patterns. Feeding in Ramadan is restricted to times between *Suhoor* and *Iftar* with nocturnal feeding in between. This is different from the usual feeding pattern of Breakfast, lunch and dinner with snacks in between. A typical sleeping pattern has been shown, but this often varies with the different practices observed during Ramadan.

the influence of circadian rhythms in the maintenance of metabolic homoeostasis, coordination of nutrition processes, physical activity, sleep and anabolic and catabolic pathways active at different times of the 24-h day period.[22] This has an effect on processes which are further associated with metabolic pathologies in the light of circadian disruptions. The association between time-of-day of energy intake and obesity is variable, with several studies reporting a positive link between evening energy intake and obesity.[23–25] This holds true for Ramadan due to the differences in cultural and religious practices. Other factors such as geographical locations and socio-environmental factors also have an influence on this. As in TRE, the number of fasting hours during Ramadan differs; see Figure 3.

Energy expenditure and energy balance are also significantly impacted in Ramadan. In the context of Ramadan, changes in energy dynamics have been extrapolated in our previous quantitative studies by acknowledging the bidirectional nature of this physiology and the alterations in energy utilisation during the feeding and non-feeding periods.[15] We have also previously shown a decrease in physical activity in Ramadan during the day versus night.[14] Major changes in sleeping patterns and times have also been reported by several groups, including our own[26] and have been the subject of a systematic review.[27] Data from other studies support the complex interaction between energy expenditure and food intake,[28,29] which may differentially influence weight change in humans. Weight is only one of the affected outcomes during Ramadan and more thorough investigations are needed to better understand changes in energy balance (intake and expenditure) during Ramadan and their effects, both short and long term.

Biological clocks that influence essential processes of metabolism and energy expenditure have been shown to work in synchrony with the rotation of the Earth, making geophysical time a critical factor to consider in the context of RF.[4] An aspect of relevance to the rhythmic nature of biological processes is the change in sleep pattern during Ramadan. In parallel to the drastic change in meal timing, there are important changes in sleep/wakefulness cycles. Although there is much variability in the pattern and timing of sleep during Ramadan, depending on culture and individual preference, in most individuals, a major change in sleeping times is the norm during Ramadan. This may include a shifting forward of the time of retiring to bed, broken sleep, or later waking time.[27]

3.2 | Nutrition

The link between meal timing and the body's physiological response to food is well-established. It has been demonstrated in human studies that with eating in alignment with circadian rhythms, for example, by increasing food intake at breakfast time and reducing it at dinner time, weight loss and improvements in glycaemic control and lipid levels are observed.[30] The same meal consumed in the evening leads to a lower resting metabolic rate and increased glycaemic/insulinaemic responses.[31] The phrase, "It is not only what you eat and how much you eat but also when you eat" sends a simple but clear message about circadian timing and body weight regulation.[32]

Nutritionally, as well as the major shift in meal timings, RF is associated with changes in macro-and micronutrient content.[33] RF

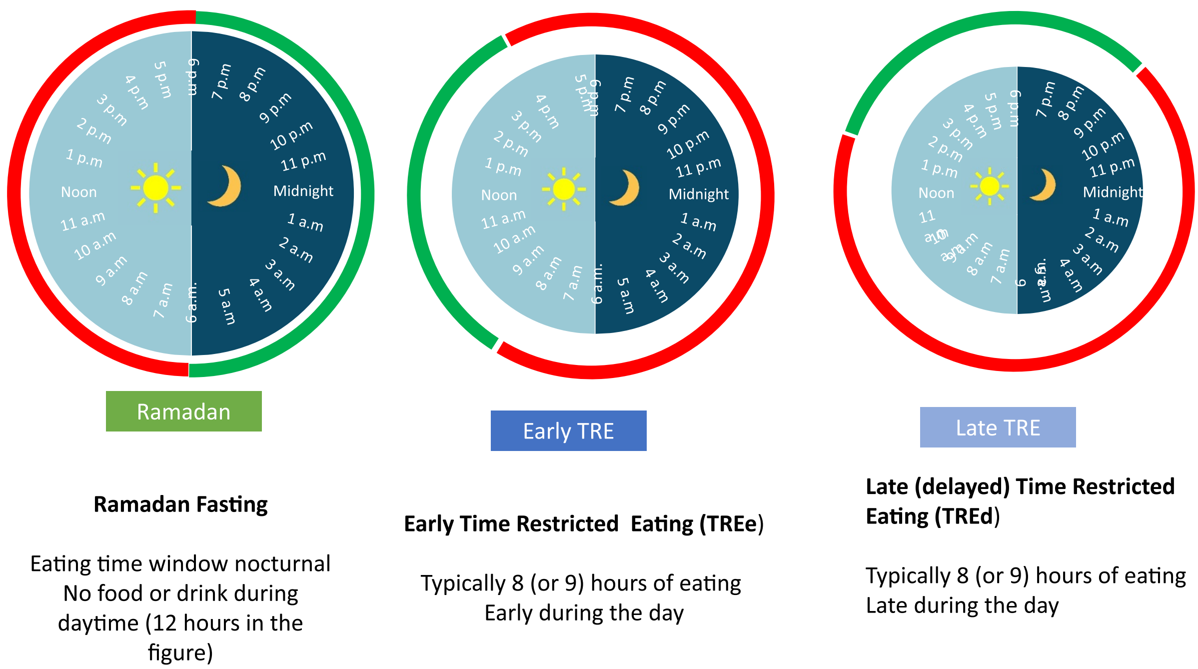

FIGURE 3 Ramadan and Time Restricted Eating (TRE). In general, Ramadan fasting occurs between dawn (*Suhoor*) and sunset (*Iftar*). However, owing to seasons (whether Ramadan falls in summer versus winter) or geographical location (equator vs northern or southern hemisphere) the actually fasting hours between dawn and sunset change. This is directly related to whether Ramadan falls under Early TRE or Late TRE at a specific date and location.

affects hunger dramatically with a progressive increase in hunger scores as the fasting day progresses.[34] Interestingly, a difference in adaptability to the hunger score has been shown between men and women, with females reducing their fasting day hunger scores at the end of the fasting month. In theory, in terms of energy intake, skipping one main meal in a 24-h period should be associated with a major reduction in food content and energy intake. Therefore, during Ramadan, this potential and expected reduction in energy intake should lead to weight loss. In practice, this is quite modest and amounts to around 1–1.5 kg by the end of Ramadan with significant inter-individual variability in the direction and magnitude of weight change.[18,19] Furthermore, overall calorie intake does not seem to alter during RF.[35,36] However, great variability in Ramadan diets[30,37] in different cultures has been observed. This variability is also determined by age groups, geographical locations and duration of fasting hours as well as the impact of physiological and pathological conditions (e.g. diabetes).

3.2.1 | Water balance and dry fasting

A distinct feature of RF is that it is a form of dry fasting. In other words, no fluid in any form is consumed during the fasting window. In theory at least, this can lead to water imbalance, dehydration, thirst and a rise in serum vasopressin. This state of daytime hypohydration, manifested in increased urine osmolality, and a rise in serum urea, creatinine, haematocrit and albumin, is followed by rehydration after the sunset hours, and during the eating time window has been shown in a number of studies in different parts of the world.[38–41] A study using isotope tracer techniques demonstrated no change in overall body water content during RF, although daily water turnover was reduced.[38] The effects of this intermittent hypo- and rehydration on eating and energy balance have not been explored.

3.2.2 | Chrono-hormonal changes

Metabolic homoeostasis is significantly influenced by circadian-related hormones such as cortisol, melatonin, adipokines, resistin, and ghrelin.[42,43] These hormones have a direct effect on health. For example, melatonin regulates energy flow by influencing the intensity and circadian distribution of metabolic processes including the proper synthesis, secretion and action of insulin, and consequently, glucose homoeostasis[44] (Figure 4). In Ramadan, the time and type of food change along with sleep.[27] How these aspects together affect physiology at the end of the Holy month remains underexplored.

There is increasing epidemiologic and clinical evidence indicating that our bodies respond and adapt to the changes in circadian rhythm with regard to nutrient sensing.[45] Nonetheless, circadian disruption is associated with increased inflammation, disordered regulation and aberrant secretion of circadian-related hormones.[46] In real life scenarios, this affects those who have shift work for instance, or those who suffer from sleep deprivation, and erratic eating patterns, thereby increasing their risk of metabolic syndrome and its components, type 2 diabetes and cardiovascular disease.[47] Late-night feeding has been associated with an increased risk of coronary heart disease by ~55%, even with controlling for diet and lifestyle.[37] Lifestyle interventions that improve daily rhythms of behaviour including eating patterns can favourably impact circadian rhythms and are expected to improve cardiometabolic health.[48] A meta-analysis on the impact on markers of glucometabolic health showed possible beneficial effects.[49] Another meta-analysis showed overall positive effects on cardiometabolic risk.[50]

Changes in energy homoeostasis directly and reversibly impact on the sleep/wake cycle, providing a mechanistic framework for investigating the association between sleep duration and obesity risk.[51] Similar studies in Ramadan are more challenging to perform.

Fasting also affects circadian rhythms of body temperature, cortisol, melatonin and glycaemia[52] (Table 1). These have been reviewed comprehensively elsewhere.[53] A blunting in the morning to evening peak/trough-level cortisol ratio from 2.55 to 1.22 was demonstrated in a study by Bahijri et al for instance.[54] An increase in HDL and apoprotein A1 and a decrease in LDL have also been reported and can be potentially beneficial for the cardiovascular system.[50,52]

A systematic review by Chawla et al showed statistically significant decreases in melatonin during Ramadan with most reviewed papers reporting an abolishing of the circadian rhythm of cortisol.[55] Dinner skipping has also been shown to significantly reduce evening cortisol, whereas breakfast skipping resulted in significantly reduced morning cortisol.[56] Other hormones such as adiponectin, leptin, ghrelin and fibroblast growth factor 21 (FGF21) are important hormones that are significantly impacted during the sleep-wake cycle change in Ramadan.[43,57,58] This has implications of poor cardiometabolic outcomes that necessitate further examination of circadian rhythmicity. This can be valuable to examine under conditions due to the shift in morning to evening feeding.

Other hormones are directly related to meal timing and can thus be expected to alter in magnitude or pattern during RF. A study comparing ghrelin levels in eight healthy individuals at four specific time points prior to and during RF found no significant differences. In the same study, a significant nocturnal reduction in plasma leptin was seen.[57] The latter was thought to be due to changes in meal times. Another study in overweight and obese individuals reported a significant reduction in mid-day (11 am-1 pm) ghrelin and leptin levels in the last week of Ramadan.[43] Notably, in the latter study, samples were only taken once at each time point (pre-Ramadan and Ramadan) and as such the findings cannot be generalised to leptin and ghrelin changes with RF at other times of the day.

4 | METABOLIC SYNDROME AND CLINICAL IMPLICATIONS: METABOLIC SYNDROME, DIABETES AND CARDIOVASCULAR DISEASE

The literature is demonstrating that disruptions of the endogenous circadian clock, environmental or genetic, can lead to metabolic dysfunctions, weight changes, obesity, diabetes, and other metabolic disorders.

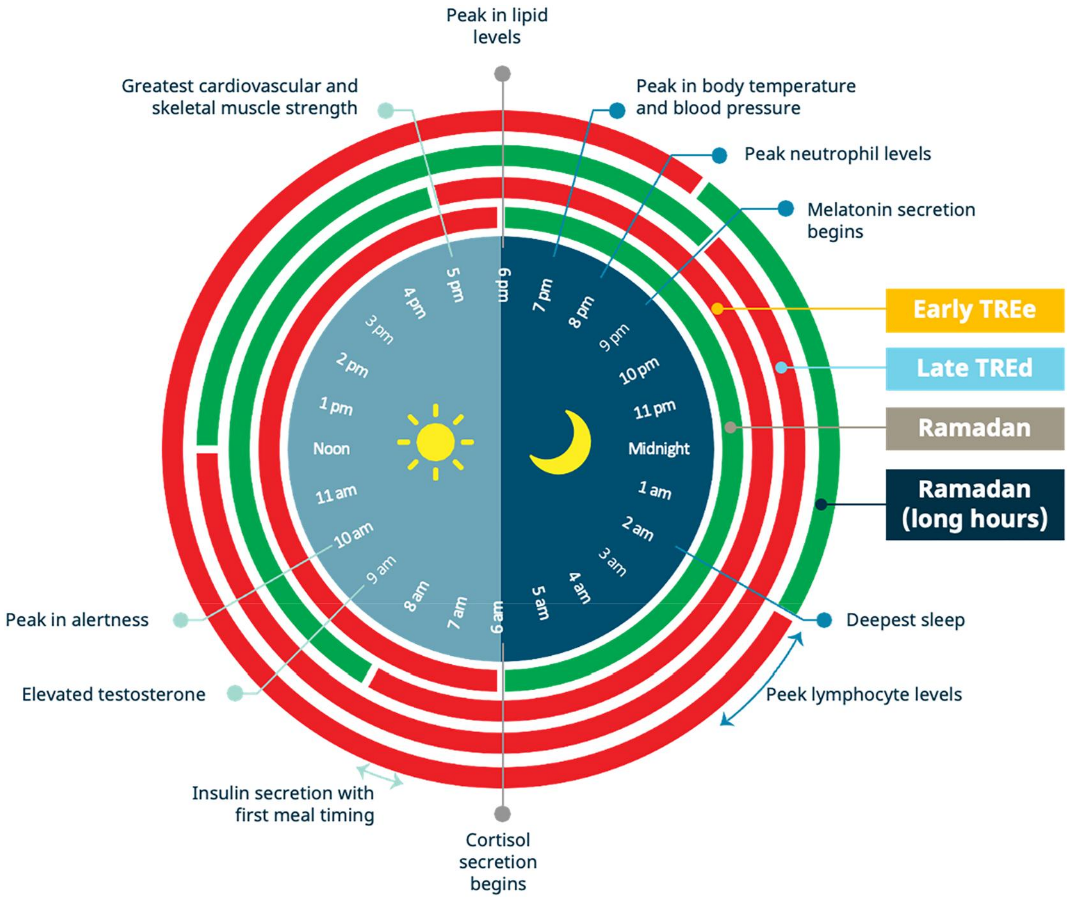

FIGURE 4 Early and delayed time-restricted eating, and Ramadan fasting relative to circadian rhythms and hormonal and other metabolic changes. Ramadan fasting with long hours as in higher latitudes has also been included for comparison only; the fasting and eating hours would follow day and night hours, which would be different from the central circle schematically depicted above.

In a review by Adafer et al between 2014 and 2020 studies, stemming from how recent observations have shown that lengthening the daily eating period may contribute to the onset of chronic diseases, they report that TRE is a simple and well-tolerated diet generating beneficial health effects based on chrononutrition principles.[59] More recently in 2021, Schuppelius et al suggested that TRE is a dietary strategy to prevent and treat metabolic disturbances, predominantly glucose and lipid (triglyceride) metabolic disturbances. In part, the reason these metabolic consequences arise is the regulation; the central clock dominates activity rhythms and is entrained by light/dark cycles, whereas the peripheral clocks regulate local metabolic rhythms determined by feeding/fasting cycles.[60]

The changes in CLOCK, DUSP and IL1 alpha genes have been shown in a study of 23 individuals from Saudi Arabia.[61] The consequences are multiple and significant and not many are fully delineated in the context of RF.

Patients with metabolic syndrome often display eating behaviour which is irregular and erratic, with eating over prolonged periods within the day along with irregular feeding times.[62] In such patients, a study by Wilkinson et al in 2020 showed not only the feasibility of TRE but also the observed improvements in body weight and fat, abdominal obesity, atherogenic lipids, and blood pressure, which occurred despite no overt attempt to change diet quantity and quality or physical activity.[63] Well-regulated eating habits are important for health as they normalise the liver clock for instance and blood cholesterol levels through insulin secretion contribute to better lipid metabolism.[64]

Metabolic states also affect the clockwork in a feedback manner. Because the circadian system organises whole energy homoeostasis, including food intake, fat accumulation, and caloric expenditure, the disruption of circadian clocks leads to metabolic disorders. The central pathophysiological feature of metabolic syndrome is a disruption in metabolic homoeostasis with excess central adiposity followed by insulin resistance, impaired FPG and/or impaired glucose tolerance.[65] Disruption in the circadian rhythm results in sustained abnormal activation or suppression of metabolic regulatory mechanisms that lead to abnormal glucose metabolism, defective glucose tolerance and insulin resistance, obesity, and diabetes.

In diabetes, food timing during the day also mattered. Insulin sensitivity, beta-cell responsiveness, thermic effect of food and fatty acids oxidation were all reported to be higher in humans in the morning than later during the day, which suggests that metabolism is optimised for food intake in the morning.[66] In type 2 diabetes, the postprandial glucose response to a meal was also affected depending

TABLE 1 Changes in selected hormones in the context of Ramadan. References have been included.

Hormone	Non-Ramadan	Ramadan	References
Hormones with a dominant circadian function			
Melatonin	Controls sleep-wake cycle	Reduced level in ramadan (checked daytime only)	Al-Rawi et al
	Highest midnight to 8 AM		
Cortisol	Stress hormone	Morning to evening ratio reduced to around 1.22	Bahijri et al
	Peak in the morning		
	Low at night		
	Morning to evening ratio typically 2.5		
Growth hormone	Pulsatile secretion with higher levels in the morning	Lower levels in morning and also evening	Ajabnoor et al
Hormones with a dominant function on controlling food intake			
Leptin	Satiety hormone	Much higher level in the morning	Ajabnoor et al
	Higher after meals (BF, L, Din)	Evening level similar or reduced compared to non-Ramadan	Alzoghaibi et al
	Dependent on fat mass and higher in obese		
	Peak 10 pm-3 am		
Ghrelin	Hunger hormone	No significant difference with non-ramadan in normal weight individuals	Alzoghaibi et al
	High before meals (BF, L, Din)	Marked reduction in overweight and obese in last week of ramadan	Al-Rawi et al
GLP-1	Rise with meals	No studies	-
	Increases insulin secretion		
	Reduces gastric motility		
	Reduces appetite		

on the type of food. Fat and protein (including amino acids) co-ingested with carbohydrate foods, such as bread and rice, can reduce the glycaemic response.[67] During this period, it is imperative to delineate due to the feeding-dependent glucose profile in Ramadan. We previously reported a sharp peak at *Iftar* followed by an elevated maintained high level of blood glucose that starts decreasing after *suhoor* when feeding stops[68]; Figure 5.

In addition, current human studies suggest that chrononutrition-based dietary interventions could also reduce the risk of cardiovascular disease by improving weight control, hypertension, dyslipidemia, and diabetes.[70] Cardiometabolic benefits of some feeding patterns, such as TRE, were attributed to the time of day in which feeding occurs and have been linked to a reduction in blood pressure and improvements in insulin sensitivity. For overweight/obese individuals, benefits such as weight loss and improvements in sleep patterns have been demonstrated. This pattern of eating has been shown to be safe even for those with existing cardiometabolic conditions. A recent review by Crupi et al in 2020 indicated that IF, TRE, PF and FMDs all show promise in the reduction of cardiovascular disease risk factors in a weight loss independent manner.[71] They further suggest that coupling periodic and prolonged feeding and fasting cycles have potential in the prevention and treatment of cardiovascular disease and metabolic syndrome. The effects of RF on cardiometabolic health have been reviewed and reported as generally positive.[50] A recent meta-analysis of several studies on different glucometabolic parameters including fasting glucose, insulin resistance (as assessed by HOMA-IR), serum leptin and adiponectin showed the overall effect size of RF in most of these parameters to be minimal, with individual studies reporting conflicting results.[49] For instance, several studies have shown an increase in insulin resistance and others, a reduction in insulin resistance. The difference has been attributed to differences in culture in different parts of the world augmenting some important confounding factors such as sleeping time and duration with interrupted and shorter sleep duration being associated with less favourable cardiometabolic outcomes.

5 | DISCUSSION

The Holy month of Ramadan is a unique form of intermittent fasting practiced annually by over a billion people globally. The time restriction on feeding hours lasting from *Iftar* to *Suhoor* as well as the nocturnal nature of this feeding provides an opportunity for examining concepts such as chrononutrition.

During RF, a major change happens to usual meal times; the first meal of the day is consumed before dawn, the mid-day meal is

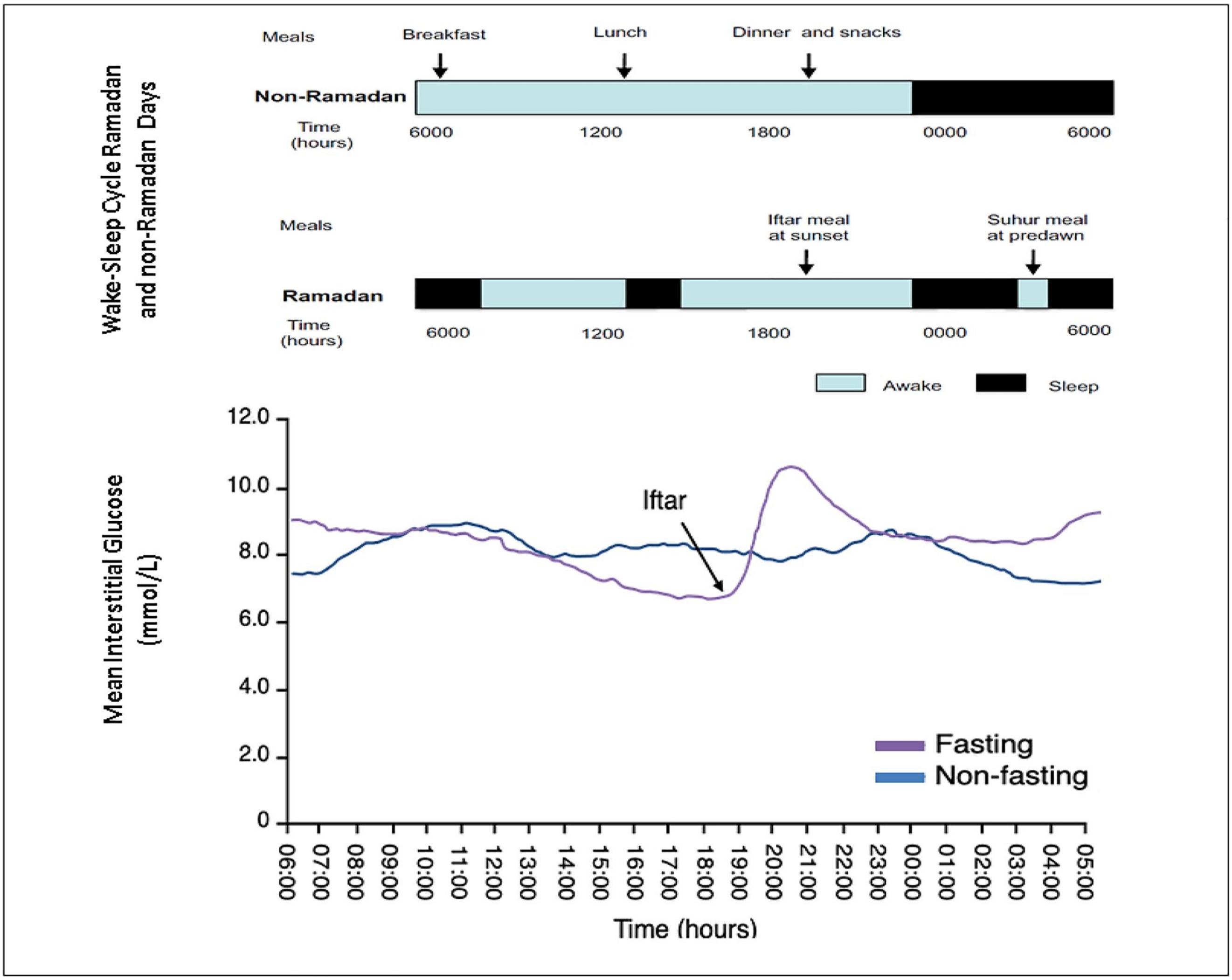

FIGURE 5 Mean continuous glucose monitoring (CGM) profiles from people with diabetes before and during Ramadan. A rapid increase in blood glucose is observed at *Iftar* time; the intake of the carbohydrate-rich meals at *Iftar*, and the involvement of hormonal changes are possible contributing factors that may explain this pattern. Inappropriate timing and inadequate dosing of glucose-lowering medication may also be important contributors to this rise. Figure adapted from Lessan et al[44] and Saadane et al.[69]

completely skipped, and the main meal of the day is taken just after sunset. One might expect to miss a major meal should be accompanied by a proportionate drop in meal content, including a reduction in calorie intake. Although overall food preference and meal content do alter, calorie intake does not seem to change significantly as indicated by a number of observational studies[33,72,73] and meta-analyses.[36] It has to be noted though that many studies of food intake are based on food recall or food diaries, thus making the results less than precise. Studies of weight change with RF point to a net weight loss of 1–1.5 kg by the end of Ramadan,[19,74] around 1 kg less than what might be expected by skipping a meal if none of the calorie deficit was compensated for during the eating hours. This underlines the importance of the timing of meals. Furthermore, the modest weight loss of RF is regained within a short time after Ramadan,[20] further emphasising the importance of meal timing, which can influence food intake as well.

During Ramadan, in addition to the shift in feeding time, the type of food consumed is often high-energy high-density food.[33,36] Given the option between nutritious low glycaemic index food items and high calorie sugary or high carbohydrate content food items at sunset (*Iftar*), the choice is often the latter. In part, the body is primed for receiving high glucose after this absolute abstinence from food and drink for many hours. Immediately afterwards, this glucose intake suppresses gluconeogenesis through the release of insulin because the body treats this physiologically as starvation. In people with diabetes, excess consumption of such foods, which is often the case in the nocturnal habitual Ramadan eating period between *Iftar* and *Suhoor*, can lead to hyperglycaemia.[68,75] This has the potential sequelae of osmotic diuresis, dehydration, metabolic acidosis, and ketoacidosis,[76,77] although a recent study showed no significant difference in the incidence of diabetic ketoacidosis between Ramadan and on-Ramadan months.[78] Chrononutrition implications in Ramadan

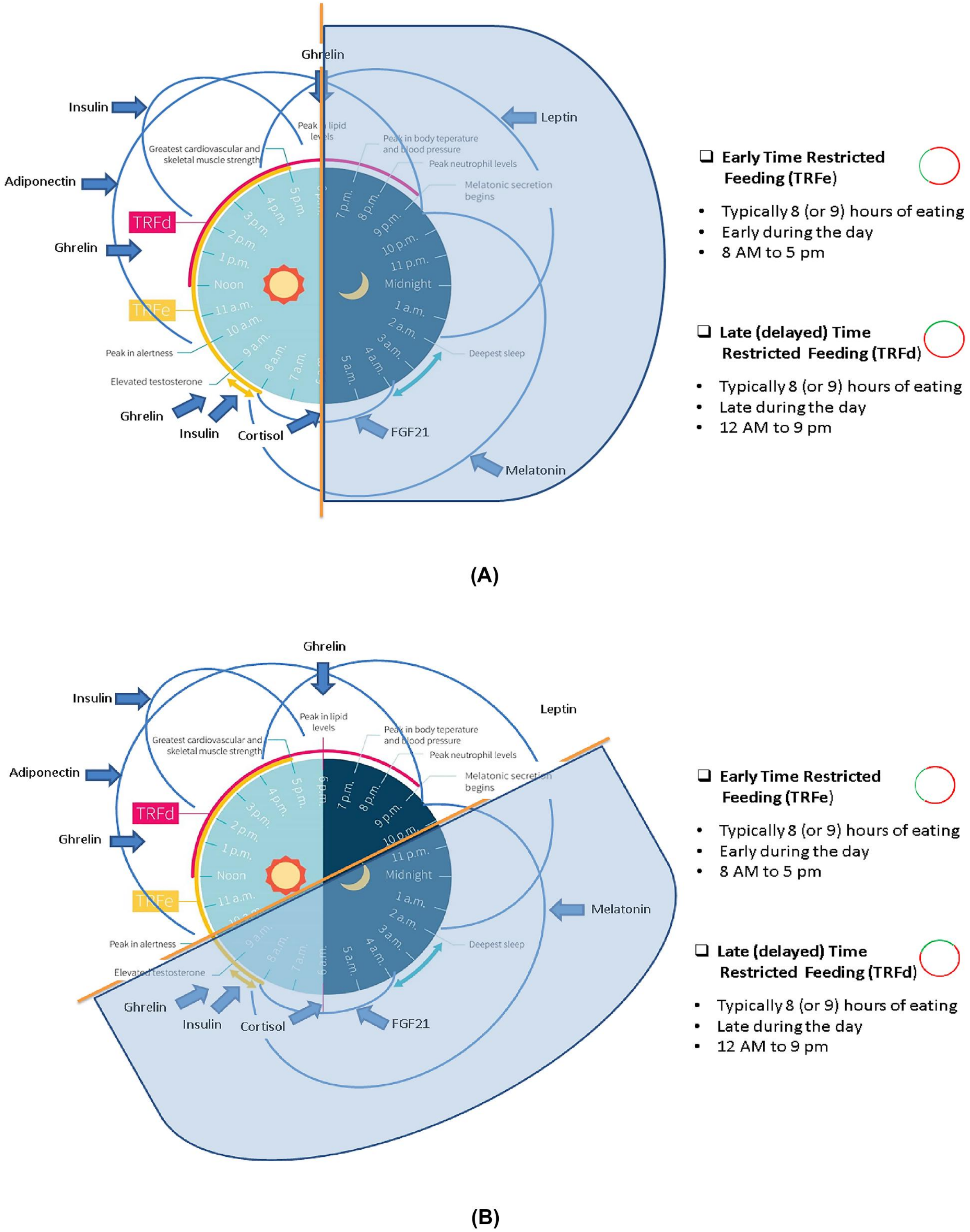

FIGURE 6 Early and delayed time-restricted eating relative to circadian rhythms and hormonal changes. In a twenty-four-hour day, various hormones are secreted at different times that affect sleep and feeding. Early time-restricted eating (TREe) usually commences earlier in the day while delayed time-restricted eating (TREd) commences later; both forms however last ~8–9 h. The shaded blue section indicates the shift in sleep-wake cycles that in turn have direct implications on hormonal and feeding hours that change dramatically between non-Ramadan (PANEL A) and Ramadan (PANEL B) days, whereby the circadian rhythm regulated hormonal release during waking hours may now coincide with sleeping hours in Ramadan, and vice versa.

therefore extend beyond the timing of eating and include the type of food consumed and sleeping changes in this unique time-restricted feeding model of fasting, with many aspects remaining to be explored in detail. Figure 6.

In Ramadan studies, the heterogeneity in the findings from many studies is often attributed to cultural variations in dietary habits, differences in the duration of fasting due to seasonal/climatic differences at various geographical locations, age, sex and socioeconomic status, as well as other health and lifestyle factors of the various study populations.[36]

Other types of intermittent fasting such as the 5:2 fast also have a similar semblance to the Monday and Thursday fasts in Islamic tradition. It exists almost in the reverse form where complete abstinence of food occurs between dawn and sunset as it does during Ramadan. However, unlike Ramadan, the days between these 2 days follow normal eating as in the 5:2 fast. The consequences of this type of fasting outside Ramadan have not been previously explored, neither as a standalone nor in comparison to other types of fasting. This has an impact on health and disease and will vary in different populations; thus, there is much room to investigate these physiological and pathological aspects further.

The religious and cultural nature of how Ramadan is observed makes it difficult to design and perform Ramadan investigations, both in terms of type and number of studies. In spite of this, a number of conclusions can be made on chrononutritional aspects of RF. With the major shift in meal timing, akin to (but also distinct from) late TRE, and with changes in activity and sleeping times RF, in healthy individuals has been shown to be associated with beneficial effects on health, and in particular, cardiometabolic risk. It seems likely that at least some of this benefit can be ascribed to changes in meal timings which are in fact not aligning with the body clock for a month. On the other hand, there are potential unfavourable effects of RF reported in some studies that may be attributable to undesirable changes in sleeping times as well as meal size and content related to cultural rather than strictly prescribed religious practices. Having more and better controlled investigations, including randomised controlled trials and/or longitudinal studies, will help us in understanding the interplay between the physiological systems during Ramadan. This allows for a deeper comprehension of whether the observations and consequent extrapolations in the literature are speculative, associative, or actually causational.

AUTHOR CONTRIBUTION

Nader Lessan and Tomader Ali both contributed equally to the writing of this manuscript. NL has done the final editing of the manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in Pubmed at https://pubmed.ncbi.nlm.nih.gov/.

ETHICS STATEMENT

This is a review article; there were no ethical considerations to be addressed.

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PEER REVIEW

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