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Review Article

Ramadan Fasting in Health and Disease (2019): A Narrative Review

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ABSTRACT

Introduction: Literature on the health aspects of Ramadan fasting (RF) is widespread in many journals, making it less readily available to those interested in the subject. **Materials and Methods:** This is a narrative, nonsystematic review of international literature from two major online databases (viz., Scopus and PubMed) in 1 year (2019). The search term "RF" was used, and relevant literature was narrated in a concise thematic account excluding diabetes. **Results:** The publications spanned the fundamental, clinical, ethical, professional, cultural, and advocacy facets of the subject. The publications crossed the conventional disciplinary lines and geographical locations and appeared in journals with different access systems. The content is presented under relevant themes depending on the available literature. Basic coverage included changes in physiology, nutrition, and metabolism during Ramadan. Clinical aspects such as the impact of RF on kidney function, pregnancy outcome, fetal life, structure and function of eyes, and athletes' well-being received comparatively prominent coverage by researchers in 2019. Gut, liver, skin, skeleton, and blood were also covered. Other workers focused on documenting the perception, attitudes, and practices of both patients and health-care professionals during Ramadan. **Conclusions:** The health aspects of RF received sustained academic interest with a wide spectrum in 2019. We provided a scoping overview to help researchers and clinicians catch up quickly with the state-of-the-art today.

Keywords: Bibliometric, diabetes, literature, patients' perceptions, pregnancy, professional, Ramadan, research, sports medicine

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Introduction

Ramadan, the 9th lunar month, is a religious month dedicated to fasting, prayer, and charity. The impact on health and disease stems from the biological impact of the fasting itself and the associated social changes. Recently, health-care providers have gained increased interest regarding the possible health-related risks as a consequence of Ramadan fasting (RF) practiced by adult Muslims in this month. It entails that they abstain from eating and drinking between the dawn and sunset.

Medical and religious scholars got closer in their approach to patients' advice based on objective risk assessment in common conditions such as diabetes.[1] Muslim patients with acute or chronic medical conditions may be exempted from fasting; many still choose to observe the fast sometimes against medical advice. This may adversely affect their health if not appropriately addressed by evidence-based recommendations.[2,3]

Keeping up with the developments in RF research may prove difficult, and, hence, a narrative overview under a single cover may be particularly useful in presenting a digest of the research and expert opinion. We have previously reviewed the literature published in 2017 and 2018 in this journal.[4,5] The aim of the present review is to provide a thematic overview of the global research work in 2019. The review aims to give a concise bird's eye view of the literature and highlight the evidence base that may direct clinical practice.

Materials and Methods

This is a narrative, nonsystematic review of the literature retrieved from two online databases over a full calendar year (2019). The search term "Ramadan fasting" was used to identify the relevant records. The PubMed and SCOPUS search retrieved 141 and 134 records, respectively. Due to their extensive number, articles on diabetes were submitted separately elsewhere and were excluded from the present manuscript to keep the size of the manuscript within reasonable limits.[6] The selected articles were reviewed and narrated thematically to provide a reasonably concise but adequate representative. SAB drafted the initial manuscript, and all authors (a) developed further their assigned sections and (b) reviewed the whole document for intellectual content using a single version loaded online using Google Docs. Only full-text research articles in English were included. The final product was refined through several multilateral rounds of discussion. All authors contributed to the revision and finalization of the manuscript. They all approved the final version of the manuscript before submission.

Results

Physiological changes in healthy individuals

RF is thought to exert a number of physiological changes in both healthy individuals and those with medical conditions. Seven studies during 2019 addressed the impact of RF on different physiological parameters in otherwise healthy people of various ages. These included effects on muscle function and muscle mass in older people; insulin-like growth factor-1 (IGF-1); interleukin (IL) (IL)-2; lipid profiles; risk of heat stroke in the summer; red blood cell and white blood cell parameters; serum levels of irisin, adiponectin, and leptin; verticality perception in young adults; and the anatomical, physiological, and cognitive function of healthy individuals practicing fasting during Ramadan.

Akın *et al*. evaluated the physiological effects of RF on muscle function and muscle mass in older people.[7] Measurements were obtained for walking speed, muscle strength, body composition, and detailed dietary diaries. The study found no significant changes in body weight, muscle function, or muscle mass before and after RF. The authors concluded that RF supplied no risk for muscle function or muscle mass in older people. Rahbar *et al*. investigated the effects of fasting in Ramadan on IGF-1 and IL-2 levels in a sample of adult men.[8] After RF, serum IGF-1 and IL-2 levels significantly decreased compared to that of before Ramadan. In addition, other favorable metabolic parameter changes were seen after Ramadan, namely, triglycerides (TGs), total cholesterol (TC), and low-density lipoprotein-cholesterol (LDL-C) levels significantly decreased, in addition to significant

decreases in weight, waist circumferences (WCs), calorie, carbohydrate, and fat intake. The authors concluded that fasting in Ramadan attenuates inflammation and is beneficial to metabolic health. Alzoughool *et al*.[9] examined the effect of RF on additional metabolic parameters such as serum levels of irisin, adiponectin, and leptin in healthy students. All levels significantly reduced after Ramadan, with irisin levels significantly correlating with the physical activity level of participants. Culha *et al*.[10] measured circulating obestatin levels in 35 normal weight and 30 people with obesity before and after Ramadan. Obestatin levels were significantly lower in obese individuals than that in controls and obestatin and high-density lipoprotein-cholesterol (HDL-C) levels increased after Ramadan in obese group. After Ramadan, body mass index (BMI), Homeostatic Model Assessment-Insulin Resistance, fasting blood glucose, and fasting insulin correlated inversely with obestatin level. These results suggest that the changes in the pattern of sleep and fasting and eating during Ramadan may lead to increased obestatin in obese subjects, and this result may positively affect obesity, glucose, and lipid metabolism. Manjunath *et al*.[11] examined the physiological effects of prolonged fasting among employees in thermally challenging conditions: an aluminum smelter. The researchers found that the average heart rate and urine-specific gravity increased in the first 4 h of shift work, while tympanic temperature did not rise significantly. The measurements stabilized in the second 4 h. The authors called for robust workplace measures for industries with high process temperatures in order to minimize the enhanced risk of heat stress and illness during Ramadan. Ahmed[12] investigated the effects of RF on red and white blood cell parameters among female subjects. The authors found that fasting in Ramadan significantly increased red blood cell counts compared to that of pre-Ramadan. In addition, total and differential leukocytes counts decreased significantly at the end of Ramadan among female participants. Razzak *et al*.[13] investigated the effect of RF on vertical perception and spatial orientation using computerized rod and frame testing. The study concluded that neither the effects of fasting status nor the time of day was significant for rod alignment errors, and that any adverse effect of RF on activities that are critically dependent on verticality perception and spatial orientation, such as sports and driving, may not be due to verticality misperception. Finally, Iqbal *et al*.[14] comprehensively investigated the anatomical, physiological, and cognitive functions of healthy individuals practicing fasting during Ramadan, utilizing a variety of tests including body composition, neurocognitive analyses, memory tasks, spatial tasks, and magnetic resonance imaging (MRI). At the end of Ramadan, there were significant decreases in body weight, fat-free mass (FFM), and trunk-predicted muscle mass. Performance at spatial tasks improved, whereas that of memory tasks did not. Cortical thickness data on whole-brain MRI did not change significantly. The authors concluded that RF may lead to weight loss, FFM reductions, and some improvements in cognitive function in some individuals.

Nutritional changes in Ramadan

RF causes important changes in the nutritional status of those fasting. Evidence of this stems from studies that addressed nutritional balance, body composition, and energy expenditure. Nachvak *et al*.[15] determined food intake, glucose homeostasis, lipid profiles, and body composition before, during, and after RF in healthy men. Statistically significant decreases were seen in food intake (except carbohydrates), BMI, body fat percentage (BFP), fasting blood sugar, and circulating TG at the end of Ramadan. In contrast, insulin resistance significantly increased at the end of Ramadan. The changes observed were transient, and returned to pre-Ramadan levels 1 month after Ramadan. Ben Jemaa *et al*.[16] determined the impact of a nutritional education program before Ramadan on dietary intake, anthropometry, and body composition in an interventional study of Type 2 diabetes mellitus patients. During RF, carbohydrate intake reduced in both the study subjects and controls. Protein and saturated and monounsaturated fatty acid intake increased significantly in the group who did not receive education. The authors concluded that a nutritional education program before Ramadan can positively impact diabetes patients who fast during the holy month. Das *et al*.[17] studied the food intake pattern among children, adults, and elderly persons

before and after Ramadan in the eastern part of India to evaluate Ramadan fasting on body weight and BMI. All the three age groups showed an increase in body weight and BMI after 1 month of RF compared to pre-Ramadan control values. Excess intake of fat, sugar, and energy, along with a sedentary work routine, was the main factor identified as a contributor toward such an increase. The study also pointed out socioeconomic status as an important determinant of anthropometric changes. While epidemiological evidence indicates an association between higher meal frequencies and lower disease risk, experimental trials have shown conflicting results. The influence of meal frequency and timing on health and disease was examined.[18] Furthermore, recent prospective research has demonstrated a significant increase in disease risk with a high meal frequency (≥6 meals/day) compared to a low meal frequency (1–2 meals/day). Apart from meal frequency and timing, they also have to consider the distribution of daily energy intake, caloric restriction, and night-time eating. A regular meal pattern including breakfast consumption, consuming a higher proportion of energy early in the day, reduced meal frequency (i.e., 2–3 meals/day), and regular fasting periods may provide physiological benefits such as reduced inflammation, improved circadian rhythmicity, increased autophagy and stress resistance, and modulation of the gut microbiota. Also, the gender-based differences in the metabolic response to fasting were studied in a cross-sectional study gathering data on subjects' demographics, anthropometrics and nutritional data.[19] Biochemical parameters were also analyzed. The results demonstrated increased weight, BMI, body fat (%), and muscle mass in women, while men demonstrated decreases in weight, BMI, and body fat (%). The WC/hip circumference ratio decreased in men, but stayed the same in women. Daily water consumption increased in both women and men. Serum levels of HbA1c decreased in both genders. Serum creatinine, uric acid, albumin, TC, HDL, and LDL altered significantly in women, whereas the only significance observed in men was in serum glucose. Systolic blood pressure (SBP) and diastolic blood pressure increased in both genders. The authors concluded that RF affects the nutritional status and serum parameters in a different way for women compared to men.

Ismail *et al.*[20] reviewed the similarities and differences between time-restricted feeding and RF in 25 articles (15 original and 10 reviews) published between 2000 and 2017. In spite of the heterogeneity of these studies, the authors concluded that time-restricted feeding and RF have many similar characteristics. They also reported positive health effects, including weight reduction, reduction in body fat, improvement in glucose tolerance and insulin resistance, and cardiometabolic benefits. Two review articles considered the effects of RF on energy balance.[21,22] The first reviewed knowledge on different aspects of energy balance in Ramadan as a standard model to learn from and also map out strategies for healthier outcomes in such settings.[21] RF is a state of intermittent liver glycogen depletion and repletion. The earlier (morning) part of the fasting day is marked by the dominance of carbohydrates as the primary fuel, but lipid becomes more critical toward the afternoon as the time for breaking the fast at sunset (Iftar) gets closer. The practice of observing RF is accompanied by changes in sleeping and activity patterns, as well as circadian rhythms of hormones, including cortisol, insulin, leptin, ghrelin, growth hormone, prolactin, sex hormones, and adiponectin. Few studies have investigated energy expenditure in the context of RF, including resting metabolic rate and total energy expenditure, and found no significant changes with RF. Changes in activity and sleeping patterns, however, do occur and are different from that of non-Ramadan days. Weight changes in the context of RF are variable and typically modest with inter-individual variation. Finally, a systematic review and meta-analysis of 33 studies including apparently healthy subjects examined the effects of RF on lipid parameters.[22] The primary finding was that LDL-C levels significantly increased, whereas HDL-C and very LDL-C significantly decreased after RF. RF showed no significant effect on circulating TG, TC, and LDL-C levels. Change in TG levels was associated with age, its baseline values, and weight changes during the fasting period. The

authors concluded that RF might be accompanied by a moderate improvement in lipid and lipoprotein parameters, especially HDL-C levels.

Impact of Ramadan fasting on inflammation

Several studies addressed the impact of RF on various markers of inflammatory and oxidative processes employing different designs, analytical methods, and statistical assessments.[23-28] Karsen *et al*.[23] compared various indices of oxidative stress (OS) in fasting and nonfasting subjects using a novel automated colorimetric method. Total oxidant status (TOS), total antioxidant capacity levels, and OS index were analyzed. With this, they determined whether fasting had any beneficial effects on human health. The authors found the TOS level of the nonfasting group to be higher. Almeneessier *et al*.[24] assessed the effect of fasting during and after Ramadan on plasma levels of IL-1β, IL-6, and IL-8, while controlling for sleep/wake pattern, sleep length and quality, meal composition, energy consumption and expenditure, and light exposure. Fasting outside of the month of Ramadan was performed to evaluate the effect of intermittent fasting (IF) in the absence of the way of life accompanying Ramadan. They demonstrated that under controlled conditions, IF led to significantly decreased plasma levels of cytokines (IL-1β, IL-6, and IL-8), particularly IL-1β and IL-6 across 24 h. IF did not affect the circadian patterns of the measured cytokines. Mushtaq *et al*.[25] investigated the effect of fasting during Ramadan on plasma adiponectin and tumor necrosis factor-alpha (TNF-α) levels in a cross-sectional study comprising a total of 55 females and 55 males, aged between 20 and 40 years, who fasted during Ramadan (2014). The study found increased plasma adiponectin and decreased TNF-α levels and body weight with RF. Mrad *et al*.[26] assessed the impacts of RF on some biomarkers measured in men with stable chronic obstructive pulmonary disease (COPD) fasting during Ramadan. Three sessions (before, at the end, and after Ramadan) were selected. Blood samples of OS (homocysteine and thiobarbituric acid reactive substances) and antioxidant system (AOS) (catalase, ceruloplasmin, superoxide dismutase [SOD], zinc, and albumin) biomarkers were obtained before the Iftar. Homocysteine, ceruloplasmin, SOD, thiobarbituric acid reactive substances (TBARS), catalase, zinc, and albumin were not significantly affected by RF. The number of patients with high OS or low AOS statuses was not significantly influenced by RF. In conclusion, RF did not induce any significant statistical or clinical changes in OS/AOS biomarkers or statuses in COPD patients. In order to determine whether RF is associated with an increased risk for infections, Ben Ayed *et al*.[27] examined the prognostic factors of recurrent urinary tract infections (UTIs) in the setting of RF through a retrospective data review of patients diagnosed with UTI in Sfax, Tunisia (2010–2017). During the follow-up of 867 patients with UTI, recurrent UTI was a prevalent and challenging condition among patients with UTI, with both diabetes mellitus and RF seemingly increasing the recurrence in UTI.

Furthermore, a systematic review and meta-analysis examined changes in inflammatory and OS markers in healthy people after Ramadan.[28] RF resulted in very small reductions in IL-1; C-reactive protein (CRP)/high-sensitivity CRP; and malondialdehyde, an OS marker, and small reductions in TNF-α and IL-6. The authors concluded that RF provides some protection against elevated inflammatory and OS markers, which may offer an opportunity to reduce low-grade systemic inflammation and OS and subsequent adverse health effects in healthy people.

Fasting and kidney disease

The interest in kidney function and disease during RF continued in 2019. Tashkandi *et al*.[29] assessed whether lipids and lipoproteins were primarily impacted during Ramadan in chronic hemodialysis (HD) patients. In addition, the group looked at parameters such as renal function, muscle mass, and muscle strength. Throughout the study, changes in renal-related parameters were minor, as were changes in plasma lipids. Proportions of LDL and HDL did not change over the study period. The mean LDL particle diameters were higher during the Ramadan period, but the changes over the study period were small. No changes were noted concerning strength or muscle mass. Megahed *et al*.[30] assessed the frequency of fasting in Ramadan in HD patients in Egypt and the possible effect of

fasting on clinical and biochemical variables in a multicentric observational study carried out during 2016. They showed that fasting may be possible in maintenance HD. It may be recommended that HD patients should be encouraged to discuss the option of fasting in Ramadan with their HD staff who might be able to give advice on whether to allow them to fast on the days off dialysis. Close monitoring of dry body weight during HD sessions and restriction in potassium-containing diet in Ramadan must be considered the essential parts of patient care during Ramadan. Khazneh *et al.*[31] examined the effects of RF on key biochemical and clinical markers among HD patients. In a prospective cohort study, 269 end-stage renal disease patients were recruited from the HD unit (Nablus, Palestine). The key clinical and biochemical markers were measured before, during, and after Ramadan. Their findings suggest that RF (fully or partially) is tolerable by HD patients and is not associated with critical clinical complications. However, these patients should be aware of the potential risk of fluid overload and hyperkalemia if they decide to fast during Ramadan. Thus, they should be closely monitored and instructed to adhere to their dietary and fluid intake allowances. Further information has been provided by Dogan *et al.*[32] who investigated the effects of RF on renal functions in patients with Stage 3 and 4 chronic kidney disease (CKD). The patients were evaluated before Ramadan, the week immediately following Ramadan's end, and 3 and 6 months after Ramadan. Twenty-four fasting and 55 age-matched nonfasting individuals were included in the study. There was no statistically significant difference for creatinine levels in the 1st week after Ramadan in both groups compared to levels before Ramadan. The groups were compared according to the criteria of deterioration in renal function (reduction of 25% in glomerular filtration rate [GFR] and a 30% increase in serum creatinine levels). There were no statistically significant differences between the two groups according to these two criteria. In a regression analysis, diabetes mellitus and proteinuria were found to be independent risk determinants of renal dysfunction. Patients with diabetes mellitus and prominent proteinuria may constitute critical patient groups for renal function deterioration during RF. Adanan *et al.*[33] evaluated the effects of RF on the nutritional and functional status of patients on maintenance HD in a 12-week, multicentric, prospective observational study. Nutritional and functional status assessments were carried out 2 weeks before ($V0$), in the 4th week of Ramadan ($V1$), and 4 weeks after Ramadan ($V2$). RF led to significant reductions in BMI, interdialytic weight gain, WC, mid-arm circumference, fat tissue mass, and BFP, but these were not accompanied by any significant change in lean tissue mass. Significant improvement was observed in serum phosphate levels. Serum albumin, urea, and creatinine reduced significantly during Ramadan. There were no significant changes in lipid profile and inflammatory markers. Interestingly, energy and protein intakes remain unchanged during Ramadan. Handgrip strength improved significantly during Ramadan and further improved after Ramadan. Intermittent RF leads to temporary changes in nutritional status parameters and poses a nondetrimental nutritional risk for patients on maintenance HD.

Three reviews addressed the impact of RF on CKD. The first review searched four databases using broad search terms with predefined eligibility criteria. Eight studies (549 patients) were identified as eligible; the studies measured renal function before and after Ramadan, with patients acting as their controls in five studies.[34] The pooled analyses showed no significant changes after fasting with regard to estimated GFR or in serum creatinine levels. In four self-controlled studies (148 patients) that had analyzed changes in SBP and diastolic blood pressure before versus after fasting, no significant differences were shown. However, in three studies that assessed changes in GFR in fasting versus nonfasting patients, there was a significant difference in change in GFR following RF; however, these results were associated with significant publication bias (systematic heterogeneity). Fasting during Ramadan did not result in significant changes in kidney function or blood pressure in posttransplant patients with good baseline kidney function when patients acted as their controls. Furthermore, the second review studied the available evidence for patients with CKD and

fasting, including HD and renal transplantation.[35] The authors suggested that all patients with CKD should be deemed high risk or very high risk for fasting. However, they concluded that patients with stable mild/moderate CKD (Stages 1–3) may be able to fast, provided they are carefully monitored and counseled. They also suggest that patients with stable renal transplants may also be able to fast, providing they are monitored carefully by their transplant team. Patients on HD or peritoneal dialysis should not be encouraged to fast, but they will need careful weekly monitoring if they do so.

Impact of fasting and pregnancy and fetal life

Safari *et al*.[36] assessed the following maternal outcomes: weight changes, gestational diabetes, preterm labor, preeclampsia, low birth weight, Apgar score, height, weight, and head circumference of the newborn during RF for those in their second trimester using a case–control study (Erbil, Iraq). Weight gain during pregnancy in fasting women was approximately 0.4 kg less than those who did not fast. The incidence of gestational diabetes was 2.6% in fasting women, while 8.3% in nonfasting mothers. Regression analysis showed that women not fasting during the second trimester of pregnancy were 1.51 times more likely to develop gestational diabetes. The authors concluded that fasting during the second trimester of pregnancy decreased the risk of gestational diabetes and excessive weight gain during pregnancy. Majid *et al*.[37] studied gender-specific Ramadan consequences to the fetal environment in Indonesia, on birth weight, future performance on Raven's Colored Progressive Matrices (CPM), math scores, hours worked, and earnings. Full month of exposure to RF *in utero* led to significant reductions: among 8–15 years, lower scores on Raven's CPM tests for females and males; lower math scores for females and males. During the fetal period, events have far-reaching consequences for females and males in the lowest (10th and 25th) quantiles of outcome distributions, affecting the "relatively poor" the most. These results call for caution in interpreting studies on child development that rely on mean comparisons alone.

Several studies have reported adverse outcomes in adulthood for those prenatally exposed to RF. However, other studies document minimal to no impact on neonatal indicators. Kunto and Mandemakers[38] used data from the Indonesian Family Life Survey consisting of 45,246 observations of 21,723 children born to 9771 mothers to examine the effects of "mother's religiosity" on stature from early childhood to late adolescence. Children were classified into three groups based on their mother's religion–religiosity: religious Muslims, less-religious Muslims, and non-Muslims. Using cluster-robust mother fixed-effects, they found adverse effects on stature for children born to religious Muslim mothers. The effects were age dependent and timing sensitive. For instance, children born to religious Muslim mothers were shorter in late adolescence compared to their unexposed siblings if they were prenatally exposed in the first trimester of pregnancy. Interestingly, they found positive effects on stature for exposed, less-religious Muslim children that peak in early adolescence, and adverse effects on stature for exposed non-Muslim children that occur only in early childhood. Makvandi *et al*.[39] compared the basic hematological parameters of healthy fasting and nonfasting pregnant women 3 months after Ramadan. The fasters and nonfasters were similar in maternal age, gestational age, gravidity, prepregnancy weight, and maternal weight at enrollment. There were no statistically significant differences between the mean of hemoglobin, hematocrit, or other hematological parameters in the fasting and nonfasting groups.

Savitri *et al*.[40] examined the Perinatal Registry of the Netherlands (Perined) on all births between 2000 and 2010 to mothers recorded as Mediterranean (i.e., of Turkish/Moroccan descent, a proxy for Muslim) or ethnically Dutch. Ramadan exposure was defined as the occurrence of a Ramadan during gestation. The study found that occurrence of Ramadan during pregnancy among Muslims was not associated with altered birth weight, gestational length, newborn's sex, perinatal mortality, low Apgar, or mild congenital anomalies. The study concluded that despite earlier research showing long-term adverse health effects of prenatal exposure to Ramadan, there seems to be little or no relation between exposure to Ramadan

during pregnancy and birth outcomes. To aid decision-making on this subject, experts' opinion on this issue were surveyed.[41] The survey was answered by 108 obstetricians and gynecologists. Most physicians recommended against fasting in the second and third trimesters, while fasting in the first trimester was controversial. Senior specialists were more lenient about fasting than younger specialists.

Tith *et al*.[42] evaluated the association between RF during pregnancy and the risk of preterm birth for Arab women in Canada. They analyzed birth certificates from 3,123,508 deliveries in Quebec, Canada, from 1981 to 2017. They identified 78,109 births of Arabic-speaking women and determined if Ramadan occurred during any trimester of pregnancy. The study showed that Arabic speakers had an overall preterm birth rate of 5.53/100 births, but rates varied with Ramadan's timing. Fasting during Ramadan between weeks 15 and 21 of the second trimester was associated with 1.33 times the risk of very preterm birth relative to no fasting. Between weeks 22 and 27 of the second trimester, fasting during Ramadan was associated with 1.53 times the risk of very preterm birth. RF was not associated with extreme or late preterm birth regardless of the trimester of pregnancy. The study concluded that RF during the second pregnancy trimester was associated with the risk of very preterm birth.

Finally, to determine the impact of RF on fetal development, Zoukal and Hassoune[43] systematically reviewed studies comparing the impact of fasting on fetal development in fasting and nonfasting pregnant women regardless of the stage of gestation. Ten studies met the research criteria and all were case–control. Studies were conducted in Turkey (6), Egypt (2), and Iran and Pakistan (1 each). Significant decreases in cephalic perimeter, biparietal diameter, and femoral length were noted in only one study. A change in the amniotic fluid index was observed in only two studies. The study showed that RF practiced by healthy pregnant women has no negative impact on fetal development.

Sports and athletes' well-being in Ramadan

Several groups developed academic interest in the impact of RF on physical work, athletes' performance, and well-being. Eleven articles were published in 2019; six reported original observations, four were systematic reviews, and one article provided a summary and recommendations. Omrane *et al*.[44] quantified the physical workload during Ramadan 2015 (summer season) and verified if this load changes significantly compared with periods of nonfasting (in summer or winter seasons). The physical workload in the month of Ramadan was found to be medium and did not significantly differ from that noted in the nonfasting periods (outside of Ramadan). Gueldich *et al*.[45] investigated RF impact on the underlying mechanisms of force production capacity during maximal voluntary isometric contraction using the superimposed twitch technique in ten healthy male physical education students before, during, and after Ramadan. The results showed that RF-related impairment of maximal muscle force seems to be related to nervous alterations of the voluntary activation level, whereas the RF did not adversely affect peripheral mechanisms. Hsouna *et al*.[46] assessed changes in short-term maximal performance, alertness, dietary intake, sleep pattern, and mood states of physically active young men before, during, and after Ramadan observance in 12 physically active young men. Ramadan had no adverse effects on the 5-jump performance, alertness, or mood states in physically active young men. However, sleep duration was shorter, and sleep quality improved following Ramadan. The fractional intake of fat also increased at the expense of carbohydrate during Ramadan, and the protein intake was lower at the beginning of Ramadan than before, at the end of, and after Ramadan. Carling and Lugier[47] examined the impact of RF on running activity profiles in elite soccer players during an official 90-min soccer match. Their results notably showed that players commencing play in a fasted state and completing 90 min generally coped physically, partly explained by nutritional intake during half-time and the adoption of a pacing strategy. Additional studies are nevertheless warranted using more controlled holistic experimental approaches and metrics (e.g., objective and subjective: physical/physiological/perceptual and technical) to improve the understanding of

Ramadan's effects on performance, particularly over consecutive matches. The inclusion of larger sample sizes (teams + matches) is also necessary to better account for the large natural variability inherent to match running performance, and assess the effects of RF on recovery following a soccer match simulation. Bouzid *et al*.[48] described eight elite soccer players who performed a modified Loughborough Intermittent Shuttle Test protocol on two occasions before and during Ramadan. Perturbations in physical performance and subjective rating parameters were higher at the end of Ramadan. However, this study's results showed that RF did not adversely affect the recovery following soccer match simulation in professional soccer players. Aziz *et al*.[49] examined the extent to which RF affects badminton skill performance under simulated (i.e., competitive) match-play conditions. Ten male Muslim national-level badminton players performed a 40-min (2 sets ×20 min per set in each match) badminton single matches in a nonfasted (CON) and in Ramadan-fasted (RAM) state on separate occasions They demonstrated that although RF resulted in increased sensations of fatigue and tiredness during match-play, skill performances were however largely maintained, with the only observed decrement being a decrease in overhead smash velocity. Boukhris *et al*.[50] evaluated the effect of RF on feelings, dietary intake, rating of perceived exertion, and repeated high-intensity, short-term maximal performance in 13 physically active young nonobese men. RF has no adverse effect on feelings, dietary intake, and short-term maximal performance. However, the rating of perceived exertion during repeated high-intensity, short-term maximal exercise reduced at twenty days after Ramadan in comparison to last 10 days of Ramadan.

Four systematic reviews addressed the different aspects of sports medicine.[51-54] Fernando *et al*.[51] examined the effect of RF on weight and body composition before and after Ramadan after excluding the effect of diet and physical activity. There was a significant positive correlation between starting BMI and weight loss during the fasting period. Consistently, there was a significant reduction in fat percentage between pre-Ramadan and post-Ramadan in people with overweight or obesity, but not in those of normal weight. At 2–5 weeks after Ramadan's end, there was a return toward, or to, pre-Ramadan measurements in weight and body composition. Chtourou *et al*.[52] evaluated Ramadan's fasting on physical performance measures in soccer players through a systematic appraisal of the literature from two databases. Most studies showed that RF did not impair short-term maximal performances in soccer players (i.e., vertical jump, sprint performance, maximal voluntary contraction, handgrip, and agility performance). The continuance of training during RF, with maintained training load, had no adverse effects on short-term maximal performances and soccer-specific skills. However, the 30-s Wingate test performances, the RSE tasks, and the long-duration incremental and nonincremental exercises were significantly impaired during RF even when the training load was maintained. Trabelsi *et al*.[53] evaluated the effects of RF on hematological data in athletes through a systematic appraisal of the literature. Ramadan-related measurements of any hematological indices in athletes were considered. Compared to before Ramadan, hematocrit and hemoglobin values increased in three studies, decreased in one study, and did not change during RF. Another study reported increased hematocrit and a puzzling decrease of hemoglobin after Ramadan compared to before RF. In most studies, blood platelet counts, and the limited number of immune functions used to date, remained unchanged. All reported changes in hematological indices remained within the normal reference range of the laboratory. Therefore, regular training can continue safely during RF from a hematological viewpoint. Aloui *et al*.[54] assessed the effects of RF on body composition in athletes. Data from 12 studies met the inclusion criteria for this review, which involved 183 athletes of different sport disciplines. The analyzed studies collectively indicate that BMI and BFP are generally lower during Ramadan than before Ramadan, while lean mass and total body water remain unchanged during Ramadan. Despite the importance of body composition control in sport and exercise settings, there are still many aspects of

body composition that should be more thoroughly assessed in athletes during Ramadan. More research, especially well-conducted randomized controlled trials, are needed to evaluate the magnitude of body composition changes in athletes during Ramadan.

Chamari *et al*.[55] provided practical recommendations based on an updated, evidence-based synthesis of the existing scholarly literature and/or expert opinions on the topic and subsequently, some useful tips for athletes, coaches, medical and scientific support, and sports managers, in order to guide them on how to promote appropriate behavioral, social, and psychological strategies to cope with the changes and potential constraints induced by the observance of RF. These recommendations should be adjusted and coped with, utilizing a holistic approach, rather than on single alteration/perturbation. Moreover, the implemented strategies should not be "one-size-fits-all" approach. It should instead take into account the variability among athletes and their specific needs including their social and living environment, as it may be more challenging when the individual is performing RF in a predominantly non-Muslim majority country.

Changes in the structure and function of the eye during fasting

Armstrong *et al*.[56] evaluated Ramadan's fasting on the level of tear film matrix metalloproteinase-9 (MMP-9) and other standard indicators of dry eye disease in forty healthy patients without a history of ocular disease before and during Ramadan. Ocular Surface Disease Index scores, tear breakup time (TBUT), Schirmer I test, and corneal fluorescein staining were evaluated at each time point. InflammaDry positivity increased during RF. The mean TBUT decreased during RF. The authors recommended that patients who suffer from dry eye disease and those who develop symptoms during Ramadan are advised to seek medical advice. Uyar *et al.*[57] assessed Ramadan's fasting on choroidal thickness (CT) and its associated diurnal variations using spectral-domain-optical coherence tomography in a single eye of 87 healthy individuals twice a day around 8.00 a.m. and during and 1 month following Ramadan. Measurements of CT and retinal thickness were performed at central, temporal, and nasal segments. The comparison of measurements revealed that temporal CT in the morning and foveal, temporal, and nasal CTs at afternoon significantly reduced during fasting. Diurnal variations of foveal and temporal CTs during fasting were significantly higher than that of the controls. In addition, retinal thicknesses during fasting significantly reduced compared to that of the controls in all segments measured at 4.00 p.m. The results suggest that fasting and dehydration caused a reduction of the CT and retinal thickness. Similarly, they are also responsible for the increased diurnal variation of CTs. Ekici Gok *et al*.[58] evaluated the effect of fasting on contrast sensitivity (CS) during RF in 45 healthy male individuals aged between 20 and 40 years, working in the same environment. Functional acuity contrast testing was performed. CS increased at the spatial frequency of three cycles per degree (cpd) at the end of the 1st week of Ramadan in comparison to the CS measured before Ramadan. The mean CS values increased at the spatial frequencies of 3 and 12 cpd at the end of the last week of Ramadan in comparison to the mean values measured before Ramadan. However, the authors could not confirm that RF has an adverse effect on CS. Finally, in a prospective study, Duru[59] examined 34 healthy eyes. The choroidal, macular, and retinal nerve fiber layer thicknesses were measured using spectral-domain-optical coherence tomography. The results revealed that RF is associated with alterations in choroidal and paracentral macular thickness in healthy volunteers. However, more detailed investigations should be designed to evaluate whether fasting has a pivotal influence on pathological conditions.

Gut and liver in Ramadan

Several studies investigated the effects of RF on gut and liver functions, and related parameters. Rimmani *et al*.[60] investigated the efficacy of dexlansoprazole 60 mg during Ramadan in patients with symptomatic heartburn by incorporating a mean Gastroesophageal Reflux Disease Questionnaire (GERDQ). Dexlansoprazole was started on day 8 for 3 weeks. The primary end point was relief of heartburn expressed as mean 24-h free heartburn percentage (24FH%) per weekly period. On dexlansoprazole, 24FH% increased in weeks

2 and 4. The mean GERDQ scores decreased in weeks 2 and 4 and the mean heartburn severity score decreased. Early response was higher in patients with GERDQ scores ≥8. Dexlansoprazole has the potential of reducing heartburn during Ramadan. Ebrahimi *et al.*[61] determined the effects of RF on liver function, Visceral Adiposity Index (VAI), and Atherogenic Index of Plasma (AIP) in fasting and nonfasting subjects with NAFLD. Anthropometric and biochemical parameters and ultrasound grading were measured before and after Ramadan. The mean decreases in anthropometric indices were significantly different between groups. The values of AIP and VAI decreased at the end of the study in both groups, and the mean of changes showed no differences between groups. The changes in the concentrations of liver enzymes, as well as the severity of hepatic steatosis, showed remarkable differences between groups for serum glutamic oxaloacetic transaminase and serum glutamic pyruvic transaminase, and liver steatosis. Özkul *et al.*[62] enrolled nine subjects in a study during Ramadan to assess changes in stool microflora and associated nutrition parameters. Stool samples were collected at baseline and at the end of Ramadan. They found an abundance of *Akkermansia muciniphila* and *Bacteroides fragilis* group but a significant decrease in serum fasting glucose (FG) and TC levels in subjects. These findings may contribute to the understanding of fasting–gut microbiota interaction. Jarrar *et al.*[63] evaluated satiety, bowel habits, body composition, blood glycemia, and blood lipidemia after the consumption of high-fiber cereal at dawn during RF. Participants were randomized to consume either 90 g of high-fiber cereal at Sohour for 20 consecutive days (n = 45) or to maintain their habitual diet intake (control; n = 36). The intervention group reported higher satiety rating scores, improved bowel habits, and reduced bloating frequency after the 20-day intervention. Significantly higher intake of carbohydrates and dietary fiber was observed in the intervention group. TC and LDL-C were significantly lower among the intervention group compared to those of the control group. No significant differences in body weight, BFP, WC, BMI, blood glucose, HDL-C, or TG were observed between the two groups.

Spirometry and management of asthma in Ramadan

A few articles have addressed the impact of RF on pulmonary functions in healthy people and in patients with bronchial asthma. Ben Fraj *et al.*[64] studied the spirometric data of a group of fasting and age-matched nonfasting Tunisian healthy male adolescents in a comparative quasi-experimental study during Ramadan of 2015. Spirometry measurements were taken on three sessions (before, mid, and after Ramadan). There were no effects of RF on forced vital capacity, forced expiratory volume, peak expiratory flow, or maximal mid-expiratory flow between the fasting and nonfasting groups. Mohammad *et al.*[65] reviewed the Islamic jurisprudence rulings on whether inhalers invalidate fasting or not. Some Muslim scholars believe that inhalers do not break the fast because of the gaseous nature of the inhaled agents. Other scholars disagree. It is important to assist patients in dealing with this dilemma. One approach is to help patients with the timing of their inhaler use. Most preventive asthma medications are prescribed twice daily. With good timing, patients can stick to their therapeutic regimens and still observe fasting. The authors stressed that physicians should educate patients about the importance of adherence to preventive therapy during the month of Ramadan to avoid precipitation of attacks and remind patients of the divine exemptions for those with serious medical conditions. The latter may be a golden opportunity for patients to stop smoking, a process that can be enhanced by compassionate education from the physician. The authors also recommended incorporating "Asthma in Ramadan" in the education curriculum of nursing, pharmacy, and medical schools.

Impact of fasting on skin, skeleton, and blood

Several groups have investigated the impact of RF on common skin and skeletal conditions and anticoagulation therapy.[66] Patients with various health problems, including those with different skin disorders, might choose to share this event with peers and family members. Bragazzi *et al.*[66] carried out a comprehensive overview on

the topic covering all forms of fasting including RF. Damiani *et al*.[67] described the effect of RF in 55 patients with a relatively long duration of hidradenitis suppurativa (HS). RF proved to be safe and effective in HS patients. Considering the small sample size and the exploratory nature of the investigation, further studies in the field are warranted, especially longitudinal, prospective, and randomized ones. The same group also evaluated a sample of 108 moderate-to-severe plaque psoriasis patients.[68] A significant decrease in the "Psoriasis Area and Severity Index" (PASI) score after RF was seen. These findings reflect the influence of dieting strategy, the biological clock, and circadian rhythm on the treatment of plaque psoriasis. Furthermore, the association between nutritional intake and sleeping pattern during Ramadan with sebum production was explored in forty individuals evaluated before and 3 weeks into RF.[69] Parameters assessed included nutrient intake, sleep quality, and duration of sebum production. Significant decreases were found in protein and total fat intake. Glycemic load also decreased significantly. Despite no reduction seen in total sleep duration, night sleep deprivation occurring during Ramadan was associated with more subjects having poor sleep quality. Despite lower glycemic load and dairy product intake, RF was associated with increased sebum production which is more likely a result of the circadian rhythm shift in sebaceous gland activities.

To determine the effect of RF on arthritic conditions, Adawi *et al*.[70] enrolled 37 patients with psoriatic arthritis (PsA) who fasted for 17 h during Ramadan, 2016. The study participants were treated with different biologic agents including methotrexate, TNF-α blockers, and IL-17 blockers. After a month of IF, CRP levels, Bath Ankylosing Spondylitis Disease Activity Index, PASI, and Disease Activity Index for PsA decreased. Similarly, enthesitis improved after fasting, with decreased Leeds Enthesitis Index (LEI) score and dactylitis severity score. Fasting was found to be a predictor of a decrease in PsA disease activity scores. IL-17 therapy was found to be an independent predictor of decreases in LEI after fasting. These preliminary data may support the use of chronomedicine in the context of rheumatic diseases, namely PsA. Further studies are needed to support their findings.

Patients on anticoagulation therapies might be at risk of fluctuations during RF. Zghal Mghaieth *et al*.[71] compared the fluctuations of anticoagulation in fasting and nonfasting patients taking acenocoumarol to identify factors associated with such fluctuations before, during, and after Ramadan. The enrollment involved ambulatory patients aged over 18, without medical contraindications to fasting (for the fasting group), and whose international normalized ratio (INR) was within the therapeutic target range in the 3 months prior to Ramadan. Anticoagulation monitoring consisted of five consecutive INR assays before, during, and after Ramadan. INR stability was calculated for 122 patients (84 fasting patients). The fluctuations of anticoagulation balance were comparable between fasting and nonfasting patients taking acenocoumarol. Ghiasian *et al*.[72] evaluated the effect and prognosis of fasting in 58 patients with cerebral venous thrombosis (CVT) using oral-combined contraceptives (OCPs). Fasting in patients using OCPs caused significantly higher focal neurological deficit and higher hemorrhage. At discharge, 51.6% and after 3 months, 25.8% of patients with fasting had disability (6> modified Rankin Scale >1). Patients who used OCPs as a sole risk factor, 25.9%, at discharge and after 3 months (11.1%) had a disability. Fasting in patients with CVT using OCPs causes a significant increase in focal neurological deficit and hemorrhage, which also increases the hospital stay and lengthens recovery. However, the long-term prognosis and mortality of CVT were similar between the two groups.

Effects of Ramadan on endocrine and metabolic conditions

Two aspects of endocrinology (other than diabetes) were published. One considered thyroxine replacement therapy and the other impact on the components of metabolic syndrome (MetS). Dabbous *et al*.[73] compared two time points of levothyroxine intake during Ramadan in terms of change in thyroid-stimulating hormone (TSH), compliance, and convenience. Using an open-label, randomized, prospective trial on 96 adult patients

with primary hypothyroidism and stable TSH for 6 months, patients were randomized to two groups: 50 patients took levothyroxine 30 min before breaking the fast at sunset (Group A), whereas 46 patients took it 30 min before the early morning meal before dawn (Group B). TSH levels increased in both groups after RF. The authors did not detect any difference between the two groups in terms of compliance or convenience in the timing of taking the medication.

Studies on the impact of RF on MetS components among healthy Muslims observing Ramadan month have yielded contradictory results. Faris *et al*.[74] aimed to obtain a more stable estimate of the effect size of fasting during Ramadan on MetS components, examine variability among studies, assess the generalizability of reported results, and perform subgroup analyses for associated factors. They identified 85 studies (4326 participants in total) conducted in 23 countries between 1982 and 2019. RF-induced effect sizes for MetS components were small reductions in WC, SBP, FG, and TGs and a small increase in HDL-C. They concluded that among healthy people, RF shows small improvements in the five MetS components, namely WC, SBP, TG, FG, and HDL and also better post main meal control in Ramadan, without affecting HbA1c, or increasing the incidence of hypoglycemia.

Three original studies considered various aspects of metabolism.[75-77] Beltaief *et al*. studied 517 patients with ≥2 cardiovascular risk factors before, during, and after Ramadan.[75] They noted a significant and discrete rise in blood glucose level, TG, cholesterol, and creatinine during Ramadan. These disturbances decreased significantly after Ramadan. The same variations were observed among people with diabetes (n = 323). HbA1c decreased significantly after Ramadan. They found no significant correlation between variations of metabolic parameters and dietary intake. The authors concluded that Ramadan induces a transient but well-tolerated perturbation of metabolic parameters followed by a significant post-Ramadan improvement. These changes did not seem to be directly related to dietary intake. Faris *et al*.[76] examined the impact of RF on visceral adiposity, circulating adipokines, and glucoregulatory markers in patients with overweight or obesity. Body weight, visceral fat tissue area (measured by 3D-MRI), glucoregulatory factors, serum adipokine concentrations, dietary intake, and physical activity were assessed 1 week before and at the end of Ramadan. Body weight, visceral fat tissue area, serum TC, TG, HDL-C, and SBP significantly decreased at the end of Ramadan. Serum levels of adiponectin, IL-6, TNF-α, and IGF-1 also significantly decreased, but serum visfatin, leptin, apelin, IL-10, and IL-10/IL-6 ratio significantly increased at the end of Ramadan. Changes in visceral adiposity significantly correlated with changes in plasma glucose. Madkour *et al*.[77] evaluated the impact of RF on the expression of cellular metabolism (SIRT1 and SIRT3) and antioxidant genes (TFAM, SOD2, and Nrf2). They showed that the relative gene expressions in subjects with obesity in comparison to the counterpart expressions of controls for the antioxidant genes significantly increased at the end of Ramadan. However, the metabolism-controlling gene (SIRT3) showed a highly significant downregulation accompanied by a trend for reduction in the SIRT1 gene at the end of Ramadan. These results suggest that RF ameliorates the genetic expression of antioxidant, anti-inflammatory, and metabolic regulatory genes.

Fasting and neurological disorders

The impact of Ramadan on neurological diseases and their related factors also drew interest in the 2019 literature. Specific disease states were investigated by three research groups which included control of Parkinson's disease (PD) and the effects of RF on postural control in elderly fallers and nonfallers. Tabrizi and Karimi[78] compared the incidence of neurological diseases and their related factors in Ramadan and the following month (Shawal) in 2015. They found no significant difference between the 2 months in the frequency of admissions due to neurologic diseases. In another study, Kamel *et al*. observed a group of 24 patients with PD who had planned to fast during the Ramadan of 2016.[79] Twenty patients fasted during the whole month. Six were able to abstain from drug intake from dawn to dusk; the others needed one or two intakes

of L-DOPA during the day. Compared to before Ramadan, there were no significant changes after the fasting period in the quality of life (PDQ 39), Non-Motor Symptom Scale, or Clinical Impression of Severity Index scores. Finally, Laater *et al*.[80] compared the effects of RF on postural control in elderly fallers and nonfallers. The protocol involved 24 healthy elderly male volunteers who were divided into two groups: fallers and nonfallers. The results showed that RF alters the postural control of elderly fallers and nonfallers equally, but the amplitude of this alteration seems to be more pronounced in fallers than nonfallers.

Mental well-being in Ramadan

Two original studies and one systematic review addressed the mental well-being during RF.[82,83] Düzçeker *et al*.[81] examined the cross-sectional relationship between RF as a spiritual factor with prolonged hunger and disordered eating behaviors. The study was conducted in June 2016 and consisted of 238 fasting and 49 nonfasting adolescents. The risk of disordered eating, body image dissatisfaction, and nutritional status was assessed. The study suggests that because the motivation of adolescents to fast during Ramadan was due to spiritual decisions rather than weight control or other factors, RF did not correlate with disordered eating behaviors or body image dissatisfaction. Briki *et al*.[82] examined how RF could influence positive and negative feelings in 91 healthy Muslims. They voluntarily completed an online questionnaire once a week during 8 weeks before, during, and after Ramadan (2013) at the middle of the day. The results showed that RF was associated with lower levels of positive affect, negative affect, and depression. However, anxiety and well-being were not influenced by RF. This study suggests that RF would act as a buffer against the intensity of emotions. Pourabbasi *et al*.[83] performed a systematic review to evaluate the relationship between Islamic fasting and cognitive activities. The findings were inconclusive, and this might be an interesting area for further research with larger sample sizes and better evaluation tools.

Sleep pattern and quality during Ramadan

The interplay of RF with several aspects of sleep physiology was addressed by several authors in two original articles and two systematic reviews. Boukhris *et al*.[84] examined sleep and alertness during Ramadan observance in 14 young, physically active men. Information was also collected on dietary intake, muscle soreness, fatigue, and mental stress. They concluded that Ramadan observance had an adverse effect on sleep quantity and mental alertness, but not on sleep quality. However, dietary intake, muscle soreness, fatigue, and mental stress remained unaffected. Almeneessier *et al*.[85] performed a quantitative electroencephalogram (EEG) analysis of eight young, healthy volunteers with and without fasting. The authors demonstrated that during wakefulness, there was no difference in EEG slowing or absolute powers in the delta, theta, alpha, and beta frequency bands between nonfasting and fasting subjects. Spectral analysis of EEG power indicates that intermittent diurnal fasting does not increase sleepiness, but future larger studies are needed to confirm the current findings.

Two systematic reviews evaluated the impact of RF on sleep patterns with conflicting results. Faris *et al*. analyzed several sleep quality measures based on 24 studies (646 participants) conducted in 12 countries from 2001 to 2019.[86] The authors concluded that during the month of Ramadan, there is approximately a 1-h reduction in total sleep time (TST) and nearly a 1-point increase in the Epworth Sleepiness Scale. On the other hand, Trabelsi *et al*. included 13 studies evaluating the TST of active individuals in relation to RF and found that TST decreased in five studies, increased in one, and remained unchanged in seven studies.[87] As no firm conclusions could be drawn regarding sleep quality or characteristics, further studies are warranted.

Ramadan-related cultural and professional perspectives

Three aspects of professional–patient interaction were addressed in four articles. Patients' perspectives on communicating with clinicians were explored by Amin *et al*. in two different papers.[88,89] In the first, they explored Muslims' perspectives on factors influencing communication with clinicians concerning fasting during Ramadan. Semi-structured interviews were conducted with a sample of patients. Data emerging from narratives were mapped and clustered into patient participation and quality of care;

predisposing factors (perceptions about fasting and its significance including a sense of spiritual benefit when fasting and sense of guilt when not fasting, prior experiences including prior conversations with clinicians on fasting and experience of fasting while sick, patients' personality and locus of control, belief in the legitimacy of participation, motivations and perception of the need to communicate with clinicians about fasting, provider verbal and nonverbal responses, and provider–patient rapport) and enabling factors (knowledge about the topic and repertoire of communicative skills, presence of companions during the appointment, and timing of appointments). The framework provided insight into patients' perspectives on barriers and facilitators for communication with clinicians about fasting during Ramadan. Stakeholders must consider those issues when implementing interventions aiming to adopt a concordant approach in providing care for this group of patients. In the second paper,[89] the authors mapped data into clinician's belief to care for those patients, belief in group's ability to provide care, likely consequences of providing such care, knowledge, learning by observing other clinicians, cultural norms and perceived acceptability and prevalence of care provision, environmental barriers and opportunities, and communication approach. Ben Saida *et al*.[90] investigated the impacts of Ramadan on intensive care unit (ICU) admission patterns and outcomes in a retrospective study from Tunisia. Of the 748 patients who were admitted to the ICU before, during, and after Ramadan over 10 years, the number of patients with CKD and those admitted with hypovolemic shock was significantly higher. However, there was no significant difference in length of stay or mortality.

Concerns about the health effects of RF and the risks of work-related injuries have increased in Western European (EURO) countries. Riccò *et al*.[91] performed a retrospective database-based analysis assessing the impact of RF on occupational injuries (OIs) in North-Eastern Italy among migrant workers from the Eastern Mediterranean Regional Office (EMRO). They suggested that EMRO workers exhibit a significantly increased risk for OIs during Ramadan in periods characterized by heat waves, while their frequency somehow reduced for days associated with Ramadan characterized by increased but not extreme temperatures. However, these results may be attributable to explanatory causation in the specific differences between EMRO and EURO workers in the job tasks performed at the workplace. Not coincidentally, no significant differences were found regarding industrial settings, mechanisms of OIs, or final prognosis. Despite the obvious practical implications for health decision makers and policymakers, due to the limitations of the present investigation, further studies are warranted. Kankou *et al*.[92] examined the factors associated with the virological rebound (VR) at the occasion of a temporary stay to the country of origin for HIV-positive migrants from the sub-Saharan Africa participating in the ANRS-VIHVO adherence study between 2006 and 2009. They included patients on effective antiretroviral therapy with controlled pretravel HIV-1 plasma viral load. They found that traveling during Ramadan while observing the fast and extension of the stay were both associated with VR. The authors inferred that VR was partly explained by structural barriers to adherence such as the extension of the travel and inadequate management of RF. Individuals' journeys should be carefully planned with health-care providers.

Faith-related health-care needs are generally not formally addressed in the medical curricula. Therefore, Haq *et al*.[93] recommend additional content that would better tailor the undergraduate curriculum to cater to the needs of this large cohort of Muslim patients with the expectation that patients would have their faith-related health queries resolved by health-care providers. Based on a survey of select academics, the authors suggested that (a) the topics proposed were, in fact, legitimate faith-related health-care needs of Muslim patients, and (b) their inclusion would add value to the undergraduate medical curriculum and train practitioners to improve patient outcomes more holistically.

Conclusions

The interest in the implications of RF for health outcomes continues. Although fasting for healthy adults is an article of faith, there is still a lot that can be

learned from studies on how fasting may affect people in sickness or in certain stages of life such as childhood, elderly, pregnancy, or in times of hardship such as traveling and adverse weather circumstances. Through these studies, we can gather better evidence rather than rely on consensus. Impact of RF on physiology, nutrition, pregnancy, and athletes' well-being received comparatively prominent coverage by research work published in 2019. Renal function, eyes, and some metabolic concerns in patients with hepatic and metabolic conditions were also covered. Some interest in cultural and professional aspects of care for fasting people was also published. The volume remains modest when the number of people involved is taken into consideration. By reviewing all the literature published in a full year of 2019, we hope to provide a bird's eye view of the subject for those who need to catch up on the state-of-the-art today.

Authors' contribution

All authors contributed to the conception of the study. SAB performed the initial literature searches and produced the initial draft. All authors further developed their assigned sections and reviewed the whole manuscript for intellectual content and approved its final version.

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Conflicts of interest

There are no conflicts of interest.

Compliance with ethical principles

No ethical approval is required.

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