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Review

The effects of Ramadan fasting on various physiological and biochemical parameters on Muslim soccer players

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ABSTRACT

This systematic review aimed to examine the effects of Ramadan fasting on biomarkers and performance in Muslim soccer players, addressing the challenges they face due to disrupted dietary patterns and daily routines during this period. A comprehensive literature search was conducted using electronic databases, following PRISMA guidelines. Studies focusing on Ramadan fasting's impact on soccer players' biomarkers and performance were included and critically evaluated. The study revealed that Ramadan fasting did not negatively impact recovery after matches. However, it resulted in decreases in certain blood parameters and performance indicators. Increased sleepiness and muscle fatigue were also observed. Notably, maintaining a training program during Ramadan did not increase oxidative stress. Fasting improved systemic inflammation biomarkers in obese males and did not adversely affect liver and renal function biomarkers. The effects on body weight and plasma volume appeared to be linked to dietary factors or the body's biochemical response to fasting. While Ramadan fasting presents challenges for Muslim soccer players, its overall impact on performance and recovery appears manageable. The findings suggest that players can maintain their performance levels during Ramadan with proper management and training adjustments. However, individual variations and specific aspects of performance should be considered when developing strategies for Muslim athletes during this period.

Introduction

Fasting is a widespread practice in various religious traditions like Islam, Christianity, Judaism, and Hinduism. In Islam, fasting involves refraining from eating and drinking from dawn until sunset.[1] Though Islam is only 1444 years old, the world's total population includes 23% Muslims, and in about 50 countries, the majority of the population is Muslim. Muslims follow religious laws in different ways, depending on their countries and religious beliefs.[2]

However, Ramadan fasting (RF) hours differ based on a country's latitude. Usually, a summer RF has different requirements than a winter Ramadan.[3]

Ramadan is a joyous festival for Muslims, who believe that the Koran began to be revealed to the prophet Mohammed "Sal Allah alaihe Wasalam". This month is sacred for studying the Koran, prayer and fasting[4] (Russ Kavalhuna, 2020). Worldwide, more than 1.8 billion Muslims stop all food and drink from dawn to sunset[5] (Akhtar et al., 2022). However, some people are exempt from fasting, such as the elderly, the frail, those suffering from illness and even those who travel[6] (Hussain et al., 2020).

During daylight hours, Muslims refrain from consuming food, liquids, and engaging in activities such as smoking and sexual intercourse.

Abbreviations: RF, Ramadan Fasting; COPD, Chronic Obstructive Pulmonary Disease; ESR, Erythrocyte Sedimentation Rate; CRP, C-Reactive Protein; RBC, Red Blood Cell; WBC, White Blood Cell; RAST, Running-based Anaerobic Sprint Test; HDL-C, High-Density Lipoprotein Cholesterol; LDL-C, Low-Density Lipoprotein Cholesterol; Apo-AI, Apolipoprotein AI; Apo-B, Apolipoprotein B; Lp-a, Lipoprotein(a); Hcy, Homocysteine; hs-CRP, High-Sensitivity C-Reactive Protein; BR, Before Ramadan; FWR, First Week of Ramadan; LWR, Last Week of Ramadan; RPE, Rating of Perceived Exertion; YYIRT, Yo-Yo Intermittent Recovery Test.

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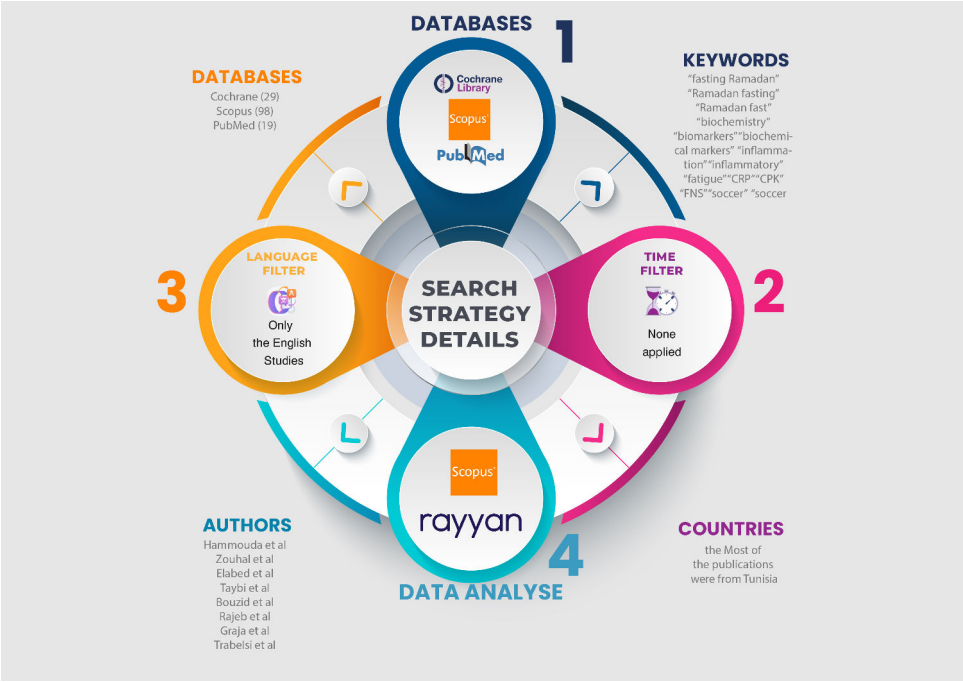

Fig. 1. Search Strategy details
CRP: C-reactive Protein; CPK: Creatine Phosphokinase.

Beyond its physical aspects, Ramadan holds great ethical and spiritual value, offering an opportunity to cleanse the soul and establish a closer connection with "Allah" through introspection and supplication. Fasting takes place from dawn until sunset, while meals, called Suhoor and Iftar, are permitted before dawn and after sunset, respectively.[7]

The list provided above does not address the specific concerns of competitive athletes, for whom fasting during Ramadan poses a significant challenge. This has raised widespread global concerns regarding the impact on their performance.[8]

This fasting period can lead to various psychological and physiological changes, including alterations in body weight, blood components, mood, and focus.[9, 10] These changes also include dehydration, metabolic responses, fluctuations in sleep and wakefulness patterns, hormone secretion, and the functioning of various organs in the body.[9, 10] Athletes are required to handle these changes effectively by devising a suitable training plan.[11] This is particularly significant for Muslim athletes who prioritize their physical well-being and strive to enhance their athletic performances.[12]

For Muslim soccer players, the decision to fast during Ramadan poses a delicate balance between honoring their faith and maintaining optimal athletic performance.[12] Soccer, being a highly demanding sport that relies on stamina, agility, and quick decision-making, requires athletes to sustain high levels of energy and physicality throughout a match.[13] Therefore, understanding the impact of Ramadan fasting on biomarkers, such as hydration status, metabolic profiles, muscle performance, and recovery, becomes imperative for both players and their coaches because gaining insight into the biological mechanisms that define the traits of contemporary professional soccer is an integral component of the ongoing development of training systems.[14, 15]

Extensive research has been conducted on the impact of RF, on aspects of health and performance covering various populations and settings. However, there remains a gap, in our understanding regarding how RF affects biomarkers related to sports and athletic training among Muslim soccer players. To address this gap our objective is to conduct an analysis that synthesizes existing literature on this subject critically evaluating the quality, consistency, and implications of the findings.

Some research demonstrated adverse impacts of Ramadan fasting on parameters like hemoglobin, hematocrit, RBC (Red Blood Cell) and WBC (White Blood Cell) counts.[16] Additionally, there were findings of heightened sleepiness, diminished performance in specific assessments like the Running-based Anaerobic Sprint Test (RAST), increased muscle damage, and elevated fatigue.[17]

On the other hand, there have been reports of beneficial outcomes from fasting ramadan. For instance, soccer players have experienced positive effects; the caloric restriction brought about by Ramadan fasting led to enhancements in cardiovascular health markers such as lipids and inflammation when engaging in intermittent evening exercise.[18] RF also improved systemic inflammation biomarkers without negatively affecting liver and renal function in obese patients.[19]

Apart from this, continuing the hypertrophic training program during the month of Ramadan did not result in elevated oxidative stress. Instead, it led to an enhancement in antioxidant status.[20] Conversely, certain indicators of kidney function and serum electrolytes exhibited an increase, pointing towards a state of dehydration associated with exercise during Ramadan.[21]

The differences observed among these studies could be attributed to variations, in study design, sample size, measurement methods, intervention duration, training intensity levels, environmental conditions, nutritional intake patterns, and individual characteristics.

However, most of these studies have primarily concentrated on isolated biomarkers than exploring how they interact and relate to one another. Additionally, a considerable number of studies have utilized unrepresentative samples, which hinders their ability to be widely applicable and reliable. Furthermore, there has been a scarcity of research specifically delving into the impact of (RF) on soccer players, who encounter obstacles due to the rigorous physical demands and competitive environment inherent, in their sport.

To address these concerns this systematic review aims to conduct an organized examination of the impact of RF, on biomarkers in sports and athletic training among Muslim soccer players.

By shedding light on the relationship between fasting Ramadan, biomarkers, and the soccer player, we aim to contribute to the broader understanding of how athletes can optimize their performance while respecting their religious and cultural practices.

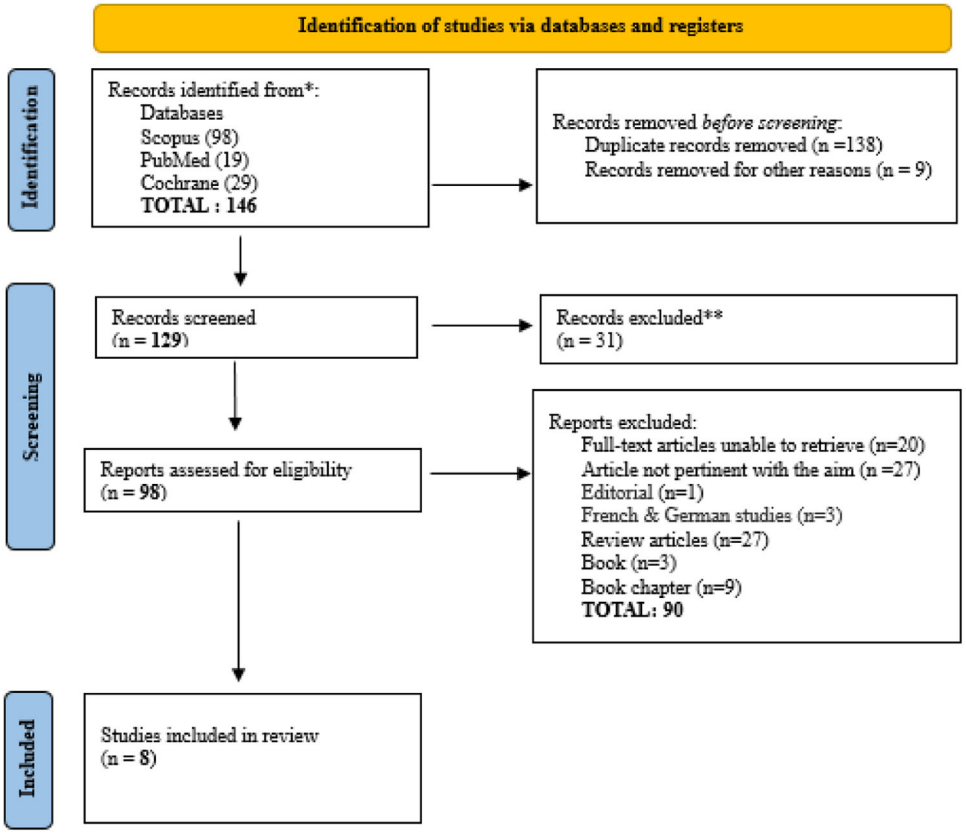

Fig. 2. Preferred reporting items for systematic reviews and meta-analyses 2020 flow diagram.

Through the integration of information gleaned from research on this topic, this review aims to present a more reliable and robust assessment of the scope, trends, diversity, and origins of variations in these effects. Moreover, it will delve into the underlying mechanisms responsible for these influences and their potential consequences on health and performance results. This investigation is set to bridge an existing gap in the current literature, offering valuable perspectives for athletes, coaches, trainers, nutritionists, healthcare practitioners, researchers, policymakers, and stakeholders engaged in this domain.

Search Strategy details

A comprehensive literature search was conducted using electronic databases. The stages of searching for documentation and its processing are described in the Fig. 1 and 2.

Results

The initial database search produced 146 items. After removing duplicates and irrelevant studies, a total of 8 studies were included in the current systematic review (Fig. 1). Among these, eight studies examined the impact of fasting on biochemistry and biomarkers, such as fatigue and inflammation, in muslim athletic (Table 1). The first study focused on how Ramadan-Fasting affects inflammatory and hematological indices in male patients with stable chronic obstructive pulmonary disease (COPD). The second study investigated the effects of ramadan fasting on recovery after a simulated soccer match in professional soccer players. The third study explored the effects of ramadan fasting on biochemical and anthropometric parameters in physically active men. The fourth study examined the effect of Ramadan intermittent fasting on cognitive, physical, and biochemical responses to strenuous short-term exercises in elite young female handball players. The fifth study analyzed the effect of resistance training during Ramadan on antioxidants and oxidative stress biomarkers in recreational bodybuilders. Another study investigated the effects of ramadan intermittent fasting on inflammatory and biochemical biomarkers in males with obesity. The seventh study focused on the simultaneous effects of ramadan fasting and time-of-day on apolipoprotein AI, B, Lp-a, and homocysteine responses during aerobic exercise in Tunisian soccer players. Finally, the last study explored the effect of Ramadan fasting and weight-lifting training on plasma volume, glucose, and lipid profiles in male weight-lifters.

The sample sizes varied from 8 to 40 participants in different studies. The majority of the research was conducted in Tunisia, with one study each in France, Germany, and Iran. The age range of the participants was 18 years and older. The fasting period varied from 8 to 17 hours, depending on the country and the year of the study. In terms of gender, seven studies focused on male participants exclusively, while only one study included a female sample. When it came to recruiting and sampling methods, most studies relied on convenience samples or purposive sampling.

The effects of Ramadan fasting (RF) on various physiological and biochemical parameters

Investigated the Effects of Ramadan Fasting on Recovery Following a Simulated Soccer Match in eight elite professional soccer players (age: 21.0 ± 0.4 years), after analyzing the data, it was found that there were significant decreases in performance measures such as squat jump, countermovement jump, maximal voluntary contraction, and 20m sprint at both the 48-hour and 72-hour time points. The decreases were more pronounced at the end of Ramadan compared to before Ramadan. Additionally, levels of creatine kinase, a marker of muscle damage, significantly increased at 24 and 48 hours after both before Ramadan and at the end of Ramadan. Uric acid levels increased only at the 0 and 24-hour time points before Ramadan. Muscle soreness increased

Table 1
studies on Fasting Ramadan and biomarkers and soccer.

References	Subjects	Test Protocol	Timing of measurement	Results
22	Eight elite soccer players (age: 21.0 ± 0.4 years)	squat jump countermovement jump maximal voluntary contraction 20 m sprint creatine kinase uric acid **subjective ratings:** feelings scale quality of sleep fatigue muscle soreness and stress	0, 24, 48, and 72 h following LISTmod	Following LISTmod, performance: 1. squat jump (48 and 72 h) ($p < 0.05$). 2. countermovement jump (48 and 72 h), maximal voluntary contraction (0, 24, 48, and 72 h). 3. 20 m sprint (0 and 48 h) decreased significantly on both occasions. Decreases were higher at End-R than BR. 4. Creatine kinase levels increased significantly at 24 and 48 h at BR and End-R ($p < 0.05$) 5. Uric acid increased at 0 and 24 h only on BR. 6. Muscle soreness increased throughout the recovery period at both occasions, with a higher level at End-R. 7. Stress rating increased only at 0 h on End-R, while fatigue rating increased at 24 h at BR and at 0, 24, and 48 h at End-R.
23	Fifteen COPD patients (mean ± SD of age: 71 ± 6 years) who fasted during Ramadan	Spirometry Inflammatory (ESR; CRP; RBC; WBC) Hemoglobin Hematocrit mean corpuscular volume mean corpuscular haemoglobin platelets	2.5–4.5 hr before the interruption of the fasting	Findings were analyzed by applying Friedman ANOVA: 1. ESR Before-Ramadan: 3 (2–9), End-Ramadan: 7 (0–13), After-Ramadan: 9 (5–15) mm/h. 2. CRP Before-Ramadan: 20 (11–38), End-Ramadan: 15 (9–34), After-Ramadan: 20 (12–46) mg/L (were not significantly affected by RF). 3. Among all the hematological indices, RF influenced only hemoglobin: Before-Ramadan: 14.4 ± 2.2, End-Ramadan: 13.4 ± 1.3, After-Ramadan: 12.2 ± 0.9 g/dL. hematocrit Before-Ramadan: 45 ± 7, End-Ramadan: 40 ± 4, After-Ramadan: 39 ± 4% RBC Before-Ramadan: 5.1 ± 1.0, End-Ramadan: 4.6 ± 0.7, After-Ramadan: 4.4 ± 0.5 106/mm^3 WBC Before-Ramadan: 8673 ± 1911, End-Ramadan: 7840 ± 1526, After-Ramadan: 9507 ± 2190/mm^3. 4. Compared to the Before-Ramadan session, the End-Ramadan session values for hemoglobin, hematocrit, RBC and WBC were lower.
21	Eighteen physically active men (10 fasters and 8 non fasters)	anthropometric measurements dietary questionnaire fasting blood sample	before Ramadan (Bef-R), the 15th day of Ramadan (Mid-R), the 29th day of Ramadan (End-R), and 21 days after Ramadan (Post-R)	1. In fasters, body weight decreased by 1.9% ($P<0.001$) and body fat percentage decreased by 6.2% ($P=0.003$), while in nonfasters, body weight increased by 2.2% ($P<0.001$) and body fat percentage increased by 10.2% ($P=0.001$) from BR to End-R. 2. Fasters' hematocrit increased by 5.3% ($P<0.001$) and hemoglobin increased by 6.3% ($P=0.01$) from Bef-R to End-R. No changes in these parameters were observed in non-fasters. 3. Fasters experienced an increase in the following parameters from Bef-R to End-R: urea (8.7%; $P<0.001$), creatinine (7.5%; $P<0.001$), uric acid (12.7%; $P<0.001$), serum sodium (1.9%; $P<0.001$), serum chloride (2.6%; $P<0.001$) and high-density lipoprotein cholesterol (27.3%; $P<0.001$). 4. Only creatinine increased (4.4%; $P=0.01$) in non-fasters.
17	Twelve-woman athletes (elite)	Hooper index vigilance test (VT) Epworth sleepiness scale (ESS) five jump test (5-JT) modified agility T-test (MAT) maximal standing ball-throw velocity test (MSBVT) Running-based Anaerobic Sprint (RAST) Test Blood samples	one week before ramadan (BR) during the first week of Ramadan (FWR) and during the last week of Ramadan (LWR)	Rating of perceived exertion (RPE) was recorded immediately after the RAST. Blood samples were collected before and after exercises during each session: 1. ESS scores were higher during LWR than BR ($p < 0.05$). 2. MSBVT time decreased ($p < 0.05$) during LWR. 3. The power of three final sprints from the RAST decreased significantly only during LWR compared to BR ($p < 0.05$). 4. RAST fatigue index and RPE scores were

(*continued on next page*)

Table 1 (*continued*)

References	Subjects	Test Protocol	Timing of measurement	Results
				higher during LWR more than BR ($p < 0.05$). 5. hematological measures (i.e., red blood cells, hemoglobin and hematocrit), plasma osmolarity and energetic markers were unaffected by RF. 6. Biomarkers of muscle damage were higher after the RAST only during LWR compared to BR ($p < 0.01$ for all).
20	Eight male bodybuilders	anthropometric measurement and dietary questionnaire urine samples and Blood samples	one week before Ramadan (BR) during the first week of Ramadan (FWR) and during the last week of Ramadan (LWR)	Rating of perceived exertion (RPE) was recorded immediately after the RAST. Blood samples were collected before and after exercises during each session: 1. ESS scores were higher during LWR than BR ($p < 0.05$). 2. MSBVT time decreased ($p < 0.05$) during LWR. 3. The power of three final sprints from the RAST decreased significantly only during LWR compared to BR ($p < 0.05$). 4. RAST fatigue index and RPE scores were higher during LWR more than BR ($p < 0.05$). 5. hematological measures (i.e., red blood cells, hemoglobin and hematocrit), plasma osmolarity and energetic markers were unaffected by RF. 6. Biomarkers of muscle damage were higher after the RAST only during LWR compared to BR ($p < 0.01$ for all).
19	Twenty-eight males with obesity	Blood samples C-reactive protein (CRP) interleukin-6 (IL-6) tumor necrosis factor-alpha (TNF-α) aspartate aminotransferase (AST)	Blood samples were collected 24 h before the start of Ramadan (T0), on the 15th day of Ramadan (T1), the day after the end of Ramadan (T2), and 21 days after the end of Ramadan (T3)	Decreases were noted for interleukin-6 ($p = 0.02$, $d = 1.4$) and tumor necrosis factor-alpha ($p = 0.01$, $d = 0.7$), with no changes for C-reactive protein ($p = 0.3$; $d = 0.1$) in the EG compared to CG group. There were no changes ($P > 0.05$) in ΔPV recorded after RIF for either EG (-0.035 ± 0.02%) and CG (0.055 ± 0.06%).
16	Forty male weight-lifters 4 groups (n=10 each) control (C) fasting (F) traning (T) fasting-training (F-T)	medical questionnaire and Blood samples	Blood samples were taken at 24 hr before and 24 hr after one month of fasting and weight-lifting exercise.	1. Body weight and plasma volume showed significant ($P< 0.05$) decrease and increase in the F group ($P< 0.05$) respectively. 2. significant reduction was observed in F-T group body weight ($P< 0.01$). 3. significant increase was found in FBS level of F group ($P< 0.05$). 4. The lipid profiles and lipoproteins didn't change significantly in C, F, T and the F-T groups.
18	Fifteen male soccer players	The Yo-Yo intermittent recovery test (YYIRT) dietary intakes, lipid (HDL-C, LDL-C, Apo-AI, B and Lp-a) and inflammatory (hs-CRP and Hcy) profiles.	two times-of-day (07:00 and 17:00 h), 1-week before RF (BR), the second week of RF (SWR), and the fourth week of RF (ER)	1. Performances during the YYIRT were higher in the evening than the morning BR ($P < 0.05$), but this fluctuation was not observed during RF. 2. LDL-C, ApoB, and Lp-a were stable throughout the daytime BR. However, during RF they decreased at 17:00 h ($P < 0.05$). 3. HDL-C and Apo-AI increased after the exercise and were higher at 17:00 h BR ($P < 0.001$). Moreover, these parameters increased during RF ($P < 0.01$). 4. Hcy and hs-CRP increased during the exercise ($P < 0.01$) with higher evening levels BR. During ER, the diurnal pattern of Hcy was inversed ($P < 0.001$).

COPD: Chronic obstructive pulmonary disease, SD: Standard deviation; EG: Experimental Group, CG; Control Group. ΔPV; Resting plasma volume variation between pre andpost-RIF, LDL-C: Low-Density Lipoprotein Cholesterol; ApoB: Apolipoprotein B Lp-a: Lipoprotein (a); Apo-AI: Apolipoprotein AI; Hcy: Homocysteine; hs-CRP: high-sensitive C-reactive-Protein

throughout the recovery period, with higher levels observed at the end of Ramadan. Stress ratings increased only at the start of Ramadan, while fatigue ratings increased at the 24-hour time point before Ramadan and at the 0, 24, and 48-hour time points at the end of Ramadan. Overall, there were greater disruptions in physical performance and subjective ratings at the end of Ramadan. However, the study results indicated that Ramadan fasting did not have a negative impact on recovery following a simulated soccer match among professional players.[22]

When discussing the second study conducted by[23] which focused on the impact of Ramadan fasting (RF) on inflammatory and hematological indicators in male patients with stable chronic obstructive pulmonary disease (COPD), fifteen COPD patients (with an average age of 71 ± 6 years) who fasted during Ramadan 2017 volunteered for the research. Among the various hematological indicators, RF affected only hemoglobin levels (Before-Ramadan: 14.4 ± 2.2, End-Ramadan: 13.4 ± 1.3, After-Ramadan: 12.2 ± 0.9 g/dL), hematocrit (Before-Ramadan: 45 ± 7, End-Ramadan: 40 ± 4, After-Ramadan: 39 ± 4%), red blood cell count (Before-Ramadan: 5.1 ± 1.0, End-Ramadan: 4.6 ± 0.7, After-Ramadan:

4.4 ± 0.5 106/mm3), and white blood cell count (Before-Ramadan: 8673 ± 1911, End-Ramadan: 7840 ± 1526, After-Ramadan: 9507 ± 2190/mm3). The values of hemoglobin, hematocrit, RBC, and WBC in the End-Ramadan session were lower compared to the Before-Ramadan session. Additionally, the values of hemoglobin and WBC in the End-Ramadan session were higher and lower, respectively, compared to the After-Ramadan session. Overall, RF resulted in a significant decrease in hemoglobin, hematocrit, RBC, and WBC, while not causing any significant changes in the CRP and ESR indices.

The aim of the third study, conducted by[21] was to examine the effects of Ramadan fasting on various biochemical and anthropometric parameters in physically active men. The study compared individuals who fasted and those who did not fast before, during, and after Ramadan. Eighteen physically active men participated in the study, with 10 being fasters and 8 being nonfasters. The results showed that fasters experienced a decrease in body weight by 1.9% ($P<0.001$) and body fat percentage by 6.2% ($P=0.003$), while nonfasters showed an increase in body weight by 2.2% ($P<0.001$) and body fat percentage by 10.2% ($P=0.001$) from the beginning of Ramadan to the end. Fasters also had an increase in hematocrit by 5.3% ($P<0.001$) and hemoglobin by 6.3% ($P=0.01$) during the same period, whereas these parameters did not change in nonfasters. Fasters exhibited increased levels of urea (8.7%; $P<0.001$), creatinine (7.5%; $P<0.001$), uric acid (12.7%; $P<0.001$), serum sodium (1.9%; $P<0.001$), serum chloride (2.6%; $P<0.001$), and high-density lipoprotein cholesterol (27.3%; $P<0.001$) from the beginning to the end of Ramadan. Among these parameters, only creatinine increased (4.4%; $P=0.01$) in nonfasters. The researchers concluded that Ramadan fasting leads to a decrease in body weight and body fat percentage, while increasing high-density lipoprotein cholesterol in physically active men. However, engaging in aerobic exercise during a hot and humid Ramadan month can cause dehydration, as indicated by an increase in certain renal function markers and serum electrolytes.

The fourth study conducted by[17] aimed to examine the impact of Ramadan intermittent fasting (RF) on cognitive and physical performance, as well as biochemical responses to specific exercises, in elite young female handball players. Twelve athletes participated in three experimental sessions: one week before Ramadan (BR), during the first week of Ramadan (FWR), and during the last week of Ramadan (LWR). The findings indicated that ESS scores were higher during LWR compared to BR ($p < 0.05$), indicating increased sleepiness. Additionally, the MSBVT time decreased ($p < 0.05$) during LWR, suggesting improved performance. The power of the final three sprints in the RAST test decreased significantly only during LWR compared to BR ($p < 0.05$). The RAST fatigue index and RPE scores were higher during LWR compared to BR ($p < 0.05$), indicating increased fatigue. Hematological measures (red blood cells, hemoglobin, and hematocrit), plasma osmolarity, and energetic markers were not affected by RF. However, biomarkers of muscle damage were higher after the RAST test only during LWR compared to BR ($p < 0.01$ for all). In conclusion, RF led to increased sleepiness (ESS) and decreased performance in the RAST test, accompanied by higher muscle damage and fatigue, particularly during LWR. These observed changes may be attributed to disturbances in sleep patterns and circadian rhythms rather than nutritional deficiencies or dehydration.

The[20] study, which is the fifth study in our review, aimed to examine the impact of a hypertrophic training program on the levels of circulating antioxidants and oxidative stress biomarkers in trained bodybuilders during Ramadan. Eight male bodybuilders were assessed two days before Ramadan and on the 29th day of Ramadan. They underwent anthropometric measurements, completed a dietary questionnaire, and provided fasting blood and urine samples. Measurements of plasma thiobarbituric acid reactive substance and protein-bound carbonyl concentrations were used to indicate lipid and protein oxidation, respectively. These measurements did not show significant changes during Ramadan. However, the activities of superoxide dismutase and glutathione peroxidase, which are indicators of erythrocyte antioxidant status, increased by 24% ($p = 0.011$) and 12% ($p = 0.01$) respectively, from before Ramadan to the end of Ramadan. Erythrocyte catalase activity did not show a significant change. Uric acid values increased by 17% ($p < 0.001$) from before Ramadan to the end of Ramadan, while ferric-reducing ability and plasma Vitamin E levels remained unchanged. At the end of Ramadan, a significant correlation was found between uric acid values and urine specific gravity ($r = 0.70$; $p < 0.05$). In conclusion, maintaining a hypertrophic training program during Ramadan fasting does not lead to increased oxidative stress but does enhance antioxidant status in bodybuilders.

When we talk about the sixth study conducted by[19] we find it discussing the effects of intermittent fasting during Ramadan on inflammatory and biochemical biomarkers in obese males. This is relevant to our review, but its not related to physical training or specifically not related to football. This study focused exactly on the effects of Ramadan intermittent fasting (RIF) on inflammatory (C-reactive protein (CRP), interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α)) and biochemical markers of liver-renal function (aspartate aminotransferase (AST), alanine amino transferase (ALT), bilirubin, lactate dehydrogenase (LDH), urea and creatinine) in twenty-eight males with obesity. The results indicate a decrease in IL-6 ($p = 0.02$, $d = 1.4$) and TNF-α ($p = 0.01$, $d = 0.7$), while no significant changes were observed for CRP ($p = 0.3$, $d = 0.1$) in the experimental group compared to the control group. Additionally, there were no significant changes in ΔPV (blood volume changes) between the experimental group (-0.035 ± 0.02%) and the control group (0.055 ± 0.06%) after RIF. So this study demonstrates that RIF improves systemic inflammation biomarkers in obese males and does not have a negative impact on biomarkers of liver and renal function

The seventh study conducted by[16] aimed to investigate the impact of Ramadan fasting and weight-lifting training on plasma volume, glucose, and lipid profiles in male weight-lifters. The study involved forty male weight-lifters, and blood samples were collected 24 hours before and after one month of fasting and weight-lifting exercise. The blood samples were analyzed to assess plasma volume, fasting blood sugar (FBS), lipid profiles, and lipoproteins. The results revealed a significant decrease in body weight and an increase in plasma volume in the fasting group (F) ($P< 0.05$). Furthermore, the F-T group (fasting and weight-lifting training) showed a significant reduction in body weight ($P< 0.01$). The F group demonstrated a significant increase in FBS levels ($P< 0.05$). However, there were no significant changes observed in lipid profiles and lipoproteins among the control group (C), fasting group (F), weight-lifting training group (T), and the F-T group. In conclusion, the effect of Ramadan fasting on body weight and plasma volume may be closely associated with dietary factors or the body's biochemical response to fasting.

The last study in our review was conducted by[18] which focused on the Concomitant effects of Ramadan fasting and time-of-day on apolipoprotein AI, B, Lp-a and homocysteine responses during aerobic exercise in fifteen Tunisian soccer players. The participants underwent the YYIRT test, and blood samples were taken before and three minutes after the test for biochemical analysis. The study found that performance during the YYIRT was superior in the evening compared to the morning ($P < 0.05$), but this distinction was not observed during Ramadan fasting. Moreover, LDL-C, ApoB, and Lp-a remained consistent throughout the day under normal circumstances. However, during Ramadan fasting, they decreased at 17:00 h ($P < 0.05$). On the contrary, HDL-C and Apo-AI increased after exercise and were higher at 17:00 h under normal conditions ($P < 0.001$). These parameters also increased during Ramadan fasting ($P < 0.01$). Additionally, homocysteine and hs-CRP levels rose during exercise ($P < 0.01$), with elevated levels noted in the evening under normal conditions. However, during Ramadan fasting, the diurnal pattern of homocysteine was reversed ($P < 0.001$). In conclusion, this study suggests that the restriction of caloric intake during Ramadan fasting seems to enhance lipid and inflammatory markers associated with cardiovascular health when intermittent

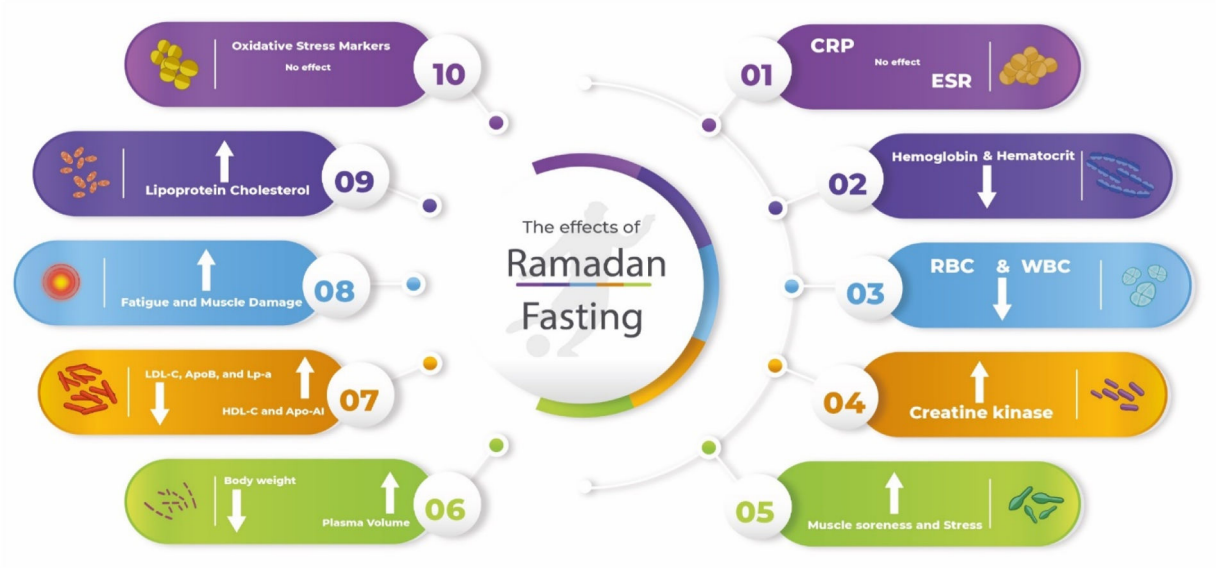

Fig. 3. The effects of Ramadan fasting (RF) on various physiological and biochemical parameters.

exercise is performed in the evening.

In summary, the reviewed studies provide insights into the effects of Ramadan fasting on various physiological parameters, including physical performance, hematological markers, inflammatory responses, body composition, antioxidant status, and biochemical profiles (Fig. 3). The findings highlight both positive and negative impacts of Ramadan fasting, depending on the specific context and individual characteristics. It is important to consider these factors when designing training programs or evaluating the effects of fasting on athletes or individuals with specific health conditions.

Conclusion

The objective of this review was to investigate the impact of Ramadan fasting on biomarkers, including physiological and performance related factors, in athletes specifically focusing on Muslim soccer players. We reviewed a total of 7 studies that fulfilled our criteria and evaluated outcomes associated with Ramadan fasting.

In general, our research discovered that fasting during Ramadan had varying impacts, on factors, which depended on factors such as the group being studied the type and timing of exercise, and the methods used for easurement. Some common results of Ramadan fasting included a decrease in body weight and fat mass an improvement in antioxidant levels changes in lipid and inflammatory markers and alterations in indices. However, it's worth noting that Ramadan fasting could also lead to effects like increased sleepiness, fatigue, muscle damage, dehydration, and impaired performance, in specific tests.

Our review has strengths, including the implementation of a thorough and comprehensive search strategy the application of strict inclusion criteria, and the synthesis of results, through a narrative approach. However, it is important to acknowledge that our review does have some limitations.

• Firstly, we must recognize that our analysis was based on a number of studies with varying designs, populations, interventions, comparators, and outcomes. This restricted our ability to conduct an analysis and draw conclusions.

- Secondly, it should be noted that many of the studies included in our review had either an unclear risk of bias due to factors such as lack of randomization, blinding, or allocation concealment. This potential bias could impact the validity and reliability of our findings.
- Thirdly, certain outcomes within the studies were measured using indirect methods which may not fully capture the physiological changes being investigated.
- Fourthly, it is worth mentioning that some studies did not adequately account for confounding factors such as intake, hydration status, sleep quality, or environmental influences during Ramadan fasting. These factors could potentially influence the observed effects.
- Lastly, while our findings provide insights into this topic during Ramadan fasting specifically in populations and settings with similar cultural and religious practices or environmental conditions; they may not necessarily be generalizable or applicable to other populations or settings, with different circumstances.

Based on the data we've gathered it is recommended that athletes and coaches who engage in sports and athletic training during Ramadan should be mindful of how fasting can impact their well-being and performance. It is important for them to keep track of their hydration levels, dietary intake, sleep quality, and recovery methods in order to optimize their health and performance during this period. Additionally, they should customize their training intensity and duration based on what works for them. Further research is necessary to understand the mechanisms behind the effects of Ramadan fasting on biomarkers well as to determine the most effective strategies, for minimizing or enhancing these effects.

CRediT authorship contribution statement

Yakoub Fenni: Writing – original draft. **Mourad Ikiouane:** Writing – original draft. **Mourad Redjal:** Writing – original draft. **Hocine Remini:** Writing – review & editing. **Ayoub Allam:** Writing – review & editing. **Salim Zaabar:** Conceptualization, Methodology.

Conflicts of interest

There are no conflicts of interest between the authors that may undermine the credibility or reliability of this study. The research received no support, from any industry or organization with a vested interest in the topic or materials under consideration. The authors have no associations that could compromise their integrity. Additionally, there are no affiliations with any entities or organizations that are interested in the results or publication of this manuscript.

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