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REVIEW

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The role of lifestyle changes to diet, physical activity, and sleep during Ramadan in controlling metabolic syndrome in adults: a scoping review

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Abstract

This scoping review aimed to investigate the role of lifestyle changes during Ramadan in controlling metabolic syndrome (MetS) in adults. The lifestyle factors investigated were diet, physical activity (PA) and sleep. The review was guided by the Preferred Reporting Items for Systematic Reviews, Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) checklist, and Joanna Briggs Institute methodological frameworks. The Web of Science, Google Scholar, PubMed, CINAHL (EBSCO), and Scopus databases were searched using the following terms: "diet", "physical activity", "sleep" and/or "lifestyle" with "Ramadan", "Ramadan month" or "the month of Ramadan". The selection included all research articles published from January 1998 until the end of June 2023. Only full-text studies that met the selection criteria were reviewed. A lack of robust evidence exists on the impact of lifestyle changes during Ramadan on MetS components. The scarcity of cohort studies in this area is likely because they could only be conducted during a particular month each year. However, the available evidence shows that lifestyle changes during Ramadan, including PA, diet and sleep, may be significant in MetS control. The evidence suggests that diet is the most influential factor on MetS components during Ramadan month, whereas sleep is the least influential. Ramadan represents an opportunity for patients to enhance their control of MetS components by combining a healthy diet with PA and good sleep hygiene. Further robust studies are required to develop an in-depth understanding of the impact of lifestyle changes during Ramadan on MetS components.

Keywords

Metabolic syndrome; Obesity; Ramadan; Fasting; Diet; Physical activity; Sleep

1. Introduction

The global Muslim population is expected to increase to 2.2 billion by 2030 [1]. During the month of Ramadan, observant Muslims fast from dawn to sunset, abstaining from food and drink, including medication, following Islamic Rule. As such, Ramadan is associated with significant lifestyle changes such as diet, physical activity (PA) and sleep, for Muslims around the world. Ramadan is a lunar month (lasting 29–30 days) and thus occurs approximately 11 days earlier each year. Ramadan can occur in all seasons, and the average diurnal fasting time varies from 12–18 hours per day [2, 3]. Our findings in a previous study showed that diurnal fasting during Ramadan may improve some metabolic syndrome (MetS) components when combined with a healthy lifestyle including adequate diet, PA and sleep [2].

Genetic susceptibility is known to be a factor in MetS development. For instance, the condition is more prevalent among some ethnic groups [4], and plasma HDL levels associated with dyslipidemia have an estimated heritability of up to 70% [5]. MetS is also associated with lifestyle factors, including diet [6, 7], so diurnal fasting during Ramadan may have a positive impact on its components [8, 9]. A recent review and meta-analysis reported a dramatic increase in the number of studies investigating the impact of Ramadan fasting on health between 2010 and 2021, with a total of 1276 publications [10]. However, robust studies exploring the impact of lifestyle changes (*i.e.*, diet, PA and sleep) during Ramadan on MetS components are limited [8–12]. Thus, this scoping review aimed to determine the role of lifestyle changes during Ramadan, specifically to diet, PA and sleep, on MetS components, based on high-quality evidence.

1.1 MetS

MetS was defined in 1923 as a cluster of cardiovascular risk factors comprising hypertension, hyperglycemia and gout [13]. The definition of MetS has been modified over time, however. Central obesity, glucose intolerance, hypertension, and dyslipidemia remain the main diagnostic criteria, predisposing

the patient to numerous cardiovascular and metabolic diseases [14–16]. In the 1990s, the term "metabolic syndrome" was given the International Classification of Disease (ICD-9) code 277.7, and central obesity was recognized as one of the major causes of insulin resistance syndrome [17]. In 1998, the World Health Organization (WHO) released the first definition of MetS [18]. In 2001, the National Cholesterol Education Program's Adult Treatment Panel III (NCEP: ATPIII) launched its own MetS criteria: abdominal obesity as indicated by waist circumference (WC), blood lipids (TG, HDL), blood pressure (BP) and fasting glucose (FBG) [19, 20].

1.2 MetS diagnostic criteria

In the last three decades, various organizations have issued MetS diagnostic criteria [21]. The WHO launched a formal worldwide definition of MetS in 1998. The definition was subsequently modified by some organizations including the European Group for the Study of Insulin Resistance, and the American Association of Clinical Endocrinologists issued a MetS definition in 2003. Table 1 demonstrates the stages of the diagnostic criteria for MetS [22].

2. Materials and methods

2.1 Study design

A scoping review design was used to determine the influence of lifestyle changes during Ramadan, comprising diet, PA and sleep, on MetS components. The review protocol was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) checklist [23] and methodological frameworks developed by the Joanna Briggs Institute [24]. Because the study used feasible and published data, Institutional Review Boards (IRB) and ethical approval were not sought.

Articles that described MetS and its components using an official definition [18, 25] were considered for inclusion. These definitions of MetS are shown in Table 1. Studies were limited to those conducted in adult populations (≥18 years old).

2.2 Search strategy

To identify relevant studies, searches of the Web of Science, PubMed, Scopus, CINAHL (EBSCO) and Google Scholar databases were conducted. All studies investigating the role of lifestyle changes during Ramadan on MetS components in adults were included. Searches were designed to retrieve all research articles published until the end of June 2023. The search terms "diet", "physical activity", "sleep" or "lifestyle" with "Ramadan", "Ramadan month" or "the month of Ramadan" were used.

TABLE 1. Criteria for the definitions of the metabolic syndrome.

Component	WHO (1998)	NCEP ATP III (2001)	IDF (2005)	Modified NCEP ATP III (2005)	Harmonized (2009)
Metabolic syndrome diagnosis	T2DM or IFG or IGT plus ≥2 of the following	≥3 of the following	Central obesity plus ≥2 of the following	≥3 of the following	≥3 of the following
Body weight (Obesity/ Overweight)	WHR >0.9 in men >0.85 in women or BMI >30 kg/m^2	WC ≥102 cm in men WC ≥88 cm in women	WC ≥90 cm in men WC ≥80 cm in women	WC ≥90 cm in men WC ≥80 cm in women	WC ≥90 cm in men WC ≥80 cm in women
Blood glucose	T2DM or IFG or IGT	≥6.1 mmol/L or T2DM	≥5.6 mmol/L or T2DM	≥5.6 mmol/L or on specific treatment	≥5.6 mmol/L or on specific treatment
Blood pressure	≥140/90 mmHg	≥130/85 mmHg	≥130/85 mmHg or on hypertension treatment	≥130/85 mmHg or on hypertension treatment	≥130/85 mmHg or on hypertension treatment
Triglycerides	≥1.7 mmol/L	≥1.7 mmol/L	≥1.7 mmol/L or on specific treatment	≥1.7 mmol/L or on specific treatment	≥1.7 mmol/L or on specific treatment
HDL cholesterol	<1.03 mmol/L in men <1.29 mmol/L in women	<1.03 mmol/L in men <1.29 mmol/L in women	<1.03 mmol/L in men <1.29 mmol/L in women or on specific treatment	<1.03 mmol/L in men <1.29 mmol/L in women or on specific treatment	<1.0 mmol/L in men <1.3 mmol/L in women or on specific treatment
Other	Microalbuminuria	-	-	-	-

BMI: Body mass index; HDL: High-density lipoprotein; IFG: Impaired fasting glucose; IGT: Impaired glucose tolerance; T2DM: Type 2 diabetes mellitus; WC: Waist circumference; WHR: Waist-to-hip ratio; WHO: World Health Organization; NCEP: National Cholesterol Education Program; ATP III: Adult Treatment Panel III; IDF: International Diabetes Federation.

All full-text studies that investigated the impact of diet, PA or sleep during Ramadan on MetS in adults were reviewed. In cases where the full text of an article was unavailable, at least two emails (one week apart) were sent to the corresponding author to increase the coverage of the included studies.

2.2.1 Inclusion criteria

1. Types of studies: All applicable experimental and clinical studies (including double-blind trials, single-blind trials, parallel-group and crossover design) that investigated the impact of diet, PA or sleep during Ramadan on MetS components were included in the review. All studies published from January 1998 until the end of June 2023 were screened and reviewed based on their titles and abstracts. Only full-text articles published in English were included in this review.

2. Subjects: Only studies of adults (male or female, ≥18 years old) were searched and reviewed.

3. Intervention: The review focused on primary research that investigated diet, PA or sleep during Ramadan and the impact of these lifestyle factors on MetS components, including abdominal obesity, FBG, TG, HDL and BP.

4. All eligible studies were classified based on their main results.

2.2.2 Exclusion criteria

1. Types of evidence: Editorials, letters to the editor, pilot studies, short communication, commentaries, studies in animal models, conference and abstract papers, and all review types (systematic review and meta-analysis, literature or narrative review) were excluded from this scoping review.

2. Participants: Studies in children or adolescents were excluded from this scoping review.

3. Search period: Studies conducted before 1998 were excluded because the first formal definition of MetS was provided in 1998 by the WHO [18].

4. Intervention: All studies that investigated the impact of any kind of fasting, other than diurnal fasting during Ramadan, were excluded.

3. Results

3.1 Data collection and analysis

Following the removal of duplicate publications, the abstracts of the selected studies were assessed for eligibility according to the inclusion criteria. The extracted data included the principal author, title, sample size, population age, gender and physical characteristics, study design, publication year, journal name, article type, instrument and measurements, period of data collection (during and/or after Ramadan), criteria used to define MetS, arterial BP, hematological measurements, outcomes measured, and main findings. The search process is illustrated in Fig. 1, which shows the PRISMA 2020 flow chart, delineating the study selection criteria.

The literature search yielded 2298 records. A further 42 studies were retrieved from manual searches. Following the removal of 488 duplicate records, the titles and abstracts of a total of 1852 articles were screened, of which 1243 were omitted on the following bases: review and meta-analysis studies, pilot studies, insufficient study design, small sample size, unrelated results, opinion letters, short-communication, and studies of animal models. The full texts of the remaining 28 articles were screened. A final total of 22 full articles were included in the scoping review. Fig. 1 illustrates the search stages, including the selection process as well as the rationale for exclusion. Details of the 22 studies selected for inclusion are provided in Table 2.

3.2 Lifestyle changes during Ramadan

Lifestyle, including diet, PA and sleep, may change during Ramadan [32, 46–48]. Recommended PA levels vary by age group [49]. Lifestyle changes during Ramadan may reduce cardiovascular disease risk factors in both obese and normal-weight adults *via* a reduction in body mass and improvements in blood lipid profiles [35, 50]. Lifestyle changes may positively improve health and well-being [51–55]. One study reported no significant change to PA levels in university students during Ramadan compared to the pre-Ramadan period [2]. However, the sample mainly comprised university students who were focused on their studies during their summer semester. Thus, in that study, significant changes to PA levels during Ramadan were not anticipated. Insignificant changes in PA levels during Ramadan appear in some cases to be due to the use of subjective measurements, such as questionnaires or self-reporting, or small sample size ($n \leq 16$) [2, 42, 43, 56]. Therefore, in future studies, the use of objective measurements and larger sample sizes are encouraged. Some studies did report significant reductions in PA levels [46, 57, 58] in either men or women. Bakhotmah (2011) found that one third of Saudi families significantly reduced their PA during the month of Ramadan [59]. Furthermore, physical performance, including cardiorespiratory fitness, may be impaired during Ramadan, as shown in football players [60]. Despite changes to PA levels during Ramadan, some studies found no significant change in total energy expenditure (TEE) [57]. However, any reduction in PA could result in adverse outcomes in MetS patients [60]. These results may help to understand the impact of changes to PA during Ramadan on MetS control.

Numerous studies showed significant changes in diet and eating behavior during Ramadan [26, 33, 61]. Although some Muslim adults reported no significant changes to their diet [2], both the season and the climate may affect the type and quantity of food consumed during Ramadan. Most included studies reported either a reduction or no change in food intake during Ramadan in comparison with the pre- or post-Ramadan period [26, 62]. Only a few studies reported a significant increase in food and energy intake during Ramadan [63, 64]. Nevertheless, the included studies assessed food and energy intake with subjective instruments (questionnaires), which are less reliable than objective measures [65, 66]. Most of the studies included in the review reported positive changes to diet during Ramadan, which appeared to alleviate and control MetS components [26–29, 33].

Sleep, as one of the main components of a healthy lifestyle, may be affected by changes to working hours as these become shorter during Ramadan in some Muslim countries. In most Muslim-majority countries, workers usually sleep after their

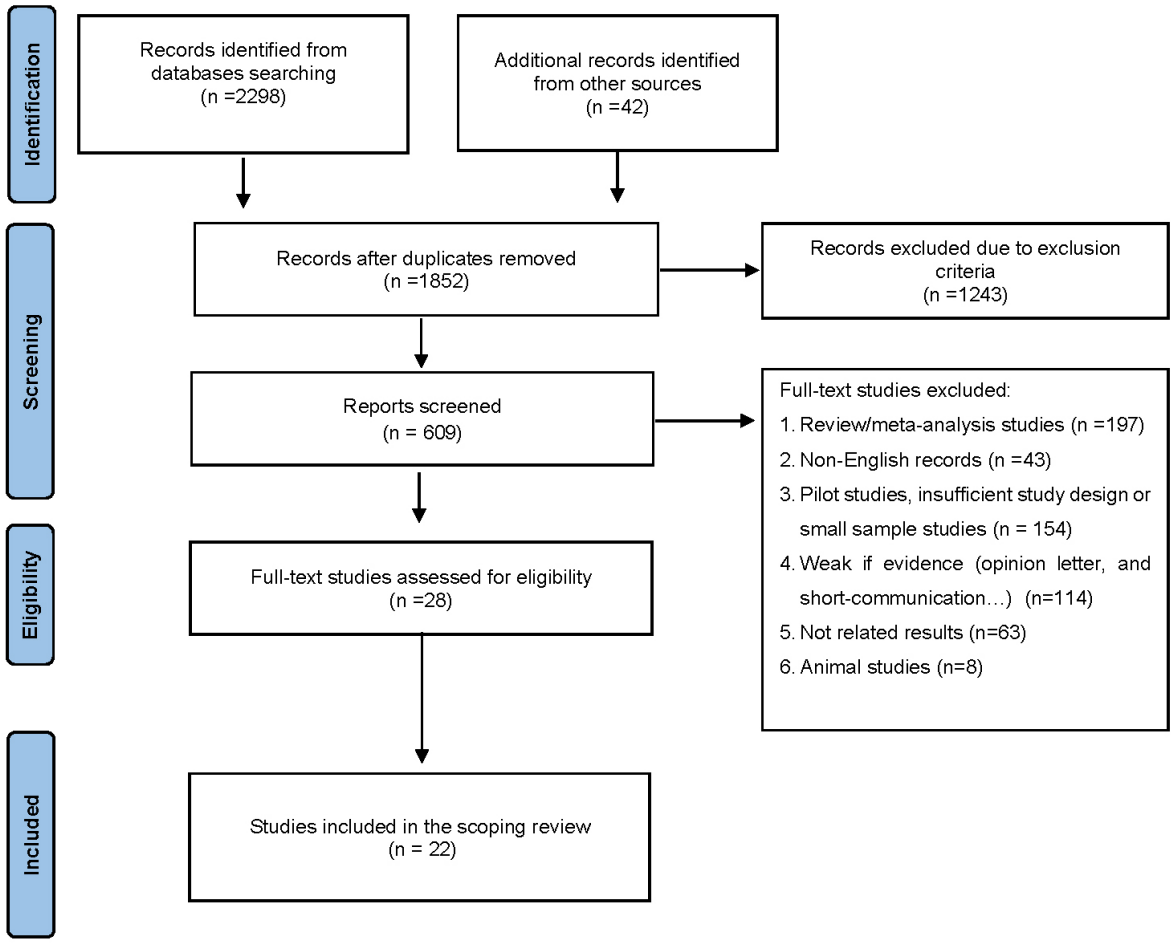

FIGURE 1. PRISMA 2020 flow chart delineating the study selection process.

Sahour meal (just before dawn) and start work later in the morning (at 09:00 or 10:00 instead of 08:00). In addition, some individuals may sleep more during the daytime. Hence, the sleeping and waking hours of Muslim adults may change during Ramadan [47, 67, 68]. This changing sleep pattern may impact some MetS components [69–71]. In one study, following adjustment for sleep–wake time, no significant change in sleep duration or circadian rhythm was reported [72]. However, some studies reported changes to sleep duration and onset [39], and significant delays to both sleep and wake times during Ramadan were also reported [73]. Poor sleep quality has been linked to MetS components [74–76]. Thus, changes in sleep quality during Ramadan may adversely affect MetS components.

4. Discussion

4.1 Changes to PA levels during Ramadan and MetS control

PA is a well-established important factor in MetS improvement [77, 78]. Although several studies found significant reductions in PA during Ramadan, some MetS components improved [79, 80]. Improvements in MetS components (such as body mass index (BMI), WC, FBG, HDL, TG and BP) could be attributed to the impact of other lifestyle factors, notably the practice of intermittent fasting for one month [2, 30, 31, 40]. The impact of PA on MetS components becomes more efficient when combined with a healthy diet during Ramadan [39, 81]. One of the primary mechanisms by which PA improves MetS is through a reduction in body mass and adiposity [79, 82, 83]. Most of the available evidence found a negative association between all levels of PA and MetS, including light, moderate, vigorous, and moderate-to-vigorous PA [78]. For instance, Maaloul *et al.* (2023) concluded that both trained and non-trained groups showed a significant reduction in central obesity markers (body fat % and WC), FBG and TG and some improvement in lipid profile. Moreover, participation in training programs, including high-intensity interval training (HIIT) and resistance exercises, for one month was found to reduce body fat % and improve lipid profiles, including TG and LDL, in comparison with a non-trained control group [32]. Thus, combining PA with diurnal intermittent fasting during Ramadan represents an effective strategy to control MetS. Compared to diet alone, most studies reported a greater effect on body composition and lipid profiles when combining PA and diet during Ramadan [79, 84].

TABLE 2. Impact of lifestyle during the month of Ramadan on MetS components.

References	Investigated lifestyle	Sample size (Male%)	Obesity	BP (SBP/DBP)	FBG	HDL	TG	Main findings
[2]	PA, Diet & Sleep	44 (100%)	↔	↑	↑	↔	↔	Lifestyle during Ramadan may not affect WC and characteristics of metabolic syndrome markers in healthy adult men.
[7]	Diet	49 (42.9%)	↓	NA	↔	↔	↔	There was no significant difference in fasting total cholesterol, triglyceride, HDL and LDL observed in Sudanese and Emiratis group, while HDL has significantly reduced in Pakistanis group.
[26]	PA & Diet	21 (47.6%)	↓	NA	↔	↔	↔	Caloric intake decreased during Ramadan, while PA remain stable. Body mass, WC and BMI reduced during Ramadan.in both males and females.
[27]	PA & Diet	81 (6.0%)	↔	NA	↔	↔	↔	Consuming high fiber cereal had a positive effect on blood lipids and body fat during the month of Ramadan.
[28]	PA & Diet	39 (53.8%)	↓	↔	↔	↔	↓	Intermittent fasting increases the production of short-chain fatty acids, and decreased the circulating levels of lipopolysaccharides which may lead to improve some of the MetS components.
[29]	PA & Diet	65 (47.7%)	↓	↓	↓	↔	↓	Both techniques used (intermittent or continuous) to achieve energy restriction appears to alleviate the metabolic syndrome biomarkers.
[30]	PA & Diet	114 (65.8%)	↓	↔	↔	↑	↓	Ramadan fasting was found to significantly improve MetS components including WC, HDL and TG.
[31]	PA & Diet	61 (37.7%)	↓	↓	↔	↔	↓	Ramadan fasting decreases body weight, TG and systolic blood pressure without adversely affecting markers of glucose homeostasis in individuals with overweight or obesity.
[32]	Diet & Sleep	20 (100%)	↓	NA	↓	NA	↓	Ramadan fasting plus concurrent training program reported greater improvements in Fat % and WC and greater decrease in lipid biomarkers including TG as well as lower FBG.
[33]	Diet	160 (100%)	↓	NA	↓	↑	↓	Body weight, body mass index and body fat percentage (BFP) as well as FBG and circulating triglycerides were all decreased while HDL increased significantly at the end of Ramadan compared with the same indices measured prior to Ramadan.

TABLE 2. Continued.

References	Investigated lifestyle	Sample size (Male%)	Obesity	BP (SBP/DBP)	FBG	HDL	TG	Main findings
[34]	Diet	55 (100%)	↓	↓	↓	↑	NA	The combined change in the number and timing of meals and portioning of the entire intake into only two meals per day may improve metabolic syndrome components including WC, BMI, FBG, BP and HDL even when the decrease in energy consumption is minimal.
[35]	Diet	45 (57.8%)	↓	NA	↓	↑	↔	Islamic fasting can prevent cardiovascular diseases in obese and normal-weight individuals through reducing weight, BMI, and some blood lipids, and elevating HDL-c level.
[36]	Diet	152 (100%)	NA	↓	NA	↔	↓	Significant increase was observed in HDL-C following Ramadan compared with earlier measurements. Triglyceride decreased following Ramadan but returned to the same level one month later. Systolic blood pressure increased and diastolic blood pressure decreased during fasting period.
[37]	Diet	80 (65%)	↓	NA	↓	↑	↔	A decrease was reported BMI, waist circumference. An increase was observed in fasting glucose. However, a decrease in HDL-C levels was reported.
[38]	Diet	14 (57%)	↓	↓	↔	↔	↔	Subjects had a significant reduction in BMI, WC and improvement in blood pressure. These findings suggest that intermittent fasting from dawn to sunset can be an adjunct treatment in metabolic syndrome.
[39]	PA, Diet & Sleep	155 (43.2%)	↔	↓	↓	NA	NA	Ramadan fasting could be able to control blood pressure and blood glucose levels. Fasting blood glucose significantly decreased in the diabetic patients, while blood pressure significantly reduced in the hypertensive patients.
[40]	Diet	75 (62.6%)	↓	NA	↓	↑	↔	A significant reduction was reported in BMI and FBG and TG. A positive improvement in HDL during Ramadan was reported.
[41]	Diet	82 (46.3%)	↓	↔	↔	↑	↓	Ramadan fasting reduced WC and TG. There were no significant changes in BP and FBG. However, a significant improve was observed in HLD after Ramadan fasting.

TABLE 2. Continued.

References	Investigated lifestyle	Sample size (Male%)	Obesity	BP (SBP/DBP)	FBG	HDL	TG	Main findings
[42]	PA & Diet	65 (32.3%)	↔	↔	↔	↔	↔	There were no significant changes in WC, FBG, HDL and TG and blood pressure in both genders before Ramadan, end of Ramadan.
[43]	Diet	120 (50%)	↓	↓	NA	↔	↓	A significant decrease after Ramadan fasting in blood pressure, WC, and TG. No significant change was reported in HDL.
[44]	PA & Diet	19 (26.3%)	↓	↔	↑	↔	↔	Total energy consumption remained similar. Meal frequency decreased. Protein intake decreased but fat intake increased. Both WC and FBG decreased, while blood pressure, HDL and TG remained unchanged.
[45]	Diet	50 (66%)	↔	↓	↑	↑	↑	There was a significant increase in HDL, TG and FBS, while there was a significant decrease in blood pressure after Ramadan.

BP: blood pressure; FBG: fasting glucose; HDL: high-density lipoprotein; PA: physical activity; WC: waist circumference; BMI: body mass index; MetS: metabolic syndrome; SBP: systolic blood pressure; DBP: diastolic blood pressure; TG: triglyceride; LDL: low-density lipoprotein; NA: not available.

4.2 Changes to diet during Ramadan and MetS control

Changes in dietary quality as well as the types of food consumed and the timing of meals may play a role in improving MetS components, including body composition and blood lipids. Research has shown that in some countries, Muslims exceeded the recommended fat intake during Ramadan [85]. Moreover, they may consume more simple sugars than complex sugars, such as cereal and bread [44], which may explain the observed elevations in some MetS components, particularly plasma lipids and glucose. Although some studies reported significant reductions in body weight in the last week of Ramadan, such weight loss appears to be temporary [38]. However, the role of Ramadan fasting on body composition (BMI, body fat %, and WC) is more established. A recent study reported significant improvements in body composition in overweight and obese adults at the end of Ramadan but not in those of normal weight. By the end of Ramadan, body fat %, FBG, and TG all significantly decreased, whereas HDL increased [33, 40]. Interestingly, most of the reviewed studies demonstrated that any reduction in body composition during Ramadan was temporary, and most participants returned to their normal weight after Ramadan [86–88]. Thus, improvements in body composition during Ramadan as a result of lifestyle factors, including changes to diet, appear to be temporary. However, the eating behaviors adopted during Ramadan appear to have a significant role in controlling MetS components, including WC, FBG, HDL and TG, because fasting techniques (intermittent or continuous) to achieve energy restriction have been shown to improve these [29, 41]. A reduction in the number of daily meals and portioning food into two meals per day may control some MetS components, including WC, BMI, FBG, BP and HDL, even without reducing the total energy intake [34, 40, 63, 89]. Some studies reported that changes to TG levels were positively associated with sugar intake (g/day) during Ramadan [90, 91].

Although evidence shows that lifestyle changes during Ramadan may improve some MetS components, others may be exacerbated [37–45]. Nevertheless, greater improvements to MetS components were reported by studies that combined PA with dietary changes during Ramadan compared to dietary changes alone [79]. Further lifestyle changes during Ramadan, such as practicing good sleep hygiene, may enhance control of MetS components [39, 47, 92].

4.3 Changes in sleep during Ramadan and MetS control

Alterations to sleep patterns have been reported during Ramadan [65, 67, 72, 93]. Although the topic of sleep is well-researched generally, few robust studies have investigated sleep during Ramadan specifically. Furthermore, studies investigating sleep quality during Ramadan have reported conflicting findings [72, 94, 95]. Sleep may impact MetS components such as BP [38, 96], but few studies have investigated the impact of changing sleep patterns during Ramadan on MetS. Sleep pattern alterations associated with Ramadan, such as changes to sleeping and waking hours, may affect MetS components [97, 98]. Interestingly, when controlled for environmental factors, Ramadan fasting itself did not result in significant disturbances to sleep architecture, sleep–wake time, or circadian rhythm [72]. Nevertheless, challenges are associated with the absence of control for related confounding

factors that may modify the effect of lifestyle changes during Ramadan, including sleep patterns.

Intervention and control studies may demonstrate the role of positive lifestyle changes during Ramadan in improving MetS components [99]. In terms of positive practices during Ramadan, individuals who ate two main meals, slept well during the night, and performed daily PA were expected to improve MetS components [100, 101]. In some cases, adopting positive habits during Ramadan is not always possible, and cultural factors, including insufficient allowance for compensatory sleep, may impact MetS negatively [102]. Significant disturbances in sleeping patterns (sleep delay in combination with an earlier wake-up time) during Ramadan may adversely affect cortisol levels, circadian rhythm, and the production of hormones associated with the control of MetS components. Therefore, negative changes to sleep quality may lead to poorer outcomes in MetS patients [103].

5. Recommendation

The current study recommended carry out more studies to investigate the impact of diet type and timing during Ramadan on MetS with conceding fating duration time. More researches are encouraged to clarify type of PA that may help to eliminate the negative impact of unhealthy diet that may consumed during Ramadan and its impact on MetS components. Although few studies have investigated the impact of changing sleep patterns during Ramadan on MetS, Ramadan fasting itself did not result in significant disturbances to sleep–wake time, or circadian rhythm. Thus, challenges are associated with the absence of control for related confounding factors that may modify the effect of sleep patterns such as climate and work time. Furthermore, other related cofounders linked with lifestyle changes also needs to be investigated.

6. Limitations

There are some constraints and limitations in the present study. The inclusion criteria of the present study did not include studies published in other languages such as Arabic, Persian and Indonesian studies. Moreover, the nature of investigation in the field of religious topics may lead to biases that may affect the results of such studies. In addition, this scoping review searched the available full-text studies. Thus, some of the robust studies may missed due to the disability of getting access to these studies

7. Conclusion

In general, lifestyle changes adopted during Ramadan, including diet, PA and sleep, appear significant in controlling MetS components in adults. The available evidence indicates that Ramadan represents an opportunity to enhance MetS management, particularly *via* the adoption of a healthy dietary pattern, PA regime, and good sleep hygiene [64, 71]. Of the three lifestyle changes investigated in this scoping review, diet appears the most influential on MetS components during Ramadan [54, 57], whereas sleep was found to be least influential [63]. Further robust studies are warranted to fill the evidence gap and quantify the effects of lifestyle changes during Ramadan on MetS components.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

AUTHOR CONTRIBUTIONS

KSA—Conceptualization, methodology, software, formal analysis, investigation, resources, data curation, writing-original draft preparation, writing-review and editing, visualization, supervision, project administration, funding acquisition, read and agreed to the published version of the manuscript. The author approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

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CONFLICT OF INTEREST

The author declares no conflict of interest.

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