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Chapter

The Effect of Ramadan Fasting on Metabolic Syndrome (MetS)

Khalid S. Aljaloud

Abstract

The effect of Ramadan fasting on most of the metabolic syndrome (MetS) markers is still controversial. However, most of the available evidences showed positive effect on most of the MetS markers. In general, Ramadan fasting may help to reduce the risk of MetS. Nevertheless, most of the positive results seem to be impermanent and reading many variables (MetS markers) return to the previous reading after few weeks (~3–4 weeks). Therefore, intermittent fasting such as Ramadan fasting could be one of the cure alternatives especially in people with MetS, cardiovascular or metabolic diseases with considering their physician supervision. Again, more evidences are recommended to clarify the controversial issues related to the role of Ramadan fasting on MetS markers.

Keywords: Ramadan fasting, cholesterol, glucose, metabolic syndrome (MetS)

1. Introduction

Lifestyle plays significant role in metabolic syndrome. Habitual diet, physical activity status, type of sleep—including quantity and quality—and unhealthy behaviors such as smoking, consuming alcohol, etc. may affect metabolic syndrome markers [1]. This chapter will demonstrate overview of lifestyle during the month of Ramadan including diet, physical activity and sleep. Moreover, the effects of Ramadan fasting on each metabolic syndrome (MetS) markers will be revealed including central obesity, plasma triglyceride, high density lipoprotein-cholesterol, fasting plasma glucose and blood pressure.

2. Lifestyle during the month of Ramadan

The month of Ramadan is a holy month in the Islamic calendar (lunar calendar vary between 29 or 30 days) once a year. About 1.5 billion Muslims worldwide are—religiously—abstained from having any kind of food, oral intake such as medicine (unless in necessary cases) or smoking during the daylight starting from dawn to sunset. The Holy month of Ramadan retreats 11 days each year. As a result, Ramadan month moves in all seasons over time including summer season. Usually fasting time extends between 13 and 18 hours per day depending on season (spring, summer, autumn or winter) and the geographical location of the country. During the month of Ramadan, lifestyle of most Muslim people changes. In most Muslim country, people become less active during the daytime (before the sunset) compared with the nighttime (after the sunset), especially when most

are Muslims population [2]. The reason is mainly due to their nature of life during the night as majority of them engaging in social activities with friends and family. Moreover, most of the markets and media become more vital. However, the lifestyle of some Muslims will not change greatly during Ramadan [3]. Hence, the change in habitual diet, physical activity and sleep may change the body composition and some blood markers such as cholesterol, triglyceride, glucose which may alert MetS markers.

3. Diet during the month of Ramadan

Muslims break their fasting just after sunset by having a main meal and then they may have two or three meals during the night until the dawn time. Current study found that diet did not change significantly during the month of Ramadan while comparing before or after Ramadan [2]. However, Al-barha's study recruited apparently healthy graduate and undergraduate students. Data from different studies reported that diet during the month of Ramadan varies due to the differences between Muslim population in different countries and their habitual lifestyle. Further, seasonal and weather differences may play role in the quality and quantity of the food intake as well as the diet behavior during the month of Ramadan. In a review study, 9 out of 13 publications reported either significant reduction or no significant difference in energy intake between during and pre-or-post the month of Ramadan [4–12]. Only four studies showed a significant increase in energy intake during Ramadan [13–16]. However, all of the studies in these publications use self-report to assess the energy intake, which is known to be less accurate comparing to objective measures [17, 18]. Amount and type of food intake as well as timing are key factors in diet and its effect on body including metabolic syndrome. During the month of Ramadan, carbohydrate and fat are consumed just after sunset. Different Muslim population reported high intake of dietary fat during Ramadan which exceeded the dietary recommendations [6, 11, 19]. In contrast, some studies found no significant change in carbohydrate and protein. However, the type of carbohydrate switched from complex sugar such as bread, cereal and vegetable to more simple sugar such as sweets [20]. These changes could elevate blood parameters such as blood lipids level. Hence, it could affect the metabolic syndrome markers negatively.

4. Physical activity during the month of Ramadan

The recent guidelines of physical activity and exercise encourage people to be physically active. The recommendation has been issued for each age group such as children and adult as well as people with special conditions such as elderly, diabetics and obese individuals [21]. The changes in people lifestyle may affect health and wellbeing [3]. During Ramadan, lifestyle may change including habitual physical activity. Although some studies found that there is no significant change in physical activity levels during Ramadan comparing to pre-Ramadan [2], numerous evidences reported significant changes in physical activity levels during the month of Ramadan. Ramadan fasting has been found to affect physical activity level in different ways. Some studies indicated that habitual physical activity may change during the month of Ramadan [22, 23]. Moreover, number of previous studies has investigated the association between Ramadan fasting and physical activity in Muslim population. These studies reported that physical activity levels were

lowered in Muslim population during the month of Ramadan [24–28]. For instant, about one-third of Saudi families reported a decrease in physical activity levels [29]. Furthermore, recent study found that Ramadan fasting is associated with decrease in physical activity levels [30]; and may causes a decline in the physical work capacity in adolescent soccer players especially cardiorespiratory fitness capability [31]. However, these evidences showed no significant change in resting metabolic rate (RMR) or total energy expenditure (TEE) [30].

The reduction in physical activity and exercise may alert the metabolic syndrome markers. Several studies have shown significant association between low physical activity level and negative changes in some of the metabolic syndrome markers. Individuals with low physical activity are more likely to have negative changes in metabolic syndrome [20, 32]. More about the impact of low physical activity in MetS will be discussed later in this chapter. These results may help to understand the influence of Ramadan fasting on body composition and the characteristics of metabolic syndrome.

5. Body composition

Body mass, BMI and waist circumference (WC) decreased gradually, especially in the end week of Ramadan compared with the reading before Ramadan. However, most of the recent studies concluded that the slightly decrease in some body composition parameters were not significant [4, 20, 33–36]. Although some the studies reported significant reduction in body weight at the end of Ramadan, the reduction was temporary. In a recent review study, the relationship between body composition parameters (i.e. body mass, body mass index, fat percentage and waist circumference) and Ramadan fasting is elucidated. Fernando and colleagues [29] concluded that there was a significant reduction in fat percentage at the end of Ramadan compared with pre-Ramadan in overweight or obese individuals, but not in those of normal weight. Moreover, even the change in body composition during the month of Ramadan was temporary as most of the investigated body composition parameters return to the normal weight [37].

6. Sleep during the month of Ramadan

In terms of sleep pattern, working hours during the month of Ramadan—at least in some countries—are shorter for those who fast. In such countries, workers are given more time to sleep after having the last meal just before the dawn time. For this reason, people start work later in the morning (between 09:00 and 10:00 am) instead of the early morning (i.e. 07:00–08:00 am). This change could affect sleep patterns. Hence, this may affect the times they go to bed and wake up [38]. Moreover, sleep habits may change more during the daytime. In turn, the change in sleep pattern may lead to some changes in some of the physiological parameters including metabolic syndrome as well as body composition [39, 40]. In a recent review study, they found that well-organized studies that controlled sleep/wake time, sleep duration and light exposure do not influence Ramadan fasting.

Furthermore, well-designed studies showed no effect of Ramadan fasting on circadian rhythms. However, in unstable society in which they do not control for lifestyle changes, evidences have demonstrated sudden and significant delays in bedtime and wake time [41]. Controllable and uncontrollable MetS risk factors may lead to cardiovascular and metabolic diseases as illustrated in **Figure 1**.

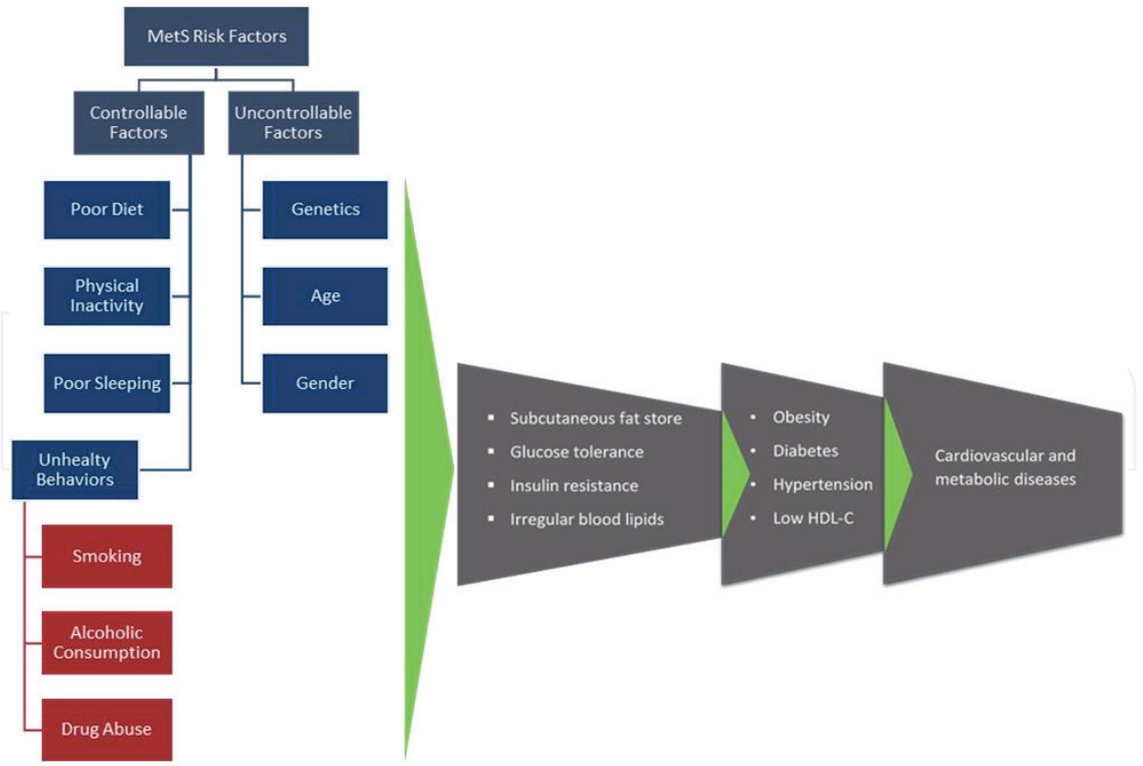


Figure 1.
Risk factors of MetS including controllable and uncontrollable factors that might lead to cardiovascular and metabolic diseases.

7. Metabolic syndrome

Historically, the first time metabolic syndrome (MetS) was defined by Kylin , a Swedish physician, in 1923 [42]. He described MetS as a cluster of cardiovascular risk factors comprising of hypertension, hyperglycemia and gout. Since then, the metabolic syndrome has gradually progressed over time with definition modification. However, the core turbulences, hypertension, consisting of glucose intolerance, obesity and dyslipidemia remain the cornerstone of all diagnostic criteria. In turn, these features may develop and increase the risk of cardiovascular morbidity and mortality [43, 44]. The term "Syndrome X" was commonly used in 1980s to describe the proposed interrelationships between resistance to insulin-stimulated glucose uptake, hypertension, type 2 diabetic and cardiovascular diseases. Now, the term MetS has the International Classification of Disease (ICD-9) code 277.7. In 1990s, visceral adiposity becomes important when obesity is considered as a main factor of the insulin resistance syndrome [45]. World Health Organization (WHO) launched the first formal definition of the MetS in 1998 [46]. In 2001, the National Cholesterol Education Program's Adult Treatment Panel III (NCEP:ATPIII) issued a set of criteria based on common clinical investigations: WC, blood lipids, blood pressure and fasting glucose [47–49].

8. Diagnostic criteria for MetS

Over the years, there have been several societies attempted to issue the diagnostic criteria for metabolic syndrome [50]. In 1998, WHO is the first organization that launched the worldwide definition of MetS, which was modified by other organizations such as the European Group for the Study of Insulin Resistance (EGSIR). In 2003, the American Association of Clinical Endocrinologists (AACE) proposed

WHO, 1998	EGIR, 1999	NCEP:ATPIII, 2001	AACE, 2003	IDF, 2006
High insulin levels, IFG or IGT, and two of the following:	Top 25% of the fasting insulin values among nondiabetic individuals and two of the following:	Three or more of the following:	IGT and two or more of the following:	Central obesity as defined by ethnic/racial, specific WC, and two of the following:
Abdominal obesity: WHR 0.9, BMI 30 kg/m^2, WC 37 inches	WC: 94 cm for men, 80 cm for women	WC: 40 inches for men, 35 inches for women	Triglycerides 150 mg/dl	Triglycerides 150 mg/dl
Lipid panel with triglycerides 150 mg/dl, HDL-C 35 mg/dl	Triglycerides 2.0 mmol/liter and HDLC 1.0 mg/dl	Triglycerides 150 mg/dl	HDL-C: 40 mg/dl for men, 50 mg/dl for women	HDL-C: 40 mg/dl for men, 50 mg/dl for women
BP 140/90 mm Hg	BP 140/90 mm Hg or antihypertensive medication	HDL-C: 40 mg/dl for men, 50 mg/dl for women	BP 130/85 mm Hg	BP 130/85 mm Hg
	Fasting glucose 6.1 mmol/liter	BP 130/85 mm Hg FPG 110 mg/dla		FPG 100 mg/dl

WHR, Waist-to-hip ratio; BP, blood pressure; FPG, fasting plasma glucose. In 2003, the ADA changed the criteria for IFG tolerance from 110 to 100 mg/dl.
Source: Ref. [51].

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

their definition. However, the definition of the cut-off for obesity was not agreed yet. **Table 1** illustrates the development stages of the MetS diagnostic criteria [52].

9. The effect of Ramadan fasting on metabolic syndrome

In this section, the role of Ramadan fasting positively affect the MetS markers including central obesity, waist circumference (WC), fasting plasma glucose (FPG) level, triglycerides (TG) level, high density lipoprotein (HDL) and blood pressure (BP), will be deliberated with recent evidences. In terms of metabolism and hormonal serum levels, Ramadan fasting may affect the metabolism of lipids, carbohydrates and proteins, as well as related hormones levels. Although there are beneficial changes in HDL and LDL levels, evidences showed that Ramadan fasting could lead to elevate the urea and uric acid which may be attributed to dehydration during the Holy month of Ramadan [23]. In the next sessions, the effect of Ramadan fasting on metabolic syndrome markers will be elucidated with more details.

10. The effect of Ramadan fasting on central obesity

Intermittent fasting during the month of Ramadan may enhance the cure from some of the MetS markers including body weight reduction. Although some evidence showed increase in some of the body composition parameters [53], Ramadan

fasting has been found to reduce waist circumference even in apparently healthy young adults [54]. In some studies, the reported weight reduction occurred without significant changes in energy and macronutrient intake and physical activity level [4]. The reduction was interpreted as loss of body water and body fat percentage.

There is a strong recent evidence that support the effect of Ramadan fasting on reducing body fat percentage and even fat-free mass especially with obese/overweight people. In a recent review and meta-analysis study, data obtain from 70 publications found a significant reduction in fat percentage between pre-Ramadan and post-Ramadan in overweight and obesity individuals. (−1.46 [95% confidence interval: −2.57 to −0.35]%, $P = 0.010$). However, there was no changes reported in those of normal weight (−0.41 [−1.45 to 0.63]%, $P = 0.436$). The reduction also reported in fat-free mass between pre-Ramadan and post-Ramadan. Nevertheless, the changes in body composition measurements seem to be temporary. Evidences showed that body weight body composition parameters were returned toward the pre-Ramadan measurements just after 2–5 weeks from the month of Ramadan [37]. Furthermore, it has been suggested that this decrease in body weight could be attributed to a decrease in fluid intake [34, 55–57]. Sequentially, dehydration during the month of Ramadan may cause increase in urea and uric acid which is attributed to the reduction of the glomerular filtration rate [58]. The physiological aspects that may explain the association between Ramadan fasting and body composition parameters has been investigated. For instance, plasma leptin and insulin have been found to play a key role in body weight regulation homeostasis. Leptin level send signals to the brain about the amount of energy stores which in turn, stimulates the hypothalamic centers to regulate the energy intake and energy expenditure [59]. Although an evidence showed that there is a positive association between plasma leptin and insulin levels and body fat, the elevation in plasma leptin and insulin during the month of Ramadan is probably due to the energy intake and diet behavior [14]. In sum, Ramadan fasting may help to reduce body composition including central obesity such as waist circumference. However, the reduction may not be healthy as the weight loss attribute to loss of body water. One possible reason for this greater weight loss is that people with greater BMI are due to greater glycogen stores than people of normal weight, and hence would be expected to lose more fluid in response to fasting [60], and in some cases loss of lean tissue [34] carry more body. One of the most challenges is that body composition parameters are affected by different factors including calorie intake, physical activity level, age and gender. More investigations are needed to clarify the role of Ramadan fasting on central obesity.

11. The effect of Ramadan fasting on triglycerides

In general, the role of Ramadan fasting on triglyceride concentration tends to be more positive in many case studies. This may enhance health promotion for people who have no clinical conditions that may prevent them from fasting during the month of Ramadan. In a systematic review study, data revealed that 6 out of 15 studies reported reduction in triglyceride level at the end of Ramadan month. Nevertheless, other 9 studies showed no significant changes in triglycerides concentration [61]. Moreover, Ramadan fasting also has been found to be healthy by helping diabetic patients to reduce triglycerides level especially those who can fast the whole month of Ramadan. Recent evidence indicated clear effect of Ramadan fasting on triglycerides level in diabetic patients. Bener et al. [62] tried to investigate the effect of Ramadan fasting on some blood parameters including blood lipids (total cholesterol, triglycerides, high-density lipoprotein, low-density lipoprotein, etc.)

in patients with type 2 diabetes mellitus (T2DM) in Turkey. They concluded that fasting during the month of Ramadan may help to reduce triglycerides level even in people with type 2 diabetes [62]. Interestingly, rare of the available evidences showed negative effect of Ramadan fasting on triglycerides concentration. Thus, Ramadan fasting could enhance health promotion and reduce the risk of cardiovascular and metabolic diseases via the positive control of different lipid profile including triglycerides level.

12. The effect of Ramadan fasting on high-density-lipoprotein (HDL)

Health organizations recommend lifestyle that help to elevate high-density-lipoprotein (HDL) [46]. In general, a desired improvement has been found in plasma HDL at the end of Ramadan month and even after few weeks afterward [63]. Although there are some few studies that found no favorable changes in HDL as a result of Ramadan fasting [2, 64], recent strong evidences approved the health effect of Ramadan fasting on plasma HDL [61, 62]. However, the contradictory may due to the limitations of some studies. Kul et al. [65] did a meta-analysis to investigate the impact of Ramadan fasting on some health-related parameters in healthy population including blood lipids. They analyzed the data obtained from 13 studies to explore the effect of Ramadan fasting on HDL concentration (661 healthy individuals: 462 men and 199 women). They concluded that Ramadan fasting may help to reduce HDL concentration in women but not in men [65]. Moreover, the negative effect of Ramadan fasting has been observed in special population such as older adults with hypertension disease [66]. In sum, most of the recent and soled evidences have proved the beneficial effect of Ramadan fasting on plasma HDL level. Furthermore, more studies are encouraged to clarify the role of Ramadan fasting on HDL in different cases and population.

13. The effect of Ramadan fasting on fasting plasma glucose

Unhealthy elevation in fasting plasma glucose (FPG) has been found to be one of the MetS markers. The holy month of Ramadan has different lifestyle in most Muslim populations including diet and physical activity pattern which may influence the FPG [20]. Nevertheless, Ramadan fasting may help to reduce FPG even in diabetic individuals in both male and female [62]. However, the beneficial reduction in FPG during or end of Ramadan month seems to be temporary [67, 68]. Hence, any change in blood glucose during Ramadan is minor and improbable to affect healthy people especially if there is no major changes in diet or physical inactivity levels [69]. Recently, the effect of Ramadan fasting on FPG has been investigated in health young adults. The study found that Ramadan fasting elevated FPG significantly during the end of Ramadan comparing the levels before Ramadan. Nevertheless, the elevated value of FPG was within the normal level in both occasions [2]. On the other hand, Ramadan fasting may reduce FPG of apparently healthy young adults (19–23 years old) during the end of Ramadan month [70]. Furthermore, intermittent fasting such as Ramadan fasting improve FPG in obese/overweight adults. One of the main outcomes of Ramadan fasting is losing weight and FPG as well as related metabolic parameters such as insulin, Homeostatic Model Assessment of Insulin Resistance (HOMA-IR) [71]. Insulin promotes the storage of glucose in liver and muscles as glycogen. However, during Ramadan fasting, circulating glucose levels decrease which lead to decrease the secretion of insulin and increase the level of glucagon hormone and catecholamines to enhance the

breakdown of glycogen to provide body with energy [64]. Hence, one can conclude that Ramadan fasting may improve FPG especially after a couple of weeks. One of the explanation is that alterations in lifestyle during the month of Ramadan may lead to changes in the rhythmic pattern of different related hormonal including thyroid hormones, melatonin, pituitary hormones (prolactin, luteinizing hormone, follicular stimulating hormone, growth hormone and thyroid-stimulating hormone) and steroid hormones (cortisol and testosterone) [72]. These hormones are related to energy metabolism and regulation of energy intake [14, 72]. These hormonal changes could explain decreases in blood glucose levels.

However, FPG may return to previous level afterward. Thus, intermittent fasting is recommended to reduce the risk of having one or more of the MetS markers such as FPG.

14. The effect of Ramadan fasting on blood pressure

Blood pressure (BP) is one of the complicated factors liked to different cardiovascular diseases.

High blood pressure is one of the MetS that may develop cardiovascular and metabolic diseases [52]. Although some studies reported slight, but significant, elevation in blood pressure in apparently healthy young adults during the month of Ramadan [2], different evidences concluded that Ramadan fasting may lead to reduce blood pressure in apparently healthy people as well as patients with hypertension, stable cardiovascular, metabolic syndrome and dyslipidemia [73]. In a systematical review study, Mazidi and colleagues found that data from different studies reported reduction in blood pressure especially systolic blood pressure (SBP) but no significant changes has been observed in diastolic blood pressure (DBP) [61]. Data from several investigations revealed that Ramadan fasting could reduce blood pressure unless there are some conditions that may influence BP such as diet and stress [74–76]. However, Topacoglu et al. [77] observed an increase in the number of admissions for hypertension during the holy month of Ramadan [77]. The reduction in blood pressure parameters during the month of Ramadan can be explained as a result of dehydration due to the long fasting time. On the other hand, it can be attributed to lower daytime activity which may cause a noticeable reduction in sympathetic tone [78]. In some countries the holy month of Ramadan comes in hot season (June–August) which makes people fast longer (~15 hours). Therefore, hypertensive patient should be advised to avoid diuretics during fasting and they can fast with paying attention to type and amount of food that may raise BP [79]. Remarkably, very few available evidences observed unhealthy effects of Ramadan fasting on hypertensive patients. In fact, the role of Ramadan fasting on controlling blood pressure is controversial. Partly, it is due to the lack of the available evidences that investigated the comprehensive effect of Ramadan fasting on blood pressure in people with different health conditions. Thus, more investigations are recommended to clarify the role of Ramadan fasting on blood pressure parameters.

15. Conclusion

The effect of Ramadan fasting on most of the MetS markers is still controversial. However, most of the available evidences showed positive effect on most of the MetS markers. In general, Ramadan fasting may help to reduce the risk of MetS. Nevertheless, most of the positive results seem to be impermanent and

reading of many of the variables (MetS markers) return to the previous reading after few weeks (~3–4 weeks). Therefore, intermittent fasting such as Ramadan fasting could be one of the cure alternatives especially in people with MetS, cardiovascular or metabolic diseases with considering their physician supervision. In general, Ramadan fasting is associated with positive improvements in different related hormones such as insulin, leptin, adiponectin, adipocytokine, Gamma glutamyl transferase and others that may be directly or indirectly affect MetS markers. Hence, Ramadan as an intermittent fasting might be more beneficial for most population and cardiovascular and metabolic patients should consult their physicians when they decide to fast during the month of Ramadan. Again, more evidences are recommended to clarify the controversial issues related to the role of Ramadan fasting on MetS markers.

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