

Is Ramadan fasting related to health outcomes? A review on the related evidence

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Background: Fasting during Ramadan is an Islamic rule. Although previous review studies have assessed the impact of Ramadan on cardiovascular risk factors, athlete performance, diabetes and transplantation, in this study we have appraised some on these reviews by focusing on limitations and also, we have reviewed more recently published study and several recent studies, which are not reviewed till now. **Materials and Methods:** In this article, we reviewed recently conducted studies in regarding the impact of Ramadan fasting on weight, lipid profile, diabetes, immune system and gestation. MEDLINE (<http://www.pubmed.com>) was searched by using "Ramadan" as keyword and the most recent articles in mentioned topics since 2009 until February 2014 were selected. **Results:** Although weight has been decreased during Ramadan in the most studies, weight regain is prevalent during the following months. Meta-analysis of pre-Ramadan lipid profile in comparison to post-Ramadan values had been showed that total cholesterol and triglyceride were decreased in men and high-density lipoprotein was increased among women. In regarding diabetes and fasting, diabetic patients should be aware that medical, nutritional and physical activity consulting is necessary for individuals with diabetes who want to fast during Ramadan. Although published studies show that Ramadan fasting had no serious adverse effect on offspring, it is strongly recommended that pregnant women avoid fasting because of the limitations of studies. The effect of fasting during Ramadan on the immune system is favorable. Ramadan fasting has no impact on kidney function and urine component. **Conclusion:** Studies showed that Ramadan fasting has health protective effects. More precise studies should be conducted for more reliable conclusion.

Key words: Body weight, diabetes, fasting, immune system, lipid profile, pregnancy, Ramadan

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INTRODUCTION

Fasting during Ramadan is an Islamic rule and, therefore, Muslims fast a 29-30-day consecutive period per year. This Islamic rule is excepted for patients and whom fasting may be harmful to them. Ramadan is a month of Islamic lunar calendar and, therefore, its duration varies in different seasons year to year. In fasting days, individuals do not eat anything from brightening to sunset. From sunset to brightening, Muslims can eat freely. Hence, time of sleeping and eating may be affected by Ramadan.^[1] Approximately, 1.5 billion Muslims live world widely, especially in Asia and Africa.^[2] So, many studies have focused on the effect of Ramadan fasting on metabolic changes and health outcomes in different groups of Muslims population. Studies reported that total cholesterol (TC), low-density lipoprotein (LDL), high-density lipoprotein (HDL) and blood glucose have been improved after Ramadan compared to before Ramadan among athletes.^[3] As Smoking has been forbidden during fasting of Ramadan, studies revealed a significant reduction in second-hand smoke levels in public places^[4] that might be related to mortality and morbidity.^[5]

Moreover, reported evidence illustrated that smoking is positively related to elevated TC and LDL,^[6] poor glycemic control^[7] and increased risk of type 2 diabetes prevalence,^[8] lower birth weight and increased short for gestational age rates,^[9,10] impaired function of dendritic cells^[11] and altered immune cell count.^[12] Furthermore, a direct association between smoking and weight reduction was observed among older adults.^[13] Conducted studies have assessed the impact of Ramadan fasting on a different aspect of human metabolic and healthy such as an immune system, hormones secretion and gestation. The effect of Ramadan on diseases (e.g., gastrointestinal diseases)^[14,15] has been also examined. Although previous review studies have assessed the impact of Ramadan on cardiovascular risk factors (i.e., body mass index [BMI] and lipid profile),^[16] athlete performance,^[17] diabetes^[18-20] and transplantation,^[21] in this study we have appraised some on these review by focusing on limitations and also, we have reviewed more recently published study. Moreover, several recent studies have been published in these regards (e.g., the impact of Ramadan fasting on the immune system) that is not reviewed till now. In this article, we reviewed recently conducted studies in regarding the impact of Ramadan

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fasting on weight, lipid profile, diabetes, gestation, immune system and kidney function.

MATERIALS AND METHODS

MEDLINE (<http://www.pubmed.com>) was searched by using "Ramadan" as keyword. Found articles were categorized as original or review article. Included papers were sorted by year of publication to determine the most recent review articles. Then we reviewed original articles published after the last review article. Therefore, we can choose the most recent studies and articles not reviewed till now regarding weight, lipid profile, diabetes, gestation, immune system and kidney function [Table 1]. Reviewed articles have been published since 2009 until February 2014.

RESULTS

Weight

Based on the results of a currently published meta-analysis included 21 articles, 531 men and 299 women, fasting during Ramadan results in a moderate reduction in body weight

in men but not in women (-0.24 , 95% confidence interval [CI] = -0.36 to -0.12 ; $P = 0.0001$ and -0.04 , 95% CI = -0.20 to 0.12 ; $P = 0.62$, respectively).^[2] The overall estimated effect size for both genders was also significant (-0.17 , 95% CI = -0.26 to -0.07 ; $P = 0.001$). Moreover, within study heterogeneity was not significant ($I^2 = 0\%$, $P = 0.82$).

A recent study reported that body weight, BMI and body fat had a significant reduction in 3rd week of Ramadan in comparison with 1 week before or after Ramadan fasting ($P < 0.01$ for all).^[22] However, the changes in hip circumference, weight circumference and waist to hip circumference ratio were not significant. Moreover, lost weight during Ramadan was regained and reduced BMI was returned to pre-Ramadan values in short-term after Ramadan.^[22] Moreover, a significant increase in body fat percent measured in 30th day after Ramadan was observed in comparison to pre-Ramadan values.^[22]

Lipid profile

Meta-analysis of pre-Ramadan lipid profile in comparison to post-Ramadan values showed that TC (-0.44 , 95%

Table 1: Characteristics of included studies

Author	Year	Main outcome	Result
Kul <i>et al.</i> ^[2]	2014	Weight	Weight reduction was observed just in men
Faris <i>et al.</i> ^[22]	2012	Weight	Weight during Ramadan may be regained in short-term after Ramadan An increase in body fat percent measured in 30 th day after Ramadan was observed in comparison to pre-Ramadan values
Kul <i>et al.</i> ^[2]	2014	Lipid profile	TC and TG were decreased in men and HDL was increased among women. In both genders, a significant reduction in LDL was observed
Almaatouq ^[19]	2012	Diabetes	Hyperglycemia usually occurred due to overeating during nonfasting hours of Ramadan and change in dosage of antidiabetic drugs to prevent hypoglycemia
Khalil <i>et al.</i> ^[23]	2012	Diabetes	Insulin delivery should be rescheduled during Ramadan in which need to insulin reduction in daytime and increase in nighttime
Vasan <i>et al.</i> ^[24]	2012	Diabetes	FBS and PPPG were decreased among type 2 diabetic patients during Ramadan in comparison to before and after Ramadan values
Ziaee <i>et al.</i> ^[25]	2010	Pregnancy	Fasting in well-nourished women had no adverse effect on offspring
Moradi ^[26]	2011	Pregnancy	There are no significant differences in bone growth, biparietal diameter, fetal weight, amount of amniotic fluid and fetal heart rate between fasting and non-fasting pregnant women
Awwad <i>et al.</i> ^[27]	2012	Pregnancy	Time of delivery had no difference between fasted and non-fasted pregnant women and BMI is the most important factor which affect on time of delivery
van Ewijk <i>et al.</i> ^[28]	2013	Pregnancy	Subjects with fetal period during Ramadan were thinner and shorter than other Muslims
Develioglu <i>et al.</i> ^[29]	2013	Immune System	Ramadan fasting has no severe effect on immune system
Faris <i>et al.</i> ^[22]	2012	Immune system	Concentration of IL-6, IL-1 β and TNF- α and the number of total leukocytes, granulocytes, lymphocytes and monocytes were significantly decreased during Ramadan in comparison to pre-Ramadan
Bernieh <i>et al.</i> ^[30]	2010	Kidney function	In comparison to before Ramadan period, eGFR was improved, and proteinuria and urinary sodium were decreased during and after Ramadan
Boobes <i>et al.</i> ^[31]	2009	Kidney function	Creatinine, urea, uric acid, and sodium, potassium and HCO ₃ content of urine had no significant difference between pre and post of Ramadan
Qurashi <i>et al.</i> ^[32]	2012	Kidney function	The changes in the eGFR were not significantly different between fasters and non-fasters
Miladipour <i>et al.</i> ^[33]	2012	Calculus formation	In comparison to non-fasting period, a reduction in calcium, phosphate, magnesium and urine volume was observed but the concentration of uric acid, citrate, phosphate, sodium, and potassium was increased

BMI = Body mass index; eGFR = Estimated glomerular filtration rate; FBS = Fasting blood sugar; HDL = High-density lipoprotein; IL-6 = Interleukin 6; LDL = Low-density lipoprotein; PPPG = Postprandial plasma glucose; TC = Total cholesterol; TG = Triglyceride; TNF- α = Tumor necrosis factor- α

CI = -0.77 to -0.11; $P = 0.009$) and triglyceride (TG) (-0.35, 95% CI = -0.67 to -0.02; $P = 0.04$) were decreased in men and HDL (0.86, 95% CI = 0.11 to 1.61; $P = 0.03$) was increased among women. Although the overall pooled changes for TC (-0.29, 95% CI = -0.57 to 0.00, $P = 0.05$) was marginally significant, the pooled effect sizes for TG (-0.20, 95% CI = -0.44 to 0.04, $P = 0.1$) and HDL (0.73, 95% CI = -0.10 to 1.57, $P = 0.09$) were not statistically significant. In both genders (500 men and 240 women), a significant reduction in LDL (-2.22, 95% CI = -3.47 to -0.96; $P = 0.0005$ in men and -0.81, 95% CI = -1.61 to -0.00 in women; $P = 0.05$) was observed.^[2] The data of 581 men and 225 women was used to calculate overall effect size of TC. Analyses for estimating overall changes in HDL were conducted on 462 men and 199 women.

The effect of Ramadan fasting on lipid profile has been assessed among athletes.^[3] Results showed that TC and LDL were decreased, and HDL and TG were increased during Ramadan in compared with pre-Ramadan assessment.^[3] A trend of reduction in TG and very low-density lipoprotein and increase in HDL was observed after Ramadan month. TC and LDL reached to pre-Ramadan values during after Ramadan fasting period. Another study conducted on healthy subjects reported that Ramadan fasting had a favorable impact on LDL and HDL among men ($P < 0.001$ for both).^[34] The authors of foresaid study could not observe any reduction in TG and TC after Ramadan fasting in comparison with pre-Ramadan values in men ($P = 0.25$ for TG and $P = 0.06$ for TC). In women, although TC was decreased during Ramadan in compared with pre-Ramadan measurements, it reached higher values in after Ramadan period than pre-Ramadan. In contrast to LDL that showed a remarkable reduction trend, an increasing trend was observed for HDL and TG from pre-Ramadan to post-Ramadan period in women.

Diabetes

Reported evidence showed a decrease in intake of total fat, saturated fatty acid, cholesterol and polyunsaturated fatty acid during Ramadan month among type 2 diabetic obese women.^[35] On the other hand, there are two major complications for diabetic patients during Ramadan: Hypoglycemia, hyperglycemia.^[19] The risk of hypoglycemia is increased significantly among diabetic individuals during Ramadan.^[36] Hyperglycemia usually occurred due to overeating during nonfasting hours of Ramadan and change in dosage of antidiabetic drugs to prevent hypoglycemia.^[19] Fasting during brightening to sunset results in remarkable changes in eating pattern and daily physical activity. Studies reported that insulin delivery should be rescheduled during Ramadan in which need to insulin reduction in daytime and increase in nighttime.^[23] Therefore, it is recommended that diabetic patients use the insulin pump

for regulating their insulin requirement during Ramadan.^[23] Previous studies demonstrated that fasting blood sugar and postprandial plasma glucose was decreased among type 2 diabetic patients during Ramadan in comparison to before and after Ramadan values.^[24] Serum fructosamine, an indicator of overall glycemic control, showed a favorable change during Ramadan fasting.^[24] Reported guidelines for diabetic subjects during Ramadan emphasized that all recommendations should be individualized for each person.^[37] Nutritional recommendations advised that carbohydrate and fat content of sunset meal should be restricted and complex carbohydrate should be consumed before daily fasting.^[37] Diabetic patients should be aware that they have to break fast as hypoglycemia occurred.^[37] Medical, nutritional and physical activity consulting is necessary for individuals with diabetes who want to fast during Ramadan.^[38]

Pregnancy

In the most cases, pregnant women have been forbidden to fast during Ramadan but arbitrary fasting is observed in pregnant women. An Iranian historical cohort study on pregnant women aged 20-35 years ($n = 189$) who fasted 13 days in average, illustrated that in comparison to nonfasting mothers' offspring, fasting could not significantly affect on incidence of low body weight in neonatals.^[25] In comparison to those who were nonfasting during Ramadan, the risk of low birth weight was not statistically higher in fasting mothers (odds ratio: 1.50; 95% CI: 0.23-1.74; $P > 0.05$).^[25] In overall, the results of foresaid study showed that Ramadan fasting had no effect on intrauterine growth, pregnancy duration and anthropometrical measures of infants.^[25] Similarly, another study conducted on 25 fasting (mean of fasting days: 23 ± 6) and 27 nonfasting healthy women reported that there are no significant differences in femoral length, abdominal circumference, biparietal diameter, fetal weight, amount of amniotic fluid and fetal heart rate between two groups.^[26] The results of a prospective cohort study on 402 women (201 Ramadan fasted and 201 nonfasted) demonstrated that time of delivery had no difference between fasted and nonfasted pregnant women and BMI is the most important factor which affect on time of delivery.^[27] The mean of fasting days in foresaid study was 22 ± 9 . Moreover, the finding disclosed that Ramadan fasted mothers had lower rate of cesarean delivery (28.4% in fasted and 39.3% in nonfasted women; $P = 0.027$) and birth weight average (3094 ± 467 g in fasted and 3202 ± 473 g in nonfasted; $P = 0.024$).^[27] Researches regarding the effect of fasting during Ramadan on offspring are not limited to childhood, and it is evaluated till adulthood. A recent population-based study compared the BMI and height of adults whose fetal period had been in Ramadan with those whose fetal period had not been in Ramadan.^[28] After adjusting for adulthood BMI, results showed that

subjects with fetal period during Ramadan were thinner and shorter than other Muslims.^[28] Similar differences were not observed between non-Muslims who were not in the fetal period during Ramadan and non-Muslims who were in the fetal period during Ramadan.^[28]

Immune system

Animal studies reported that the expression of immunoglobulin A (IgA) in the intestinal mucosa, monocyte killing, natural killer-cell activity and macrophage activity were increased during fasting.^[39,40] In a human study, 35 healthy men recruited and pre-Ramadan IgS concentrations and immune system activity were compared with post-Ramadan.^[29] Findings illustrated that although IgG concentration was decreased in post-Ramadan period in comparison to pre-Ramadan, it was not out of the normal range.^[29] The reduction in concentration of salivary IgA was also observed, but the lymphocyte number was elevated.^[29] These results show that Ramadan fasting has no severe effect on the immune system. Another study conducted on 50 subjects reported that the concentration of interleukin 6 (IL-6), IL-1 β and tumor necrosis factor- α (TNF- α), and the number of total leukocytes, granulocytes, lymphocytes and monocytes were significantly decreased during Ramadan in comparison to pre-Ramadan.^[22]

KIDNEY

Ramadan fasting has no impact on kidney function and urine component in healthy subjects^[41] but the effect of fasting on renal function should be assessed among nonhealthy individuals. One study conducted on 31 chronic kidney diseases patients evaluated the renal function at 3 times: 1-month before Ramadan, during Ramadan and 1-month after Ramadan.^[30] In comparison to before Ramadan period, estimated glomerular filtration rate (eGFR) was improved, and proteinuria and urinary sodium were decreased during and after Ramadan.^[30]

The effect of Ramadan fasting on kidney transplant patients has been assessed in recent studies. One study compared the post-Ramadan measurements of renal function with pre-Ramadan values.^[31] Findings illustrated that creatinine, urea, uric acid, and sodium, potassium and HCO₃ content of urine had no significant difference between two periods.^[31] These results are approved by another study conducted on 43 fasters and 37 nonfasters kidney transplant recipients.^[32] The changes in the eGFR were not significantly different between two groups.^[32] The general conclusion of these two study demonstrated that fasting has not adverse effect on kidney transplant recipients.

Water drinking is forbidden during Ramadan fasting, and consequently, dehydration may occur. Dehydration

is considered as a risk factor for kidney stones.^[33] One study evaluated the effect of Ramadan fasting on calculus formation among 57 men (37 calcium calculus formers).^[33] Results showed that in comparison to nonfasting period, a reduction in calcium, phosphate, magnesium and urine volume was observed but the concentration of uric acid, citrate, phosphate, sodium, and potassium was increased.^[33] These findings do not support the hypothesis that Ramadan fasting is a risk factor for calculus formation.

DISCUSSION AND CONCLUSION

A statistical significant weight lost was observed among men during Ramadan. A is that during Ramadan, men should continue their usual outdoor activities while most Muslim women are housekeeper and, therefore, their activity level is lower than men.^[2] In general, two possible reasons were suggested for weight reduction in Ramadan: Decrease in calorie intake and subsequently body fat reduction, and negative fluid balance.^[22] Moreover, the correlation between the decrease of body weight and a decrease in meal frequency in people with type 2 diabetes was found, which leads to a decrease in calorie intake.^[35] Although a statistical significant weight lost was observed during Ramadan, Foresaid reduction (170 g) is not physiologically valuable, because it is too small for a 1-month period. One study reported that the lost weight during Ramadan was regained and reduced BMI was returned to pre-Ramadan values. A possible reason of this finding may be that individuals would return to their pre-Ramadan lifestyle in which dietary habits result in weight regain. It is suggested to evaluate the sustainability of the reduced weight in Ramadan during the following months to see whether or not this reduced weight is maintained during the following months.

The results of a meta-analysis were reported in "weight" and "lipid profile" section. It should be kept in mind that the design of conducted studies regarding fasting during Ramadan is similar to before-after intervention studies except that the control of confounder is weaker in Ramadan-related studies because they are categorized as observational study. Hence, the results of this meta-analysis may be affected by confounders of included studies. Moreover, the authors of this meta-analysis did not discuss regarding confounder adjustments, and it seems that different studies with different confounder adjustments were pooled. These differences may be a source of heterogeneity as well as cause of attenuation of the effect of Ramadan fasting on weight and lipid profile. The heterogeneity this meta-analysis was high. So, the results were not reliable.

As mentioned regarding the effect of Ramadan fasting on pregnancy, the risk of low birth weight was not statistically higher in fasting mothers.^[25] Appropriate nutritional status

has an important role in these findings, so that fasting in well-nourished women had no adverse effect on offspring.^[25] Although published studies shows that Ramadan fasting had no serious adverse effect on offspring, it is strongly recommended that pregnant women avoid fasting because the most of current studies did not adjusted the impact of several confounder variables such as pregnancy duration, nutritional status before, during and after the Ramadan, maternal age, socioeconomic status and other potential covariates.

Studies reported that Ramadan fasting may decrease the concentration of IL-6, IL-1 β , TNF- α and number of leukocytes and monocytes.^[29] Elevated concentration of proinflammatory cytokines (e.g., IL-6, IL-1 β and TNF- α) is known as a risk factor for cardiovascular diseases,^[42,43] insulin resistance^[44] and cancers.^[22] Suggested mechanism is that Ramadan fasting results in oxidative stress reduction, and therefore, lower level of reactive oxygen species.^[45] On the other hand, body fat decreased during Ramadan in this study, and therefore, proinflammatory cytokines secretion would be decreased.

This reviewed studies approved the safety of Ramadan fasting for chronic kidney diseases patients. Suggested mechanism for this improvement in renal function is a reduction in blood pressure and body weight and decline in dietary protein and creatinine intake.^[33]

Although conducted studies regarding Ramadan fasting and health outcomes were designed similar to before-after intervention studies, confounders were not controlled as well as possible. It is suggested that researchers should collect sufficient data for estimating confounders. Several studies reported that Ramadan fasting has health protective effects; however these effects were attenuated during post-Ramadan period. Dieticians should provide a guideline for maintaining health protective effects of Ramadan fasting during post-Ramadan period. In conclusion, although studies showed that Ramadan fasting has health protective effects, patient individuals should consult their medical team for fasting during Ramadan. More precise studies should be conducted for more reliable conclusion.

AUTHOR'S CONTRIBUTIONS

MHR searched databases and selected articles. MHR and LA wrote the manuscript. All authors have read and approved the content of the manuscript.

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