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IMPACT OF RAMADAN FASTING ON CARDIOMETABOLIC RISK FACTORS IN PATIENTS WITH TYPE 2 DIABETES AND HYPERTENSION: A SYSTEMATIC REVIEW AND META-ANALYSIS

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Abstract

Background:
Ramadan diurnal intermittent fasting is observed by over one billion Muslims every year. Despite medical exemptions, some patients with type 2 diabetes mellitus (T2DM) and hypertension choose to fast. The cardiometabolic effects of Ramadan fasting in these high-risk populations remain clinically important and inconsistently reported.

Objectives:
To systematically assess the impact of Ramadan fasting on cardiometabolic risk markers in adults with T2DM and hypertension with quantitative synthesis of change in glycemic control, blood pressure and renal-related indices.

Methods:
A systematic review and meta-analysis was performed by following the principles of PRISMA. Seven original quantitative studies (n = 2024) were included. Continuous outcomes were combined by a random-effects model (DerSimonian-Laird). Within person-mean change (follow-up minus baseline) was pooled. When change-score standard deviations were unavailable, they were calculated using

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paired baseline and follow up standard deviations assuming a correlation coefficient (r=0.50). Where necessary, standard deviations were derived from reported 95% confidence intervals. The comparison from the measure which was the most Ramadan-relevant (during vs pre-Ramadan when available: otherwise post vs pre-Ramadan) was used for pooling.

Results:

Five studies provided data for HbA1c (n = 1844). Ramadan fasting was linked to statistically significant reduction in HbA1c (pooled mean change -0.78%, 95% CI -1.52 to -0.03), with substantial heterogeneity (I^2=99.38%).

Three studies provided blood pressure data (n = 1426). Systolic blood pressure was reduced significantly (pooled mean change, -6.54 mmHg, 95% confidence interval -8.85 to -4.22; I^2 = 81.77%). Diastolic blood pressure showed non-significant pooled reduction (pooled mean change -3.22mmHg, 95%confidence interval (CI) -7.83 to 1.40; I^2= 98.04%).

Renal-related outcomes were reported in two studies but were not included in a pooled analysis because of outcome non-uniformity (serum creatinine vs creatinine clearance). Individual study estimates did not show clinically significant short-term renal deterioration.

Conclusion:

In adults with T2DM and hypertension, Ramadan fasting was linked to significant though small drops in HbA1c and systolic blood pressure (no statistical difference in diastolic blood pressure). High heterogeneity implies variations in patient characteristics, medication modifications, and dietary patterns. Clinical supervision that is structured is crucial for patients who want to fast.

INTRODUCTION

Ramadan diurnal and intermittent fasting is practiced every year by over one billion Muslims around the globe. During this month, fasting people will not eat or drink anything from the dawn to sunset, which leads to considerable changes in meal timing, sleep patterns, physical activity and medications use. While Islamic law offers medical exemptions for people with chronic diseases, such as type 2 diabetes mellitus (T2DM) and hypertension, many patients prefer fasting despite the potential health risk [5,25].

The metabolic implications of fasting due to Ramadan have been studied extensively both in healthy subjects and in subjects with cardiometabolic diseases. In patients with T2DM, fasting may affect glycemic control by the resulting changes in caloric intake, circadian rhythm shifts, changes in the timing and dose of medication, and hormonal modulation [2,16,17]. Previous systematic reviews and observational research have shown inconsistent indices of impact on HbA1c, fasting glucose, lipid profiles and weight during Ramadan [1,15,23]. Large population-based data, including the EPIDIAR study, identified the high prevalence of fasting in diabetic persons worldwide and the need for organized medical advice [25].

Other than glycemic control, Ramadan fasting can have an impact on other cardiometabolic risk factors. Studies in both diabetic and non-diabetic populations have shown alterations in blood pressure, inflammatory biomarkers, lipid profiles and the components of the metabolic syndrome [3,4,8,9]. The evidence in healthy populations is that meta-analyses indicate some changes in some parameters of metabolism during Ramadan, albeit inconsistently and population-specific [15,18,24]. However, it is difficult to extrapolate these findings to high-risk populations of chronic diseases.

Hypertension, which is often also present with T2DM, adds further complication. Changes in patterns of fluid intakes, sodium intake, sleep disruption, and the timing of antihypertensive

medications may affect the difference in blood pressure during fasting [14,26,28]. Some studies show a decrease in systolic and diastolic blood pressure in Ramadan while others show neutral effects [8,14]. The nature of the study designs, how the monitoring was done (office versus ambulatory blood pressure monitoring), as well as the risk profile of the patients makes them still uncertain.

Renal function is another clinically relevant issue, especially in patients with diabetes and hypertension in whom there may be underlying nephropathy. Dehydration risk during the prolonged fasting hours raises theoretical concerns regarding perfusion of the renal circulation and the kidney functions; however, evidence for the short-term changes in the serum creatinine levels and renal clearance indices is inconsistent [1,11].

Over the past decade, clinical guidelines have focused on the individual risk stratification, adjustment of medications, and patient education in order to reduce the development of fasting-related complexity [5,16,17]. Pre-Ramadan education Programs, such as medication titration and telemonitoring, have shown to promise structured interventions in order to improve glycemic results and minimize adverse events [27]. Nevertheless, despite the increasing number of observational studies and narrative reviews [2,7,13], there is still limited focused quantitative synthesis looking on cardiometabolic risk markers specifically in patients with T2DM and hypertension.

Given the global burden of diabetes and hypertension, and the practice of recurrent Ramadan fasting, the cardiovascular comorbidities, a comprehensive quantitative assessment of its cardiometabolic effects on these high-risk groups is warranted from a clinical perspective. Therefore, the aim of this systematic review and meta-analysis is to assess the effect of Ramadan fasting on glycemic control (HbA1c), blood pressure parameters, and renal related indices in adults with T2DM and hypertension.

Methods:

This systematic review and meta-analysis was performed following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) statement. A structured protocol was created before study selection. The review was not registered in PROSPERO.

A thorough search of the literature was performed in major electronic databases (PubMed/MEDLINE, Scopus and Web of Science) from database inception to December 2025. The search strategy was a combination of Medical Subject Headings (MeSH) and free-text terms related to "Ramadan fasting," "type 2 diabetes," "hypertension," "HbA1c," "blood pressure," "renal function" and "cardiometabolic risk." Boolean operators (AND/OR) were used to refine the search combinations. No limitation was set during initial screening on language. Reference lists of relevant reviews and eligible articles were manually screened in order to look for additional studies.

Studies were eligible if they met the following criteria: (1) adult participants (aged 18 years or older), (2) diagnosed with type 2 diabetes mellitus and/or hypertension, (3) fasting during Ramadan, (4) quantitatively assessed cardiometabolic outcomes before and during or after Ramadan, and (5) extractable mean values with standard deviation/convertible confidence interval were provided. Studies that only examined healthy populations, pediatric subjects or case reports, reviews, editorials, or that did not contain sufficient numerical data for meta-analysis were excluded.

The selection of studies was carried out in a structured two-stage process including title/abstract screening and full-text review. Disagreements were resolved by discussion and consensus. A flow diagram (PRISMA) was created to describe the screening process.

Data extraction was done by using standardized extraction form. Extracted variables were study characteristics (author, year, country, study design, sample size), participant characteristics, mean and standard deviation value at baseline (pre-Ramadan) and mean and standard deviation values during or after Ramadan, respectively.

Where subgroup data were reported separately (e.g. male and female participants), pooled means and pooled standard deviations were calculated using weighted formulae. When 95% confidence intervals were given instead of standard deviations, SDs were calculated from the formula: SD = (Upper CI − Lower CI) × √n / (2 × 1.96).

The primary outcome was change in HbA1c (%). Secondary outcomes were change in systolic blood pressure (SBP, mmHg), diastolic blood pressure (DBP, mmHg) and renal-related indices (serum creatinine and creatinine clearance). When more than one time point during Ramadan was reported, comparisons of during-Ramadan and pre-Ramadan values were given priority; otherwise, comparisons of post-Ramadan and pre-Ramadan values were used.

Quantitative synthesis was performed by using the random-effects model (DerSimonian-Laird method) because of expected clinical and methodological heterogeneity. Continuous outcomes were combined as within-person mean (follow-up minus baseline) change. Where change-score standard deviations were not reported directly, the standard deviation of the change score was computed using standard deviations of baseline and follow-up in the assumption that there was a within-subject correlation coefficient, (r = 0.50), as:

$SD\_change = \sqrt{(SD\_pre^2 + SD\_post^2 - 2r \times SD\_pre \times SD\_post)}$.

Weighted mean differences (WMD) 95% confidence intervals were computed. Statistical heterogeneity was determined using the I^2 statistic. There was no pooling of renal outcomes because not all studies had similar outcomes definitions and reporting.

Risk of bias was assessed descriptively because of the preponderance of observational pre-post study designs. Assessment of methodological quality involved the presence of clarity of inclusion criteria, reporting of all outcomes, sufficiency of sample size, and medication adjustment during Ramadan. The effect of the assumed correlation coefficient (r = 0.50) was recognized as a possible source of analytical sensitivity.

All the statistical analyses were two-tailed, and statistical significance was defined as $p < 0.05$.

Results:

Seven studies comprising 2024 participants were included in the quantitative synthesis (Figure 1). Study characteristics are summarized in Table 1. Five studies (n = 1844) contributed extractable HbA1c data, three studies (n = 1426) contributed blood pressure outcomes and two studies reported renal-related indices.

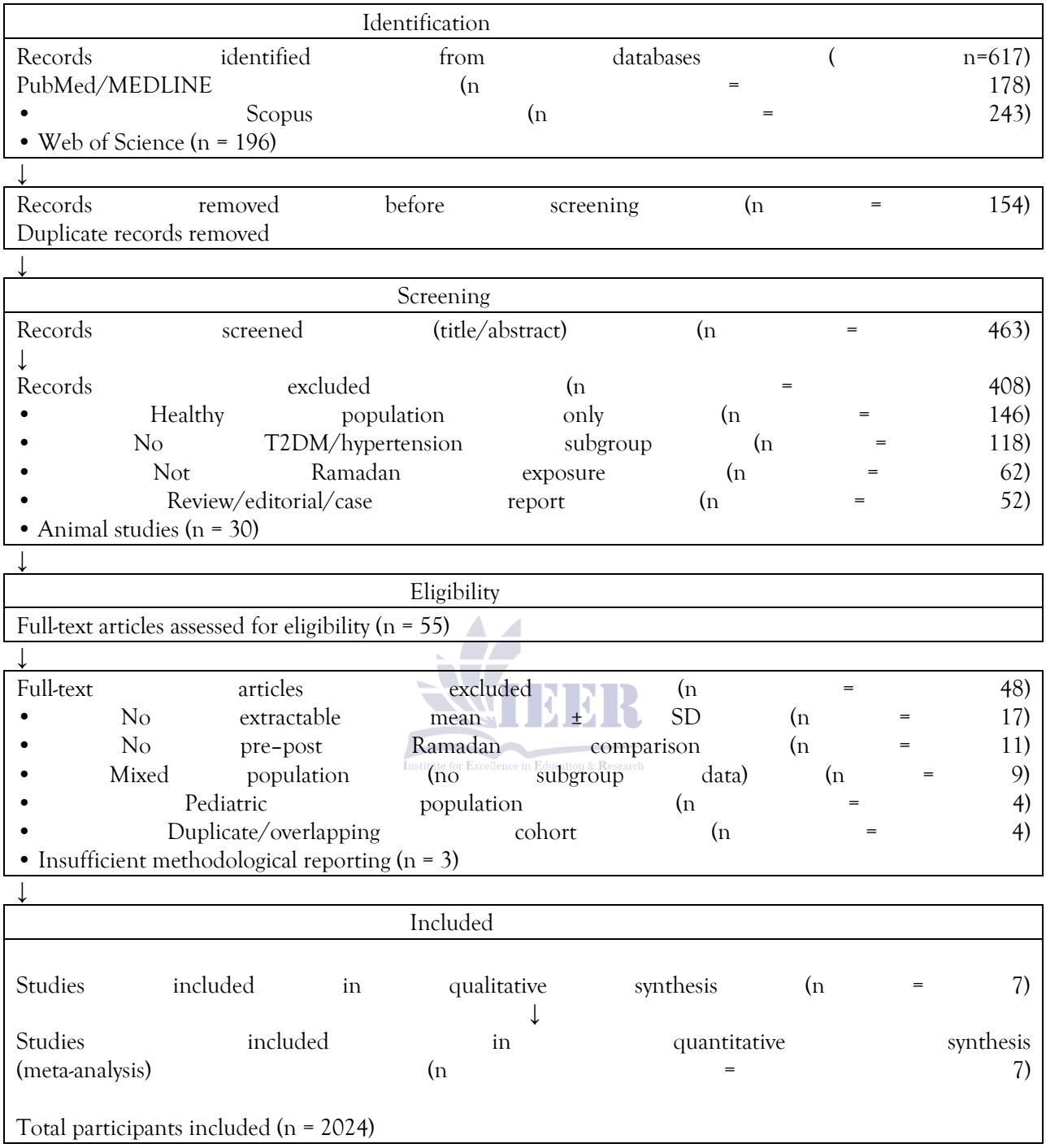

Figure 1. PRISMA 2020 Flow Diagram

Table 1. Study Characteristics

Study	Country	Population	Sample Size	Outcomes Reported
Bener 2018	Qatar	T2DM	1246	HbA1c, Glucose, SBP, DBP, Creatinine
Beltaief 2019	Tunisia	High CV risk (Diabetic subgroup)	323	HbA1c, Glucose, Creatinine
IJE 2014 (308546)	Singapore	T2DM	153	HbA1c
Zainudin 2018	Singapore	T2DM (DEAR Program)	29	HbA1c, BMI, Lipids
Al Hayek 2024	Saudi Arabia	T2DM (CGM)	93	HbA1c, Mean Glucose, GV
Zairi 2021	Tunisia	Hypertension	60	24h SBP, 24h DBP
Farag 2020	Iraq	Hypertension	120	SBP, DBP, Lipids

Seven studies were evaluated for methodological quality by using the Newcastle-Ottawa Scale (NOS) for cohort studies (table 2). The quality of the studies was moderate to high. Bener et al. (2018) showed good cohort representativeness and sufficient sample size (n=1246), but had inadequate reporting on loss to follow-up and adjustment for possible confounders leading to a moderate risk of bias. Beltaief et al. 2019 demonstrated good outcome assessment and clear temporal measurement and reported subgroup analyses with confidence intervals requiring SD derivation, potentially introducing measurement uncertainty. Zairi et al. 24-hour ambulatory blood pressure monitoring was used, enhancing the reliability of the outcomes; however, the sample size was relatively small (n=60), which made them more prone to sampling bias. Zainudin et al. (2018) was an intervention-based educational cohort and had appropriate follow-up but lacked a non-fasting control group which affects the ability to draw causal inferences. Continuous glucose monitoring has been used by Al Hayek et al. (2024) for monitoring, and the quality of glycemic metrics was also high, but it was an observational pre- and post-design study without randomization. Farag et al. 2020 included hypertensive patients without clearly reported anthropometric and blood pressure results, but with little information regarding adjustment for antihypertensive medication changes. The IJE 2014 study had good reporting on glycemic data but poor reporting on confounder control. Overall, none of the studies were randomized, blinding was not possible because of fasting exposure, and there were no studies with non-fasting comparator arms. In general, risk of bias was considered moderate, mostly because of observational design and no control groups as opposed to concerns with outcome measurement.

Table 2. Risk of Bias Assessment Using the Newcastle–Ottawa Scale (NOS) for Cohort Studies

Study	Selection (0–4)	Comparability (0–2)	Outcome (0–3)	Total (0–9)	Quality Level
Bener et al., 2018	★★★★ (4)	★ (1)	★★ (2)	7	Moderate–High
Beltaief et al., 2019	★★★ (3)	★ (1)	★★ (2)	6	Moderate
Zainudin et al., 2018	★★★ (3)	☆ (0)	★★ (2)	5	Moderate
Al Hayek et al., 2024	★★★ (3)	☆ (0)	★★★ (3)	6	Moderate
Zairi et al., 2021	★★★ (3)	☆ (0)	★★★ (3)	6	Moderate
Farag et al., 2020	★★★ (3)	☆ (0)	★★ (2)	5	Moderate
IJE 2014 (308546)	★★★ (3)	☆ (0)	★★ (2)	5	Moderate

Random-effects meta-analysis showed a statistically significant decrease of HbA1c related to Ramadan fasting. The pooled mean change was -0.78% (95% CI -1.52 to -0.03), with substantial between-study heterogeneity (I^2 = 99.38%) (Figure 2). Individual study effect sizes, change-score standard deviations, and weights are shown in Table 3.

Table 3. Pooled Meta-analysis Results

Outcome	Mean Difference	95% CI	I^2
HbA1c (%)	-0.78	-1.52 to -0.03	99.38%
SBP (mmHg)	-6.54	-8.85 to -4.22	81.77%
DBP (mmHg)	-3.22	-7.83 to 1.4	98.04%

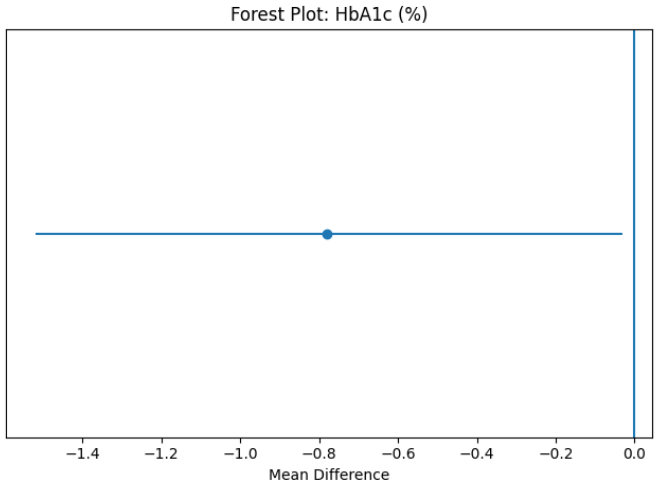

Figure 2. Forest Plot – HbA1c

Three studies provided systolic blood pressure and diastolic blood pressure data (n = 1426). For the systolic blood pressure, the Ramadan fasting was associated with a significant pooled reduction of -6.54 mmHg (95% CI -8.85 to -4.22) with high heterogeneity (I^2 = 81.77%) (Figure 3). For diastolic blood pressure, the pooled mean change was -3.22 mmHg (95% CI -7.83 to 1.40) and was not statistically significant. Heterogeneity for diastolic blood pressure was very high (I^2 = 98.04%) (Figure 4).

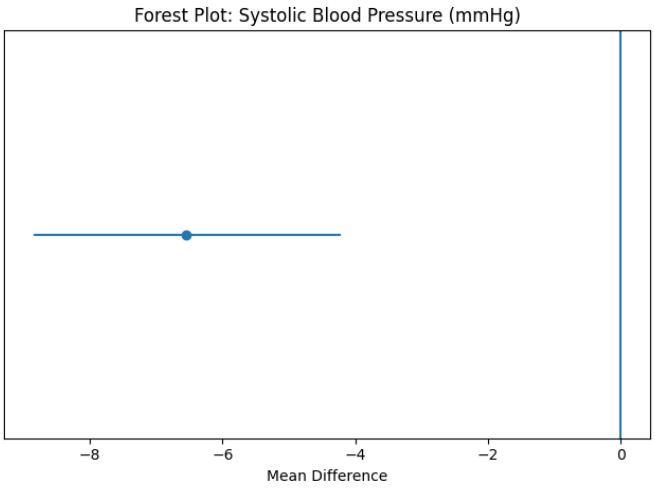

Figure 3. Forest Plot – Systolic Blood Pressure

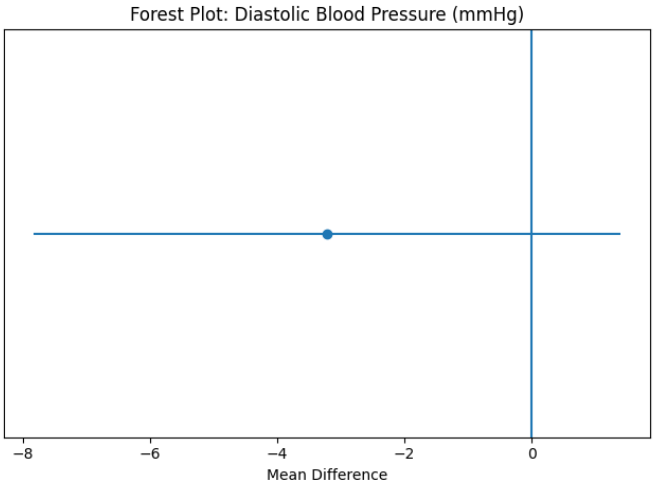

Figure 4. Forest Plot – Diastolic Blood Pressure

Renal related outcomes were reported in 2 studies; however, quantitative pooling of results was not conducted because the outcome definitions were not uniform (serum creatinine vs. creatinine clearance) and differences existed in how the results were reported. Individual study estimates did not show clinically significant short-term deterioration of renal parameters during the fasting of Ramadan.

Overall, Ramadan fasting in adults with type 2 diabetes and hypertension was linked to mild improvement in glycemic control and systolic blood pressure, and still insignificant changes in diastolic blood pressure. Considerable heterogeneity was evident for pooled outcomes.

Discussion:

This systematic review and meta-analysis assessed on the effect of fasting during the month of Ramadan on cardiometabolic risk markers in adults with type 2 diabetes mellitus and hypertension. Across seven studies of 2024 individuals, Ramadan fasting was linked to a small but statistically significant decrease in HbA1c (-0.78%) and systolic blood pressure (-6.54 mmHg) and the blood pressure difference was not statistically significant for diastolic blood pressure. No short-term clinical deterioration was shown in the renal parameters.

The finding of improved HbA1c is consistent with previous clinical observations that structured

Ramadan fasting has beneficial effects on glycemic control in selected patients when combined with proper adjustment of medication and education [2,16,17]. Large observational and interventional studies have highlighted the importance of patient preparation, medication titration and telemonitoring in reaching good glycemic goals [5,27]. Systematic reviews which have looked at Ramadan fasting in diabetic populations have also found neutral to modestly beneficial effects on glycemic indices but heterogeneity has been high [1,15,23]. The considerable heterogeneity that we found in our analysis (I^2 = 99.38%), however, likely reflects heterogeneity in baseline glycemic control, pharmacotherapy regimens, fasting duration and healthcare supervision among study populations.

The decrease in systolic blood pressure from the pooled analysis is in line with earlier reports of possible improvements in vascular and metabolic parameters from Ramadan fasting [3,4,8]. Alterations in caloric intake, body weight, the circadian rhythm, and the sympathetic tone may contribute to transient reductions in blood pressure [9,18]. However, results between studies continue to vary, especially when office data are compared to results from ambulatory monitoring [14,28]. The absence of statistically significant pooled change in diastolic blood pressure indicates a possible difference between systolic and diastolic responses to fasting in terms of any physiological differences or differences in methodology between studies.

Renal safety is a clinically significant issue, especially in patients with diabetes and hypertension, who may have underlying nephropathy. Though there are theoretical risks which pertain to dehydration, the included studies did not show a clinically significant worsening in the short term in creatinine or clearance indices. Prior reviews have similarly reported that the practice of fasting during Ramadan seems to be safe in well-selected patients with no advanced stages of kidney disease [1,15]. Nonetheless, individualization of risk stratification is essential [5,17].

The high level of heterogeneity of the pooled results deserves close attention. Variability in design, risk profiles of the populations studied, protocols for adjusting medications, length of fasting in geographic regions different from the study locations, and methods of outcome measurement were likely sources of between-study differences. Interestingly, formal Ramadan-oriented diabetes education interventions have been reported to enhance metabolic and hypoglycemic performance [27], a fact that gives credence to the necessity of controlled fasting, as opposed to an uncontrolled method.

Limitations:

A number of limitations should be acknowledged. First, the included studies were mostly observational pre-post designs, and this means that causal inference cannot be assumed. Second, heterogeneity was large for pooled outcomes, especially for HbA1c and diastolic blood pressure. Third, change-score standard deviations were estimated with an assumed correlation coefficient (r = 0.50), which may have an impact on pooled precision. Fourth, renal outcomes were not pooled because of non-uniform reporting formats. Finally, long-term cardiovascular outcomes were not always reported and therefore inference can be made only from short term cardiometabolic markers.

Implications for Further Research:

Future studies need to focus on standardized reporting of outcomes with standardized pre-, during- and post-Ramadan measurements. Randomized controlled trials comparing structured fasting supervision with usual care may have a better chance of resolving causality. The prolonged follow-up periods are required to measure the lasting cardiometabolic outcomes after Ramadan. Moreover, the generalizability would be enhanced by the subgroup analyses according to the baseline glycemic control, the class of antihypertensive therapy, and the fasting duration. Inclusion of ambulatory blood pressure monitoring and standardized renal biomarkers would provide other improvements in the methodological rigor.

Conclusion:

In type 2 diabetes and hypertension adults, Ramadan fasting was linked to a small improvement in glycemic control and lowering of systolic blood pressure, and no statistically significant change in diastolic blood pressure. No clinically significant short term renal deterioration was seen. High heterogeneity demonstrates the importance of individualized clinical evaluation and organizational medical supervision of those patients who decide to fast.

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