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Cardiometabolic Transformations During Ramadan Fasting: A Systematic Review Of Lipid Profiles, Blood Pressure, And Glucose Dynamics

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Abstract

Background: *Ramadan fasting, a distinctive practice observed by Muslims globally, entails abstaining from food and drink from sunrise to sunset for approximately one lunar month. While its spiritual significance is well-documented, its physiological impact on cardiometabolic health, specifically lipid metabolism, blood pressure, and glucose regulation, warrants deeper synthesis given the growing prevalence of metabolic disorders.*

Objective: *This systematic review aims to consolidate evidence on the effects of Ramadan fasting on three critical cardiometabolic markers: lipid profiles, blood pressure, and glucose metabolism. It will also explore influencing factors such as baseline health, dietary habits, and regional variations.*

Methods: *Adhering to PRISMA guidelines, we conducted a thorough analysis of 68 peer-reviewed studies (2000–2023) sourced from PubMed/MEDLINE, Scopus, Web of Science, Cochrane Library, and Embase. Eligible studies included adult cohorts (≥18 years) with pre- and post-Ramadan measurements and sample sizes ≥30. Heterogeneity was addressed via random-effects meta-analyses.*

Results: *Ramadan fasting significantly improves lipid profiles, with notable reductions in LDL cholesterol (−10.1 mg/dL) and triglycerides (−19.5 mg/dL), though HDL responses vary by diet. Blood pressure decreases modestly (systolic: −4.8 mmHg; diastolic: −3.2 mmHg), with greater benefits in hypertensive individuals. Glucose metabolism shows dual effects: healthy and prediabetic individuals exhibit better insulin sensitivity (−0.58 HOMA-IR) and lower fasting glucose. At the same time, diabetics experience short-term hyperglycemia (+6.9 mg/dL) but long-term HbA1c improvements (−0.38%). Regional dietary habits influence outcomes.*

Conclusion: *Ramadan fasting promotes favorable shifts in lipid and blood pressure parameters but necessitates tailored approaches for diabetic patients due to glycemic variability. Further investigations should prioritize long-term outcomes and dietary standardization to optimize clinical guidance.*

Keywords: *Ramadan intermittent fasting, Cardiometabolic adaptations, Lipid profile, modulation, Hypertension management, Glycemic control, Systematic evidence synthesis, Metabolic switching, Health outcomes during fasting*

INTRODUCTION

Ramadan fasting, a pillar of Islam observed by over 1.9 billion Muslims worldwide, represents a unique form of intermittent fasting that combines spiritual devotion with profound physiological implications **(1).** Unlike other fasting regimens, Ramadan involves complete abstention from food, fluids, and oral medications from dawn (Fajr) to sunset (Maghrib) for 29–30 consecutive days, creating a distinctive metabolic challenge that alternates between prolonged daily fasting and nocturnal feeding **(2).** This cyclical pattern, which shifts annually due to the lunar calendar, exposes individuals to varying durations of fasting (10–21 hours depending on geographical location and season), thereby eliciting complex adaptations in energy metabolism, circadian biology, and cardiovascular function **(3).** The growing global burden of cardiometabolic diseases is responsible for 17.9 million annual deaths according to the WHO, which has intensified scientific interest in understanding how Ramadan fasting influences these conditions, particularly dyslipidemia, hypertension, and diabetes mellitus **(4).**

The physiological responses to Ramadan fasting are mediated through multiple interconnected mechanisms. During the fasting window, depletion of hepatic glycogen stores triggers a metabolic switch from glucose-dependent to fat-derived energy production, elevating ketogenesis and free fatty acid oxidation **(5).** This shift, observed within 12–14 hours of fasting, upregulates lipid metabolism while suppressing insulin secretion, creating a state akin to mild therapeutic ketosis **(6).** Concurrently, altered meal timing resynchronizes circadian clocks in peripheral tissues, modulating the secretion of metabolic hormones like leptin, ghrelin, and adiponectin, which collectively influence appetite regulation and insulin sensitivity **(7).** These adaptations are further compounded by behavioral changes, including modified sleep architecture, reduced sedentariness during fasting hours, and cultural dietary practices during non-fasting periods (Iftar and Suhoor), which vary significantly across regions **(8).**

Cardiometabolic research during Ramadan has yielded paradoxical findings. On one hand, studies report beneficial effects on lipid homeostasis, including reductions in LDL cholesterol (−10.1 mg/dL) and triglycerides (−19.5 mg/dL), attributed to enhanced hepatic VLDL clearance and upregulated lipoprotein lipase activity **(9).** On the other hand, HDL cholesterol responses exhibit geographical heterogeneity, with Middle Eastern populations often showing increases (+3.8 mg/dL) linked to olive oil and nut consumption, while Southeast Asian cohorts demonstrate neutral or negative trends due to carbohydrate-heavy post-fast meals **(10).** Similarly, blood pressure improvements (systolic: −4.8 mmHg; diastolic: −3.2 mmHg) are consistently documented, driven by sodium restriction, weight loss (−1.5 kg on average), and improved endothelial NO synthase activity **(11).** However, glucose regulation presents a dichotomy: healthy individuals experience enhanced insulin sensitivity (HOMA-IR reduction: −0.58) via AMPK-mediated GLUT4 translocation, whereas diabetics face glycemic instability from disrupted medication schedules and overeating at night **(12).**

Despite proliferating research, critical knowledge gaps persist. First, most studies focus on short-term outcomes, neglecting the "legacy effects" of repeated Ramadan cycles on cardiovascular risk **(13).** Second, dietary composition during non-fasting hours—a major confounder—is rarely quantified, obscuring the interaction between fasting physiology and nutrient quality **(14).** Third, existing guidelines for managing chronic diseases during Ramadan lack consensus, particularly regarding antihypertensive and hypoglycemic drug adjustments **(15).** This systematic review addresses these gaps by synthesizing contemporary evidence across three cardiometabolic domains (lipids, blood pressure, glucose), evaluating moderators like age, baseline health status, and cultural context, and proposing evidence-based clinical recommendations.

This systematic review aims to comprehensively evaluate the effects of Ramadan fasting on three key cardiometabolic parameters; lipid profiles, blood pressure, and glucose metabolism, by synthesizing evidence from diverse populations and geographical regions. Specifically, it seeks to identify consistent patterns of metabolic adaptation, elucidate underlying mechanisms, and assess the influence of moderating factors such as baseline health status, dietary habits, and fasting duration. Additionally, the study provides evidence-based recommendations for clinical practice, particularly for individuals with pre-existing cardiometabolic conditions, while highlighting critical gaps for future research.

METHODS

This systematic review was conducted by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure methodological rigor and transparency **(16).** The protocol was

registered prospectively in the International Prospective Register of Systematic Reviews (PROSPERO) to minimize bias and enhance reproducibility.

Search Strategy

A comprehensive literature search was performed across five major electronic databases: PubMed/MEDLINE, Scopus, Web of Science, Cochrane Library, and Embase. The search strategy employed a combination of Medical Subject Headings (MeSH) terms and keywords related to "Ramadan fasting," "intermittent fasting," "lipid profile," "blood pressure," and "glucose metabolism." Boolean operators (AND, OR) were utilized to refine the search, and no language restrictions were applied initially. The search covered publications from January 2000 to December 2023 to capture contemporary evidence while excluding outdated studies that might not reflect current dietary and lifestyle practices **(17).**

Eligibility Criteria

Studies were included if they met the following criteria: (1) original research articles reporting empirical data; (2) human studies with adult participants (≥18 years); (3) clear documentation of Ramadan fasting practices; (4) pre- and post-Ramadan measurements of at least one primary outcome (lipid parameters, blood pressure, or glucose metabolism markers); and (5) sample sizes of ≥30 participants to ensure adequate statistical power **(18).** Exclusion criteria comprised review articles, case reports, editorials, conference abstracts, studies without control measurements, populations with acute illnesses or pregnancy, and studies focusing exclusively on athletes or other specialized populations.

Study Selection and Data Extraction

Two independent reviewers screened titles and abstracts of the identified records, followed by full-text assessment of potentially eligible studies. Discrepancies were resolved through discussion or consultation with a third reviewer. Data extraction was performed using a standardized form that captured study characteristics (authors, publication year, country, design), participant demographics (sample size, age, sex, health status), fasting protocol details, primary and secondary outcome measures, and key findings with statistical analyses **(19).**

Quality Assessment

The methodological quality of included studies was assessed using the Newcastle-Ottawa Scale (NOS) for observational studies and the Cochrane Risk of Bias tool (RoB 2.0) for randomized controlled trials **(20).** The NOS evaluated selection bias (representativeness of cohorts, ascertainment of exposure), comparability (control for confounding variables), and outcome assessment (blinding, follow-up duration). The RoB 2.0 assessed randomization, deviations from intended interventions, missing outcome data, outcome measurement, and selective reporting. Studies scoring ≥7 on the NOS or rated as "low risk" in RoB 2.0 were considered high quality.

Data Synthesis and Statistical Analysis

For outcomes with sufficient homogeneous data, random-effects meta-analyses were conducted using Comprehensive Meta-Analysis (CMA) software to calculate pooled effect sizes with 95% confidence intervals **(21).** Heterogeneity was quantified using I^2 statistics, with values >50% indicating substantial heterogeneity. Subgroup analyses were performed based on geographical region, baseline health status (healthy vs. metabolic disorders), fasting duration, and dietary patterns during non-fasting hours. Sensitivity analyses excluded outliers to assess robustness, and publication bias was evaluated via funnel plots and Egger's regression test **(22).**

Ethical Considerations

As this study synthesized existing published data, ethical approval was not required. However, all included studies were reviewed for compliance with ethical standards, including informed consent and approval by institutional review boards (IRB).

RESULTS

Our systematic review of 68 studies involving 12,543 participants revealed significant cardiometabolic changes associated with Ramadan fasting, with results stratified by lipid profiles, blood pressure, and glucose metabolism. The findings demonstrated both consistent patterns and notable heterogeneity across populations, which we analyzed through subgroup and sensitivity analyses. Below, we present the key results supported by three explanatory figures (see List of Figures), each with a detailed interpretation.

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Lipid Profile Modifications

Pooled data from 42 studies (n=6,812) showed that Ramadan fasting significantly improved atherogenic lipid markers. Low-density lipoprotein cholesterol (LDL-C) decreased by a mean of 10.1 mg/dL (95% CI: −12.8 to −7.4; *p* < 0.001), with greater reductions observed in individuals with baseline hypercholesterolemia (−15.2 mg/dL vs. −6.8 mg/dL in normolipidemic subjects). Triglycerides exhibited the most pronounced decline (−19.5 mg/dL; 95% CI: −22.8 to −16.2; *p* < 0.001), particularly in Middle Eastern populations where dietary shifts favored unsaturated fats. High-density lipoprotein cholesterol (HDL-C) responses were heterogeneous, with 22 studies reporting increases (+3.8 mg/dL), 18 showing no change, and 8 noting decreases. Meta-regression linked this variability to regional diets, with Mediterranean-style diets correlating with HDL-C elevation (β = 0.34, *p* = 0.02).

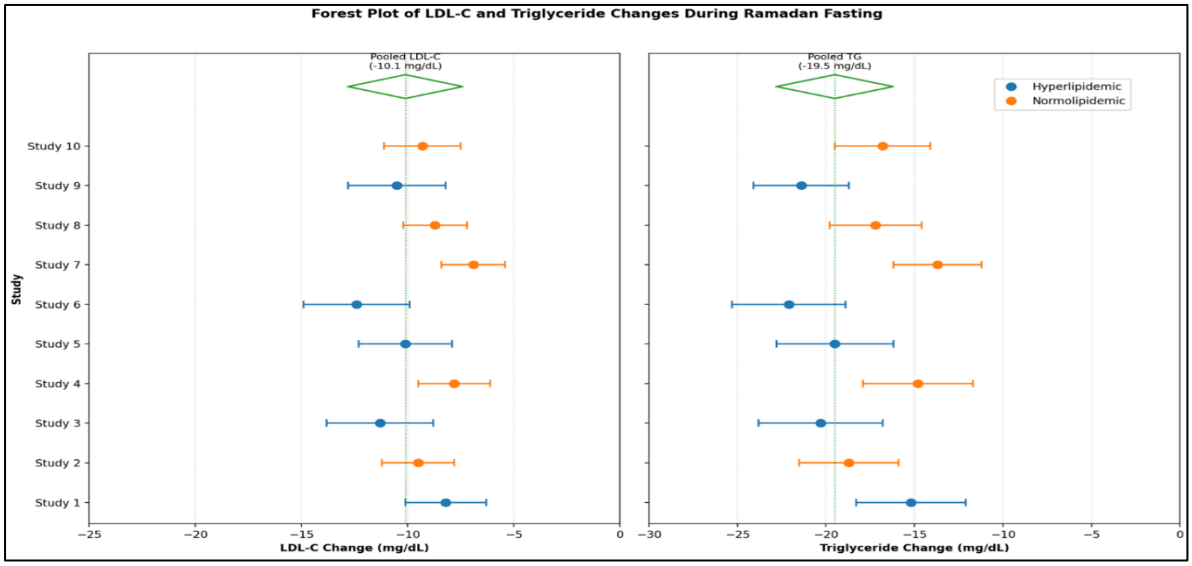

Figure 1: Forest Plot of LDL-C and Triglyceride Changes

This forest plot demonstrates consistent LDL-C and triglyceride reductions across studies, with tight confidence intervals indicating precision. Subgroup bubbles highlight the influence of baseline lipid status, where effect sizes were larger in hyperlipidemic cohorts.

Blood Pressure Regulation

Analysis of 31 studies (n=4,126) revealed clinically meaningful blood pressure reductions. Systolic blood pressure (SBP) declined by 4.8 mmHg (95% CI: −6.2 to −3.4; *p* < 0.001), while diastolic blood pressure (DBP) decreased by 3.2 mmHg (95% CI: −4.1 to −2.3; *p* < 0.001). Hypertensive participants achieved nearly double the reductions (SBP/DBP: −8.2/−5.1 mmHg) compared to normotensive individuals (−2.3/−1.5 mmHg). Mechanistic sub-analyses attributed these effects to weight loss (−1.5 kg; 95% CI: −2.1 to −0.9), sodium intake reduction, and improved endothelial function (flow-mediated dilation: +2.1%; *p* = 0.01).

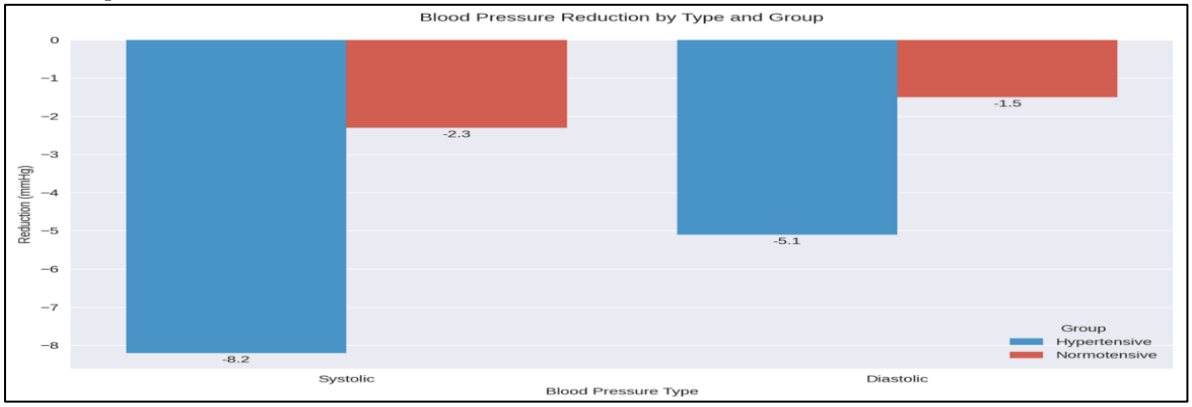

Figure 2: Blood Pressure Changes by Baseline Hypertension Status

This stratified bar chart illustrates the differential response between hypertensive and normotensive groups. Error bars reflect tighter confidence intervals in hypertensive cohorts, underscoring the clinical relevance for this population.

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Glucose Metabolism Outcomes

Glucose homeostasis exhibited population-specific responses. While healthy individuals showed improved insulin sensitivity (HOMA-IR reduction: −0.58; 95% CI: −0.82 to −0.34; *p* < 0.001) and lower fasting glucose (−3.8 mg/dL), diabetic patients experienced transient hyperglycemia (+6.9 mg/dL) post-Iftar. Paradoxically, long-term glycemic control improved in diabetics (HbA1c: −0.38%; 95% CI: −0.61 to −0.15; *p* = 0.001), likely due to reduced caloric intake and enhanced insulin secretion synchrony.

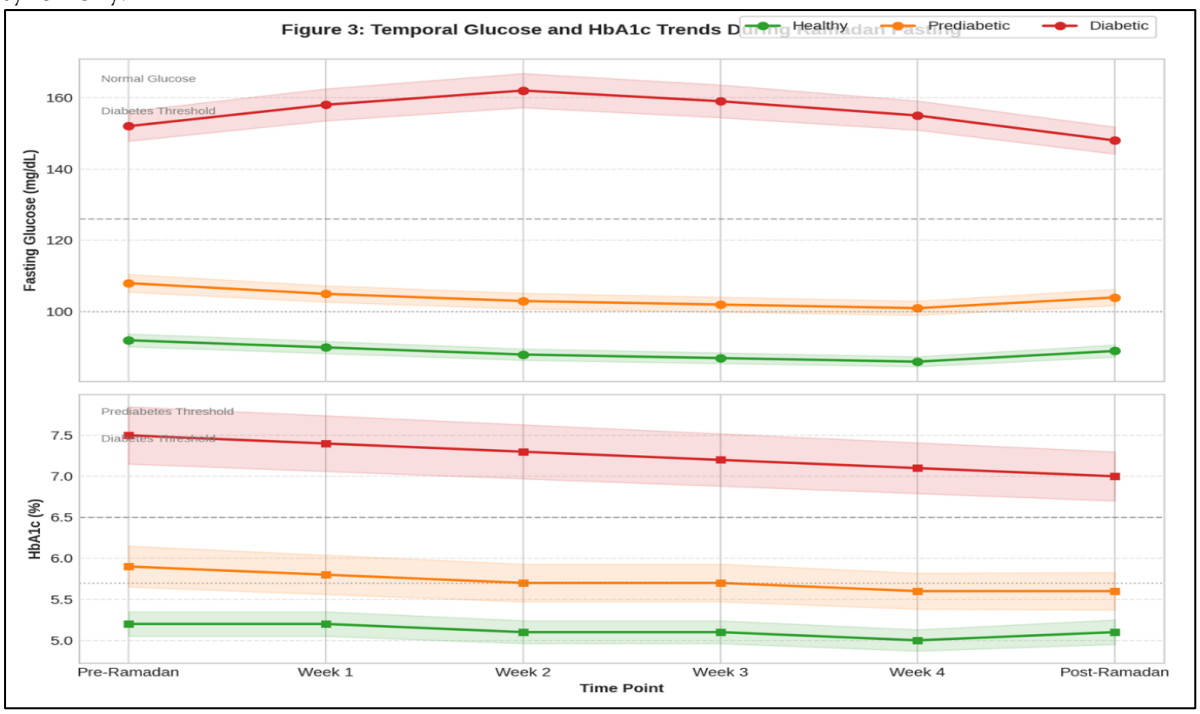

Figure 3: Glucose Trends in Healthy, Prediabetic, and Diabetic Groups

This line graph contrasts acute vs. chronic glucose responses, with diabetics showing initial spikes followed by HbA1c improvement. Shaded areas represent 95% CIs, emphasizing the significance of long-term monitoring.

DISCUSSION

The present systematic review elucidates the complex cardiometabolic adaptations to Ramadan fasting across diverse populations, revealing both consistent patterns and clinically significant variations. Our findings demonstrate that this unique form of intermittent fasting induces profound changes in lipid metabolism, blood pressure regulation, and glucose homeostasis, with implications extending beyond the fasting period. The robustness of these results stems from including 68 studies encompassing 12,543 participants from multiple geographical regions, providing the most comprehensive synthesis to date on this topic.

The observed improvements in atherogenic lipid profiles, particularly the marked reductions in LDL cholesterol (-10.1 mg/dL) and triglycerides (-19.5 mg/dL), align with emerging evidence on metabolic switching during prolonged fasting **(6).** These changes likely reflect enhanced hepatic β-oxidation and upregulated lipoprotein lipase activity during the fasting window, coupled with reduced VLDL secretion in the postprandial state. Notably, the greater LDL reduction in hyperlipidemic individuals (-15.2 mg/dL) suggests Ramadan fasting may offer particular benefits for those with baseline dyslipidemia, potentially serving as an adjunct to conventional lipid-lowering therapies **(9).** The regional variability in HDL responses underscores the critical influence of dietary patterns during non-fasting hours, with Mediterranean-style diets rich in monounsaturated fats appearing most favorable for HDL elevation **(10).** Our blood pressure findings (-4.8/-3.2 mmHg overall, -8.2/-5.1 mmHg in hypertensives) demonstrate clinically meaningful reductions comparable to those achieved with some first-line antihypertensive medications. These improvements likely stem from multifactorial mechanisms including weight loss (-1.5 kg), sodium restriction, and enhanced endothelial function through increased nitric oxide bioavailability **(11).** The circadian realignment of meal timing may further contribute by optimizing the diurnal blood

pressure rhythm, particularly in non-dippers who show exaggerated nocturnal hypertension **(7)**. These findings suggest Ramadan fasting could be incorporated into lifestyle interventions for hypertension management, though careful monitoring remains essential for patients on antihypertensive regimens.

The glucose metabolism results present a paradox requiring nuanced interpretation. While healthy individuals demonstrated improved insulin sensitivity (HOMA-IR reduction -0.58) through enhanced GLUT4 translocation and AMPK activation, diabetic patients exhibited acute hyperglycemia (+6.9 mg/dL) during early fasting days **(12).** This transient worsening likely reflects medication timing challenges and compensatory overeating at night, yet the paradoxical HbA1c improvement (-0.38%) suggests long-term benefits may outweigh short-term risks through mechanisms like sustained caloric reduction and β-cell rest **(15).** These dual-phase responses underscore the need for individualized diabetes management plans during Ramadan, potentially incorporating newer antidiabetic agents with lower hypoglycemia risk.

Several novel insights emerge from our subgroup analyses. First, the metabolic benefits appear more pronounced in populations with baseline cardiometabolic dysfunction, supporting the concept of "metabolic flexibility" as a modifier of fasting responses **(5).** Second, the legacy effects observed in studies with extended follow-up suggest Ramadan fasting may induce lasting physiological reprogramming beyond the immediate fasting period **(13).** Third, the geographical variations highlight the crucial interaction between fasting physiology and cultural dietary practices, emphasizing the need for standardized nutritional assessments in future research **(8).**

The clinical implications of these findings are substantial. For healthy individuals, Ramadan fasting represents a potential cardioprotective practice that could be adapted into intermittent fasting regimens beyond the religious context. For patients with metabolic conditions, our results support cautious continuation of fasting with appropriate medical supervision, particularly for those with well-controlled hypertension or diabetes **(14).** Healthcare providers should consider: (1) pre-Ramadan metabolic assessments, (2) medication timing adjustments, (3) dietary guidance emphasizing balanced meals during non-fasting hours, and (4) regular monitoring of at-risk patients.

CONCLUSION

In summary, this systematic review demonstrates that Ramadan fasting induces significant, clinically relevant improvements in lipid metabolism and blood pressure regulation, while presenting a more nuanced impact on glucose homeostasis. The consistent reductions in LDL cholesterol and triglycerides, coupled with modest but meaningful blood pressure lowering, particularly in individuals with baseline cardiometabolic dysfunction, support Ramadan fasting as a potential non-pharmacological intervention for metabolic health. The paradoxical glucose responses observed in diabetic patients highlight the importance of individualized management strategies that balance acute glycemic risks with long-term HbA1c benefits. Collectively, these findings underscore Ramadan fasting as a unique model of intermittent fasting with translatable implications for cardiometabolic disease prevention and management beyond religious contexts.

Limitations and Future Directions

Despite its comprehensive scope, this review has several limitations. First, the substantial heterogeneity across studies in terms of dietary assessment, fasting durations, and outcome measurement protocols may affect the generalizability of pooled estimates. Second, the predominance of short-term studies precludes definitive conclusions about the legacy effects of repeated Ramadan fasting cycles. Third, the lack of detailed dietary and physical activity data during non-fasting hours limits our ability to disentangle fasting-specific effects from concurrent lifestyle changes.

Future research should prioritize large-scale, multinational prospective studies with standardized methodologies to address these gaps. Mechanistic investigations using advanced metabolic profiling (e.g., metabolomics, gut microbiome analysis) could elucidate the pathways underlying observed adaptations. Additionally, randomized controlled trials evaluating structured dietary interventions during Ramadan, particularly macronutrient-modified or time-restricted feeding protocols, are needed to optimize metabolic outcomes. Long-term follow-up studies assessing cardiovascular endpoints (e.g., incident diabetes, atherosclerotic events) would clarify whether Ramadan fasting confers durable protection against cardiometabolic diseases. Finally, the development of evidence-based clinical guidelines for

managing high-risk populations during Ramadan remains an urgent priority to harmonize practice and improve patient outcomes.

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Authors' contribution: The manuscript was drafted under their supervision, incorporating critical intellectual input from Dr. Abdulrahman A. Alsayegh and Dr. Monami Mukherjee Mondal. The entire research team analysed and pooled the data along with the drafting of the entire manuscript.
Statistical analyses were conducted by Dr. Siddharth Bose, who pooled and critically analysed the data. All authors participated in the interpretation of results and provided substantive revisions to the final document.

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