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Cardiopulmonary Responses to Ramadan Fasting in Hypertensive Patients: A Multigroup Comparative Study

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ABSTRACT

Hypertension remains a major global health challenge, prompting exploration of culturally relevant interventions such as Ramadan fasting. This study evaluated the effects of varying Ramadan fasting intensities on cardiovascular parameters among hypertensive patients. An observational design was applied to 159 participants in a community-based management program in Pati Regency, Indonesia, categorized into non-fasting, partial fasting, and full fasting groups. Systolic blood pressure (SBP) slightly increased in the non-fasting group (164.38 ± 19.12 to 166.04 ± 20.29 mmHg; p = .019), whereas both partial and full fasting groups showed significant SBP reductions (partial: 169.76 ± 16.96 to 163.86 ± 14.30 mmHg; p < .001; full: 171.79 ± 12.78 to 161.07 ± 13.15 mmHg; p < .001). A similar pattern was observed in diastolic blood pressure (DBP), with no significant change in the non-fasting group (p = .182), but significant decreases in the partial (99.28 ± 5.36 to 93.25 ± 6.27 mmHg; p < .001) and full fasting groups (102.86 ± 5.99 to 95.00 ± 6.38 mmHg; p < .001). Only the full fasting group showed a significant reduction in heart rate (97.54 ± 5.81 to 84.25 ± 4.54 bpm; p < .001), while oxygen saturation remained stable across all groups. These findings suggest that full Ramadan fasting provides substantial cardiovascular benefits, supporting its potential as a culturally grounded, non-pharmacological approach hypertension management.

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Introduction

Blood pressure and overall hemodynamic control in hypertensive patients remain suboptimal. A cross-sectional review of 782 cases in a tertiary outpatient clinic showed that the proportion achieving target levels (<140/90 mmHg) was low [1]. Despite decades of promotive and preventive efforts, uncontrolled hypertension persists as a major global health concern. Findings from the May Measurement Month 2017 study, involving over 1.2 million adults worldwide, revealed that 17.3% of individuals with elevated blood pressure were untreated, and 46.3% of those receiving antihypertensive therapy had not achieved optimal control [2]. These data underscore that nearly half of treated patients remain at elevated cardiovascular risk, highlighting the need for more effective management strategies encompassing adherence, regimen optimization, and system-level interventions.

Uncontrolled hypertension is often accompanied by heightened sympathetic activity, resulting in elevated heart rate and increased cardiovascular workload, which contribute to poorer prognosis [3]. Heart rate thus serves as a complementary indicator of hemodynamic stability, with a 10 bpm increase associated with a higher likelihood of elevated blood pressure in hypertensive patients [4]. Moreover, sustained hypertension can damage small blood vessels, including pulmonary microvasculature, impairing perfusion and gas exchange, and thereby reducing oxygen saturation (SpO_2). Evidence shows that each 1 mmHg reduction in systolic blood pressure corresponds to a 0.02% decrease in oxygen saturation (95% CI: 0.00–0.03%), underscoring the interdependence of blood pressure and oxygenation in hypertensive individuals [5].

Achieving optimal blood pressure control remains challenging, with a study of 440 respondents reporting only 36.8% reaching target levels, largely due to poor adherence to antihypertensive therapy and insufficient lifestyle modifications, particularly in diet [6]. In addition to physical management, hypertensive patients often require psychosocial and spiritual support, as persistent uncontrolled blood pressure can exacerbate anxiety, stress, and depression, further impairing physiological stability [7]. Integrating spiritual care—such as access to prayer facilities, counseling by religious leaders, and education on acceptance and inner peace—has been shown to enhance emotional resilience, strengthen coping mechanisms, and promote stress reduction, thereby contributing to improved blood pressure control and overall well-being [8].

Ramadan fasting has been associated with favorable effects on blood pressure, heart rate, and oxygen saturation in hypertensive patients. Mechanisms such as caloric restriction, reduced sympathetic activity, and lower intake of stimulants contribute to decreases in systolic and diastolic blood pressure—typically by 5–10 mmHg—and a reduction in heart rate, thereby alleviating cardiac workload [9]. A meta-analysis of seven studies involving 260 hypertensive

patients demonstrated significant reductions in systolic (SMD = −0.77; 95% CI: −1.18 to −0.36; p = 0.0002) and diastolic blood pressure (SMD = −0.79; 95% CI: −1.35 to −0.24; p = 0.005) [10]. Similarly, the LORANS study reported a 7.29 mmHg decrease in systolic and 3.42 mmHg decrease in diastolic blood pressure post-Ramadan, while a meta-analysis of 33 studies (n = 3,213) showed consistent reductions across healthy, hypertensive, and diabetic populations [11].

Given its physiological benefits, Ramadan fasting—whether full or partial—offers a flexible, non-pharmacological strategy for blood pressure control, particularly in outpatient settings. Beyond its physical effects, fasting also enhances spiritual well-being, reduces emotional stress, and promotes social empathy, thereby supporting a holistic approach to hypertension management that addresses both physiological and psychosocial dimensions. [12]. However, variations in fasting intensity—such as full, partial, or non-fasting practices—may lead to different physiological responses, yet comparative evidence on their specific impacts remains limited. Therefore, this study was designed to examine the differences in cardiovascular outcomes among these fasting patterns to better understand how fasting intensity influences blood pressure regulation. The novelty of this research lies in its focus on community-based hypertensive patients within a culturally relevant context, integrating both physiological and psychosocial perspectives. By comparing different fasting intensities, this study contributes new empirical insights into the potential of Ramadan fasting as a tailored, culturally grounded, non-pharmacological intervention for hypertension management.

Literature Review

Hypertension, defined as sustained blood pressure ≥140/90 mmHg, is a major modifiable risk factor for stroke, myocardial infarction, and cardiovascular mortality. Often asymptomatic, it requires routine screening for early detection. Established risk factors include advanced age, family history, overweight or obesity, physical inactivity, high dietary sodium intake, and excessive alcohol consumption. While lifestyle modification—such as dietary improvement, increased physical activity, weight management, smoking cessation, and reduced alcohol intake—remains central to management, many patients require antihypertensive pharmacotherapy to achieve target blood pressure and prevent complications [13].

Cardiovascular risk assessment in clinical practice integrates blood pressure with other parameters, including lipid profile, age, sex, smoking status, and current medication use, to guide individualized management strategies [14]. The International Society of Hypertension recommends that lifestyle modifications be maintained even when pharmacological therapy is

initiated, emphasizing holistic approaches that address diet, physical activity, stress management, sleep quality, and cessation of harmful habits [15]. Expanding beyond conventional measures, integrative approaches such as mindfulness-based interventions, tailored nutrition, structured exercise, and psychosocial or spiritual support have shown promise in optimizing blood pressure control [16].

Ramadan fasting, a religious practice observed globally by Muslims, is increasingly recognized for its potential cardiovascular benefits. However, clinical guidance for hypertensive patients remains limited, with available evidence largely observational and based on small cohorts with short follow-up. Low- to moderate-risk patients with stable clinical status may fast under medical supervision, while those at high or very high risk are generally advised to avoid prolonged fasting and consider modified regimens, such as intermittent or shortened fasts. Pre-Ramadan assessment and counseling are essential to address risks such as dehydration, hemodynamic instability, and medication timing, followed by post-Ramadan evaluation to reassess cardiovascular status and adjust management plans accordingly [17].

Material and Methods

This study employed a prospective observational design with pre- and post-Ramadan measurements. Participants were classified post hoc into three groups based on their fasting behavior: full fasting (completion of 30 fasting days during Ramadan), partial fasting (fasting for a minimum of 3–7 days within the Ramadan period), and non-fasting (no fasting days observed).

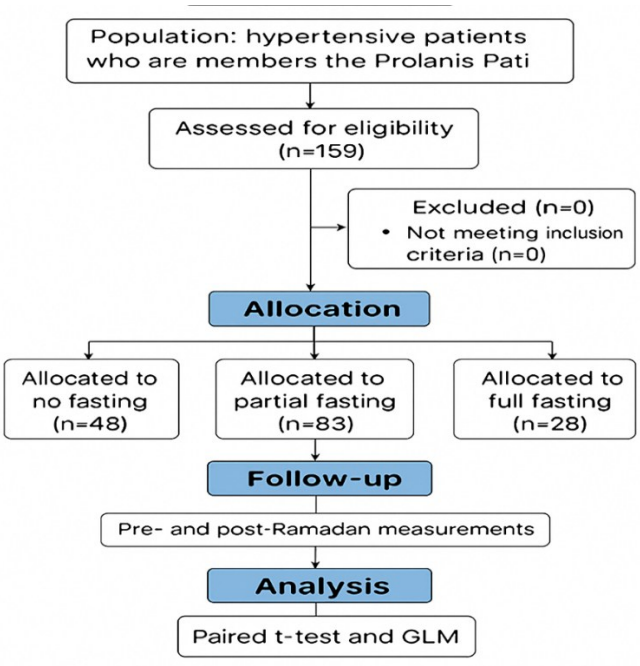


Figure 1. Flow diagram of participant enrolment, allocation, follow-up, and analysis

The study population comprised hypertensive patients enrolled in community-based chronic disease management programs (Prolanis) in Pati Regency, Indonesia. The required sample size was calculated using G*Power 3.1 software, with α = 0.05, statistical power = 0.80, and a medium effect size (f = 0.25) suitable for GLM analysis, resulting in a minimum target of 159 participants. Purposive sampling was applied with the following inclusion criteria: documented hypertension (systolic ≥140 mmHg and/or diastolic ≥90 mmHg), regular use of antihypertensive medication, and absence of chronic comorbidities such as diabetes mellitus, pulmonary tuberculosis, or stroke.

All participants shared a common spiritual and cultural background—Islam as their religion and Javanese cultural traditions. Blood pressure was measured using an aneroid sphygmomanometer, while heart rate and oxygen saturation (SpO_2) were assessed using a digital pulse oximeter. All instruments were newly manufactured and had undergone standard calibration and quality assurance by the manufacturer.

Data collection was conducted twice for all participants: the first measurement occurred one day before the start of Ramadan fasting, and the second measurement on the final day of Ramadan, approximately one hour after breaking the fast. All measurements were performed with participants seated in a relaxed position to ensure consistency and minimize external influences.

Paired t-tests were used to assess within-group differences between pre- and post-Ramadan measurements, as this test is appropriate for comparing repeated measures from the same participants before and after the intervention. Additionally, a General Linear Model (GLM) was employed to compare changes across the fasting groups while controlling for potential confounding variables, ensuring a more robust evaluation of group-level differences.

The study adhered strictly to ethical principles, ensuring equitable treatment across all participant groups, protection of confidentiality, and respect for human dignity. Ethical approval was obtained from the Ethics Committee of Universitas Muhammadiyah Kudus (Approval No. 23/Z-K/KEPK/UMKU/II/2024). All participants were informed in detail about the study objectives, procedures, and their rights, including the option to withdraw at any time without consequences. Written informed consent was obtained prior to participation.

Results and Discussions

A. Result

As presented in Table 1, 52.2% of respondents observed partial fasting during Ramadan, 30.2% did not fast, and only 17.6% completed full fasting. The majority of participants were female (57.2%), and most were taking ACE inhibitors (62.9%), followed

by calcium channel blockers (31.4%) and combination therapy (5.7%).

The mean age of respondents was 55.72 years (SD = 6.312), with a range of 42 to 70 years. The average duration of hypertension was 6.44 years (SD = 1.529), ranging from 3 to 10 years. These findings indicate that the sample primarily consisted of older adults with a relatively long history of hypertension and moderate religious engagement. Although controlling the use of antihypertensive medications such as ACE inhibitors, calcium channel blockers, and combination drugs was not feasible due to physicians' authority in prescribing treatments, the researchers systematically recorded and inventoried the types of medications consumed by each participant to account for potential variability in drug use across the study groups. The types of antihypertensive medications were inventoried (as shown in Table 1) and were found to be relatively evenly distributed across all fasting groups (full, partial, and non-fasting). This condition helps minimize potential bias related to the dominant effect of medication on blood pressure. The data indicate that the majority of participants in all three groups used ACE inhibitors, suggesting a comparable distribution of drug types among the fasting categories.

Table 1. Characteristics of Respondents

Variables	Frequency	%
Fasting		
No Fasting	48	30.2
Partial Fasting	83	52.2
Full Fasting	28	17.6
Gender		
Male	68	42.8
Female	91	57.2
Drug Consumption		
ACE Inhibitor	100	62.9
Calcium Channel Blocker	50	31.4
Combination Drug	9	5.7
Age (Mean; SD)	55.72	6.312
	Mean	**SD**
Duration of Hypertension	6.44	1.529

As shown in Table 2, systolic blood pressure (SBP) slightly increased in the non-fasting group (G1) post-intervention (164.38 ± 19.12 to 166.04 ± 20.29 mmHg; p = .019), whereas both partial fasting (G2) and full fasting groups (G3) experienced significant SBP reductions (G2: 169.76 ± 16.96 to 163.86 ± 14.30 mmHg; p < .001, G3: 171.79 ± 12.78 to 161.07 ± 13.15 mmHg; p < .001). A similar trend was observed in diastolic blood pressure (DBP), with no significant change in G1 (p = .182), but notable reductions in G2 (99.28 ± 5.36 to 93.25 ± 6.27 mmHg; p < .001) and G3 (102.86 ± 5.99 to 95.00 ± 6.38 mmHg; p < .001). Only G3 showed a significant heart rate decrease (97.54 ± 5.81 to

84.25 ± 4.54 bpm; p < .001), while changes in G1 and G2 were not statistically significant. Oxygen saturation (SpO_2) remained stable across all groups, with no significant differences before and after the intervention. Although the Kolmogorov–Smirnov test showed p-values below 0.05 for several variables, indicating that the data were not normally distributed, the relatively large sample size (n = 159) and the absence of extreme outliers justified the use of parametric tests (paired t-test and GLM). According to the Central Limit Theorem, the sampling distribution of the mean approximates normality with sufficiently large samples, thereby supporting the appropriateness of these analyses.

Table 2. Comparison of Pre- and Post-Ramadan Fasting Measurements

No	Variable	Group	Pre-Intervention (Mean ± SD)	Post-Intervention (Mean ± SD)	Mean Difference	p-value
1	Systolic BP (mmHg)	G1	164.38 ± 19.12	166.04 ± 20.29	-1.67	.019
2	Systolic BP (mmHg)	G2	169.76 ± 16.96	163.86 ± 14.30	5.90	.000
3	Systolic BP (mmHg)	G3	171.79 ± 12.78	161.07 ± 13.15	10.71	.000
4	Diastolic BP (mmHg)	G1	95.31 ± 7.95	95.00 ± 7.99	0.31	.182
5	Diastolic BP (mmHg)	G2	99.28 ± 5.36	93.25 ± 6.27	6.02	.000
6	Diastolic BP (mmHg)	G3	102.86 ± 5.99	95.00 ± 6.38	7.86	.000
7	Heart Rate (bpm)	G1	91.90 ± 11.14	92.46 ± 11.15	-0.56	.764
8	Heart Rate (bpm)	G2	96.20 ± 5.75	95.94 ± 5.92	0.27	.160
9	Heart Rate (bpm)	G3	97.54 ± 5.81	84.25 ± 4.54	13.29	.000
10	Oxygen Saturation (%)	G1	97.75 ± 0.96	97.77 ± 0.90	-0.02	.767
11	Oxygen Saturation (%)	G2	98.12 ± 0.99	98.07 ± 0.92	0.05	.288
12	Oxygen Saturation (%)	G3	97.64 ± 1.13	97.75 ± 1.08	-0.11	.375

G1: non-fasting during Ramadan, G2: partial fasting (minimum 7 days of fasting during Ramadan), G3: full fasting for the entire month of Ramadan

The results of the General Linear Model (GLM) analysis presented in Table 3 revealed several significant effects of fasting status and pre-intervention physiological measures on post-intervention outcomes. Fasting during Ramadan significantly influenced systolic blood pressure (F = 21.452, p < .001) and heart rate (F = 52.922, p < .001), but had no significant effect on diastolic blood pressure or oxygen saturation. Pre-intervention systolic blood

pressure (SBP) significantly predicted post-intervention SBP (F = 73.175, p < .001) and heart rate (F = 3.387, p = .004). Likewise, pre-intervention diastolic blood pressure (DBP) significantly influenced post-DBP (F = 32.388, p < .001), SpO_2 (F = 4.126, p = .022), and heart rate (F = 5.125, p = .010). Pre-intervention SpO_2 had a strong effect on post-SpO_2 levels (F = 88.405, p < .001), while pre-intervention heart rate was a significant predictor for post-SBP (F = 4.501, p < .001), SpO_2 (F = 2.448, p = .007), and post-heart rate (F = 40.192, p < .001).

Table 3. Group Comparison Results

Source	Dependent Variable	F	Sig. (p)
Puasa Ramadhan	SBP Post	21.452	.000
	DBP Post	2.514	.119
	SpO_2 Post	0.268	.607
	Heart Rate Post	52.922	.000
SBP Pre	SBP Post	73.175	.000
	DBP Post	0.716	.676
	SpO_2 Post	1.409	.217
	Heart Rate Post	3.387	.004
DBP Pre	DBP Post	32.388	.000
	SpO_2 Post	4.126	.022
	Heart Rate Post	5.125	.010
SpO_2 Pre	SpO_2 Post	88.405	.000
Heart Rate Pre	SBP Post	4.501	.000
	SpO_2 Post	2.448	.007
	Heart Rate Post	40.192	.000

B. Discussion

Our findings demonstrate that full Ramadan fasting was significantly associated with reductions in systolic and diastolic blood pressure, as well as heart rate. Participants in the full fasting group experienced the greatest decline in systolic (mean difference = 10.71 mmHg, p < .001) and diastolic blood pressure (mean difference = 7.86 mmHg, p < .001), along with a marked decrease in heart rate (mean difference = 13.29 bpm, p < .001). In contrast, the non-fasting group showed a slight but significant increase in systolic blood pressure (p = .019), while changes in diastolic pressure and heart rate were negligible. Oxygen saturation remained stable across all groups.

Interestingly, the partial fasting group—those who fasted intermittently or for shorter durations—showed modest reductions in both systolic and diastolic blood pressure, although these changes were less pronounced than in the full fasting group. This pattern suggests a possible dose–response relationship, where longer fasting duration and higher adherence may yield stronger hemodynamic benefits. Similar findings have been reported by Hoddy et al. (2020) and Kibret et al. (2025), who noted that partial fasting can improve

cardiovascular parameters, but its effects depend on the duration and regularity of fasting days [18][19].

The differences observed among the three groups can be interpreted through behavioral, physiological, and neurohormonal mechanisms. Full fasting participants typically show greater reductions in caloric and sodium intake, improved metabolic homeostasis, and enhanced parasympathetic tone, all of which contribute to lower blood pressure and heart rate. In contrast, partial fasting participants may experience inconsistent metabolic adaptations, while non-fasting individuals often maintain habitual eating patterns, possibly increasing their sodium and caloric intake, leading to higher systolic pressure post-Ramadan. This aligns with the findings of Campos al. (2023) and Vignesh (2024), who emphasized that dietary composition during non-fasting periods strongly influences blood pressure regulation [20][21].

These results are consistent with previous studies reporting the antihypertensive effects of Ramadan fasting [10][11]. This study aligns with the findings of Yazidi et al.(2025), who reported that Ramadan fasting contributes to reductions in both systolic and diastolic blood pressure among patients with hypertension [22].

Ramadan fasting has been reported to exert beneficial cardiovascular effects, including among individuals with hypertension, when implemented with appropriate clinical management. Evidence indicates that fasting during Ramadan may reduce blood pressure, likely through mechanisms involving decreased caloric intake, lower sodium consumption, improved metabolic balance, and favorable changes in body composition [23]. Associated weight loss—ranging from 0.4 kg after four weeks to 0.81–1.4 kg in most subjects—has been observed in both men and women, with reductions primarily in muscle mass rather than fat mass, supporting improved hemodynamic stability and blood pressure control [24][25][26].

In addition, reductions in heart rate during Ramadan fasting reflect decreased cardiovascular workload and enhanced cardiac efficiency, potentially lowering the risk of adverse cardiovascular events when achieved without hypotension or related complications [27]. However, these benefits require careful regulation of hydration, nutritional intake during suhoor and iftar, and adherence to prescribed antihypertensive therapy. Excessive sodium intake can counteract these gains, as shown in a study from Iran where increased sodium consumption during Ramadan was associated with elevated blood pressure among participants [28]. Thus, individualized dietary management and medical supervision are essential to maximize the therapeutic potential of Ramadan fasting while minimizing cardiovascular risks in hypertensive patients.

From a spiritual perspective, Ramadan fasting exerts a profound influence on

individuals with hypertension, extending beyond religious observance to encompass psychological and physiological balance. Fasting serves as a form of worship that cultivates patience, sincerity, and self-awareness, which in turn helps reduce emotional stress—one of the key factors contributing to elevated blood pressure. Through the practice of abstaining from food, drink, and negative emotions, individuals learn self-control and emotional regulation, producing a positive impact on autonomic nervous system function and hormonal balance [29].

Furthermore, Ramadan fasting fosters a deeper sense of spiritual connection with God through increased engagement in worship activities such as prayer, remembrance (dhikr), and Qur'anic recitation. This state of spiritual tranquility contributes to the reduction of sympathetic nervous system activity and enhancement of parasympathetic tone, thereby promoting lower blood pressure and stabilizing heart rate [30].

Ramadan fasting has also been associated with reductions in psychological stress, as reflected by significant post-fasting decreases in interpersonal sensitivity, phobic anxiety, general severity index, and positive symptom distress index scores. Concurrently, elevated ghrelin levels observed after Ramadan may contribute to mood enhancement and stress modulation, thereby indirectly supporting blood pressure regulation through neurohormonal pathways [31]. Furthermore, Ramadan fasting appears to influence stress-related neuroendocrine mediators, including catecholamines, dopamine, and endorphins. While catecholamines are elevated during stress and contribute to increased blood pressure and heart rate, dopamine and endorphins—typically enhanced during positive emotional states—attenuate sympathetic nervous system activity. Evidence indicates that fasting can increase dopamine concentrations, potentially reinforcing its cardioprotective effects [32][33].

Ramadan fasting has been reported to promote inner peace, which may contribute to blood pressure and heart rate regulation in hypertensive patients through mechanisms such as reduced sympathetic activity, enhanced parasympathetic tone, decreased stress hormone levels, and improved emotional resilience [34]. Beyond its physiological impact, fasting offers psychological and spiritual benefits. In a study of 200 participants, one month of Ramadan fasting was associated with improved mental clarity, emotional stability, and spiritual well-being, alongside a marked reduction in aggression, suggesting decreased emotional tension and a lower propensity for social conflict [35].

Evidence on the hemodynamic effects of Ramadan fasting remains inconclusive. A review of six studies found that in some hypertensive patients, fasting did not significantly alter blood pressure, blood glucose, or ketonemia, with variability likely driven by factors such as antihypertensive regimen, adherence to dietary and physical activity

recommendations, and comorbidities [36]. Similarly, a study of 40 hypertensive patients (mean age 57 ± 11 years; 65% women) undergoing various antihypertensive treatments reported no significant changes in 24-hour ambulatory, daytime, or nighttime blood pressure throughout Ramadan ($P > 0.05$), although a significant reduction in heart rate was observed ($P = 0.03$), suggesting a potential autonomic benefit despite stable blood pressure [37].

While some studies indicate minimal changes in blood pressure or heart rate, Ramadan fasting remains relevant to public health, particularly for individuals with chronic conditions such as hypertension. Emerging evidence underscores its role in enhancing emotional stress regulation and inner peace—psychological factors that can influence blood pressure within short time frames. Fasting also promotes compassion and social solidarity, potentially strengthening social support, a key determinant in holistic hypertension management [38].

Overall, our study contributes to the growing body of literature emphasizing that the degree of fasting adherence determines the magnitude of cardiovascular benefit. Full fasting offers the most pronounced improvement in blood pressure and heart rate, partial fasting provides moderate benefits, while the absence of fasting may result in neutral or even adverse hemodynamic outcomes. These findings open new opportunities for exploring structured or modified fasting regimens as complementary lifestyle interventions in hypertension management, particularly for patients who cannot undertake continuous fasting due to medical conditions.

Conclusion

This study demonstrates that full Ramadan fasting leads to significant reductions in blood pressure and heart rate among hypertensive individuals, while partial fasting provides moderate improvements and non-fasting participants exhibit minimal or even adverse changes. These findings emphasize that the intensity of fasting adherence influences cardiovascular outcomes. Beyond physiological effects, fasting may also improve hypertension control through emotional balance and enhanced social connectedness.

Future research should focus on verifying these results through larger, multicenter observational studies that evaluate the consistency and credibility of prior findings before proceeding to randomized controlled trials. Additionally, further exploration is needed to identify optimal fasting patterns for individuals unable to perform full fasting, ensuring safe and effective integration of culturally relevant fasting practices into hypertension management.

Limitation and Suggestions

This study provides evidence linking full Ramadan fasting to reductions in blood pressure and heart rate in hypertensive patients; however, several limitations should be acknowledged. The observational design limits causal inference, and small subgroup sizes reduce the ability to control for confounders such as medication adherence, dietary intake, hydration, and physical activity. The use of self-reported data introduces potential bias, while the absence of hormonal or inflammatory biomarkers constrains mechanistic interpretation. Furthermore, the specific cultural context may restrict the generalizability of findings to other populations.

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Conflict of Interest

This study has no potential conflicts of interest with any parties.

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