

Subjective and Objective Cognitive Function According to Blood Pressure Status in Patients with Hypertension

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Abstract

Background

Hypertension is a major modifiable vascular risk factor that may adversely affect cognitive functioning, particularly during midlife. However, subjective cognitive complaints and objectively measured cognitive performance may provide different information about cognitive functioning. This study aimed to compare subjective and objective cognitive functioning according to blood pressure status among middle-aged patients with hypertension.

Methods

This cross-sectional study included 120 patients with hypertension attending cardiology clinics in Gorgan, Iran, in 2024. Participants were classified into two groups according to their blood pressure status at the time of assessment: normal blood pressure ($n = 60$) and elevated blood pressure ($n = 60$). Blood pressure was measured using a standardized protocol. Subjective cognitive functioning was assessed using the Cognitive Failures Questionnaire (CFQ), and objective cognitive functioning was assessed using the Montreal Cognitive Assessment (MoCA). Demographic and clinical characteristics were also collected. Differences between the two groups were examined using the Mann–Whitney U test for cognitive measures and chi-square or Fisher's exact tests for categorical variables.

Results

Participants with normal blood pressure at the time of assessment had significantly higher MoCA mean ranks than those with elevated blood pressure (71.93 vs. 49.07; $U = 1114.00$, $Z = -3.702$, $P < 0.001$), indicating better objective cognitive performance. In contrast, the difference in subjective cognitive failures was not statistically significant, although participants with elevated blood pressure had higher CFQ mean ranks than those with normal blood pressure (65.78 vs. 55.22; $U = 1483.00$, $Z = -1.665$, $P = 0.096$). The two groups also differed significantly in educational attainment and socioeconomic status.

Conclusion

Among middle-aged patients with hypertension, blood pressure status at the time of assessment was associated with objectively measured cognitive performance but not with self-reported cognitive failures. These findings suggest that subjective and objective cognitive measures may capture different and complementary aspects of cognitive functioning. Given the cross-sectional design and differences in educational and socioeconomic characteristics between groups, the findings should be interpreted as an association rather than a causal relationship. Longitudinal studies incorporating repeated blood pressure measurements are warranted to clarify the temporal relationship between blood pressure and cognitive functioning.

Introduction

Life expectancy is continuously increasing worldwide, and the proportion of older adults is expected to rise substantially in the coming decades (1,2). Iran is also undergoing a demographic transition toward an older population, with approximately 25% of its population projected to be aged over 60 years in the coming decades (3). Healthy aging is increasingly recognized as a lifelong process involving the maintenance of physical, psychological, and social well-being and quality of life (4).

Blood pressure is one of the most important physiological parameters requiring accurate assessment and monitoring and is a major modifiable determinant of cardiovascular and cerebrovascular health (5–7). Accurate blood pressure measurement is essential for the diagnosis and management of hypertension and other cardiovascular conditions (6). According to current ACC/AHA criteria, blood pressure status is categorized into normal blood pressure, elevated blood pressure, stage 1 hypertension, and stage 2 hypertension according to systolic and diastolic blood pressure levels (8). Blood pressure levels progressively increase during adulthood, particularly between 30 and 60 years of age, partly as a consequence of increasing arterial stiffness (9). Thus, middle adulthood may represent an important period during which elevated blood pressure and its cumulative vascular consequences become clinically relevant and potentially modifiable.

Hypertension is highly prevalent worldwide and represents a major public health concern (10). Population-based evidence in middle-aged adults has demonstrated a substantial prevalence of elevated and hypertensive blood pressure, with urbanization and other sociodemographic factors contributing to differences in blood pressure distribution (11). Hypertension is also highly prevalent in Iran, particularly among older populations, while awareness and treatment remain suboptimal (12). The increasing burden of hypertension during adulthood is particularly important because prolonged exposure to elevated blood pressure may contribute not only to cardiovascular disease but also to adverse cerebrovascular and cognitive outcomes.

Cognitive functioning encompasses multiple mental processes, including attention, memory, executive functioning, language, and processing speed, all of which are essential for independent functioning and quality of life (13). A growing body of evidence indicates that hypertension is an important and potentially modifiable risk factor for cognitive decline (14).

Cognitive functioning can be assessed using both subjective self-report measures and objective, performance-based cognitive tests (15, 16). Although both approaches are commonly used in clinical assessment, neither is inherently superior, as they may capture different aspects of cognition and provide complementary information (17). Increasing attention has therefore been directed toward examining the relationship between subjective and objective cognitive measures. Convergence between the two may strengthen evidence regarding cognitive functioning, whereas discrepancies may indicate that subjective and objective measures capture distinct dimensions of cognition (18). Thus, assessing both subjective and objective cognition may provide a more comprehensive understanding of an individual's cognitive functioning.

Several mechanisms have been proposed to explain this association, including cerebrovascular injury, impaired cerebral perfusion, neuroinflammation, and disruption of the blood–brain barrier (19,20). Network-based research has suggested that memory and executive functioning may be particularly vulnerable to the effects of hypertension (21). Furthermore, a systematic review and meta-analysis of midlife hypertension and later-life cognition found predominantly negative associations between hypertension and global cognition, memory, and executive functioning, with longer duration of hypertension exposure associated with greater cognitive impairment (22). These findings suggest that the relationship between hypertension and cognitive health may begin during middle adulthood, making this period particularly relevant for early identification of potentially modifiable cognitive risk.

The cognitive consequences of hypertension are likely influenced by demographic and clinical characteristics beyond blood pressure itself. Lower educational attainment has been associated with reduced cognitive reserve and greater vulnerability to cognitive decline, and evidence suggests that vascular risk factors may interact with educational level to influence cognitive trajectories (23,24). In addition, hypertension occurring alongside other vascular and metabolic conditions may be associated with a greater cognitive burden (25–28). These findings underscore the multifactorial nature of cognitive functioning in individuals with hypertension and indicate that the relationship between blood pressure and cognition should be interpreted within the broader clinical and sociodemographic context.

Importantly, cognitive functioning can be evaluated from both subjective and objective perspectives. Subjective measures assess individuals' perceptions of their everyday cognitive difficulties, whereas objective measures assess performance using standardized cognitive tasks. These approaches may capture partially distinct aspects of cognitive functioning and therefore may not necessarily show equivalent patterns. Previous research has demonstrated that subjective cognitive complaints may have only modest correspondence with objectively assessed cognitive performance, and discrepancies between different sources of cognitive information should not necessarily be interpreted as measurement error or inaccurate self-assessment (29,30). Rather, subjective and objective measures may provide complementary information regarding different dimensions of cognitive functioning. Examining both approaches may therefore provide a more comprehensive characterization of cognitive functioning in patients with hypertension.

Despite the growing evidence linking hypertension with cognitive impairment, several important gaps remain. First, much of the existing literature has focused on older adults, whereas middle-aged populations remain comparatively understudied despite representing a potentially important window for identifying and modifying vascular risk before the accumulation of more extensive cerebrovascular injury (31). Second, many previous studies have relied primarily on a single cognitive assessment approach, limiting the ability to determine whether subjective cognitive experiences correspond to objective cognitive performance. Although the use of complementary cognitive instruments has been recommended to improve the assessment of cognitive functioning, subjective and objective outcomes have often been examined separately (32,33). Third, although previous research has linked hypertension severity and blood pressure exposure with cognitive outcomes, less is known about whether blood

pressure status at the time of assessment is differentially associated with subjective and objective cognitive functioning among middle-aged patients with hypertension.

Therefore, the present study aimed to compare subjective and objective cognitive functioning according to blood pressure status among middle-aged patients with hypertension. Specifically, we compared participants whose blood pressure was within the normal range with those whose blood pressure was elevated at the time of assessment and examined differences in both objective cognitive performance and self-reported cognitive failures.

Methods

Research subjects

The data for this study were obtained from patients attending cardiology clinics in Gorgan, Iran, in 2024, from the cardiology outpatient clinic of Deziani Hospital, and the cardiology clinic of Sayyad Hospital. This survey was approved by the Research Ethics Review Committee of Golestan University of Medical Sciences (Ethics code: IR.GOUMS.REC.1403.432), ensuring strict adherence to ethical standards. The study population comprised patients with hypertension referred to the aforementioned cardiology clinics. Participants were selected using convenience sampling. Sample size was estimated using the Tabachnick and Fidell formula for regression analysis (sample size = $50 + 8 \times \text{number of predictors}$). Given the eight primary predictor variables, a minimum of 114 participants was required; this figure was inflated to enhance statistical reliability, resulting in a final sample of 120 participants. The diagnosis of hypertension was determined based on objective medical examination criteria. Specifically, hypertension was defined as systolic blood pressure ≥ 140 mmHg, diastolic blood pressure ≥ 90 mmHg, or being on antihypertensive medication, documented previous visits to Deziani Clinic for hypertension, prior hospitalization records, and current use of antihypertensives. Before the physician examination, blood pressure was measured in a quiet, stress-free room using an oscillometric blood pressure device after being at rest for five minutes. The patient's arm was positioned at heart level with feet flat on the floor. Blood pressure was recorded at least twice with an interval of 1–2 minutes between measurements. When the difference between readings exceeded 5 mmHg, a third measurement was obtained. The mean of the two closest values was reported as the final blood pressure.

Measures

Demographic Form

A structured demographic questionnaire collected information on age, sex, height, weight, marital status, socioeconomic status, educational level, lifestyle habits (smoking and alcohol consumption), and history of chronic conditions, including type 2 diabetes mellitus, hypertension, hyperlipidaemia, and coronary artery disease.

Cognitive Failures Questionnaire (CFQ)

Subjective cognitive function was assessed using the Cognitive Failures Questionnaire (CFQ), originally developed by Broadbent and colleagues in 1982 (34). The CFQ comprises 25 items across four subscales: distractibility, memory problems, blunders, and name forgetting. Each item is rated on a five-point Likert scale ranging from 0 (never) to 4 (always), yielding a total score between 0 and 100, with the higher score indicating greater cognitive failure. Scores of 0–34 indicate low cognitive impairment, 34–50 indicate moderate cognitive impairment, and scores above 50 indicate high cognitive impairment. The Persian version of the CFQ has demonstrated satisfactory internal consistency, with Cronbach's alpha coefficients of 0.83 for distractibility, 0.81 for memory, 0.74 for blunders, and 0.70 for name forgetting. In addition, a test-retest reliability coefficient of 0.77 was obtained over a one-month interval.

Montreal Cognitive Assessment (MoCA)

Objective cognitive function was assessed using the Montreal Cognitive Assessment (MoCA), a brief standardised screening tool developed by Nasreddine and colleagues (29). The MoCA evaluates multiple cognitive domains, including short-term memory (5 points), visuospatial ability (4 points), executive function (4 points), attention and working memory (6 points), language (5 points), and orientation (6 points), yielding a maximum total score of 30. A score of 26 or above is considered normal, while a score below 26 is an indication of mild to moderate cognitive impairment. The MoCA demonstrates greater sensitivity than the Mini-Mental State Examination for detecting mild cognitive impairment in the general population. The Persian version has demonstrated a reliability coefficient of 0.77 and a correlation of 0.79 with MMSE scores at a significance level of $p < 0.05$. Sensitivity and specificity for distinguishing patients with Parkinson's disease from healthy controls were 0.85 and 0.90, respectively. The MoCA was administered individually by the researcher in collaboration with each participant.

Procedure

Patients were approached before their physician consultation and invited to participate in the study. After receiving a full explanation of the study objectives and confirming eligibility, written informed consent was obtained. Questionnaires were completed in a calm, private room free from distraction. The CFQ and demographic form were self-administered by participants, while the MoCA was administered by the researcher. Where necessary, clarification was provided to ensure full comprehension of items, and responses were recorded in person.

Analysis methods

Statistical analysis Statistical

Statistical analyses were performed using IBM SPSS Statistics version 27. The normality of continuous variables was assessed using the Shapiro–Wilk test. Descriptive statistics were used to summarize participants' demographic and clinical characteristics. Categorical variables were expressed as frequencies and percentages and compared between patients with normal and elevated blood pressure at the time of assessment using the chi-square test or Fisher's exact test, as appropriate.

Because the distribution of the cognitive variables did not satisfy the assumption of normality, non-parametric analyses were performed. Differences in objective cognitive function (Montreal Cognitive Assessment)MoCA() and subjective cognitive function (Cognitive Failures Questionnaire)CFQ() between the two blood pressure status groups were examined using the Mann–Whitney U test.

Results

As shown in Table 1, the two blood pressure status groups did not differ significantly in terms of sex, smoking status, physical activity, or ethnicity (all $P > 0.05$). However, significant differences were observed in socioeconomic status and educational attainment between the groups. Participants with elevated blood pressure had a higher proportion of individuals with poor socioeconomic status compared with those with blood pressure within the normal range (28.3% vs. 10.0%, $P = 0.039$). Similarly, the proportion of participants with no formal education was higher in the elevated blood pressure group than in the normal blood pressure group (61.7% vs. 31.7%, $P = 0.004$). No statistically significant difference was observed between the groups in terms of alcohol use based on Fisher's exact test ($P = 0.061$).

Table 1

Demographic and clinical characteristics of patients with hypertension according to blood pressure status at the time of assessment

Variable	Normal BP at assessment (n = 60)	Elevated BP at assessment (n = 60)	P value
Sex, n (%)			0.705
Female	39 (65.0)	37 (61.7)	
Male	21 (35.0)	23 (38.3)	
Socioeconomic status, n (%)			0.039
Poor	6 (10.0)	17 (28.3)	
Moderate	44 (73.3)	35 (58.3)	
Good	10 (16.7)	8 (13.3)	
Education, n (%)			0.004
Illiterate	19 (31.7)	37 (61.7)	
Middle school	10 (16.7)	10 (16.7)	
High school	20 (33.3)	7 (11.7)	
Diploma	11 (18.3)	6 (10.0)	
Smoking, n (%)			0.556
No	57 (95.0)	58 (96.7)	
Yes	3 (5.0)	2 (3.3)	
Alcohol use, n (%)			0.061*
Never	52 (88.1)	58 (98.3)	
Monthly	7 (11.9)	1 (1.7)	
Physical activity, n (%)			0.587
Low	31 (51.7)	35 (58.3)	
Moderate	28 (46.7)	23 (38.3)	
Aerobic	1 (1.7)	2 (3.3)	
Ethnicity, n (%)			0.189
Fars	57 (95.0)	51 (85.0)	
Turkmen	2 (3.3)	6 (10.0)	

Variable	Normal BP at assessment (n = 60)	Elevated BP at assessment (n = 60)	P value
Sex, n (%)			0.705
Sistani	1 (1.7)	3 (5.0)	

*Chi-square $P = 0.028$; Fisher's exact test $P = 0.061$ is reported due to low expected cell counts (2 cells, 50.0%, with expected count < 5).

Table 2

Comparison of objective and subjective cognitive function according to blood pressure status (Mann–Whitney U test)

Cognitive measure	Normal BP at assessment (n = 60) Mean Rank	Elevated BP at assessment (n = 60) Mean Rank	Mann- Whitney U	Z	P value
Objective cognitive function (MoCA)	71.93	49.07	1114.00	-3.702	< 0.001
Subjective cognitive failures (CFQ)	55.22	65.78	1483.00	-1.665	0.096

MoCA: Montreal Cognitive Assessment; CFQ: Cognitive Failures Questionnaire. Bold P values indicate statistical significance ($P < 0.05$).

As shown in Table 2, a statistically significant difference was observed between the two blood pressure status groups in objectively assessed cognitive function. Participants with blood pressure within the normal range had a higher mean rank on the Montreal Cognitive Assessment (MoCA) than those with elevated blood pressure (71.93 vs. 49.07; $U = 1114.00$, $Z = -3.702$, $P < 0.001$). In contrast, no statistically significant difference was observed in subjective cognitive failures assessed using the Cognitive Failures Questionnaire (CFQ), although participants with elevated blood pressure had a higher mean rank than those with blood pressure within the normal range (65.78 vs. 55.22; $U = 1483.00$, $Z = -1.665$, $P = 0.096$).

Discussion

The present study examined subjective and objective cognitive functioning according to blood pressure status in patients with hypertension. The main finding was that objective cognitive performance, as assessed by the MoCA, differed significantly across blood pressure status groups, whereas subjective cognitive failures, assessed using the CFQ, did not show a statistically significant difference. Taken together, these findings suggest that differences in cognitive functioning associated with blood pressure status may be more readily detected through objective cognitive assessment than through self-reported cognitive difficulties. The findings also underscore the potential value of considering subjective and objective measures as complementary rather than interchangeable indicators of cognitive functioning.

Our finding of differences in objective cognitive performance across blood pressure status groups is broadly consistent with previous evidence linking hypertension and elevated blood pressure with cognitive impairment. A study of adults aged 45–65 years reported a significant association between hypertension and cognitive impairment, suggesting that the relationship between hypertension and cognitive functioning may be evident during midlife rather than being restricted to older adulthood (23). Similarly, previous research has found that patients with hypertension performed more poorly across multiple cognitive domains than normotensive controls, with hypertension severity, age, and educational level emerging as important correlates of cognitive performance (24). Evidence from another study comparing normotensive individuals with patients at different stages of systemic arterial hypertension further indicated that participants with more severe hypertension had poorer executive functioning, particularly in updating and shifting, whereas no significant differences were observed between normotensive individuals and those with stage 1 hypertension (35). Together, these findings support the possibility that the association between blood pressure and cognitive functioning may become more apparent with greater hypertension severity.

However, the relationship between blood pressure and cognition does not appear to be uniform or necessarily linear. In the SONIC longitudinal cohort of 1,186 older Japanese adults, higher systolic blood pressure was associated with higher MoCA-J scores among participants with hypertension, while higher diastolic blood pressure was associated with higher MoCA-J scores among participants with both hypertension and dyslipidemia (28). Other evidence has similarly suggested that both high and low blood pressure may be associated with poorer cognitive performance, depending on age and cognitive status (24,31). In particular, longitudinal evidence has indicated that higher blood pressure during midlife and lower blood pressure during later life may be differentially associated with the risk of cognitive decline and dementia (31). These findings suggest that the association between blood pressure and cognitive functioning may depend on factors such as age, the specific blood pressure parameter, hypertension severity, and the presence of coexisting conditions. Therefore, the differences observed in the present study should be interpreted in the context of a potentially complex and non-linear relationship between blood pressure and cognition rather than as evidence of a simple dose–response association.

The findings of the present study may also be considered alongside evidence that additional clinical conditions can influence objective cognitive performance in individuals with hypertension. For example, patients with both hypertension and obstructive sleep apnea had significantly lower MoCA and MMSE scores than patients with hypertension alone, suggesting that comorbid conditions may further contribute to cognitive dysfunction in people with hypertension (30). This observation is relevant because cognitive performance in hypertensive populations may reflect the combined influence of blood pressure exposure and other vascular, metabolic, sleep-related, or clinical factors. Consequently, differences in objective cognitive performance across blood pressure groups may not be attributable to blood pressure alone.

One of the notable findings of the present study was the discrepancy between objective and subjective cognitive measures. Although MoCA scores differed significantly across blood pressure status groups,

the difference in CFQ scores did not reach statistical significance. Previous research suggests that subjective cognitive complaints do not necessarily correspond closely with objectively measured cognitive performance. Evidence from other clinical populations has shown variable correspondence between subjective reports and objective neuropsychological measures, indicating that these measures may capture partially distinct aspects of cognitive functioning (29). A systematic review in individuals with schizophrenia-spectrum disorders similarly found generally minimal to modest associations between self-reported cognition or functioning and objective or informant-based measures. Importantly, the review emphasized that discrepancies between different sources of clinical information should not necessarily be interpreted as measurement error or inaccurate self-assessment; rather, different measures may provide complementary information about distinct dimensions of functioning (30). From this perspective, the absence of a significant difference in subjective cognitive failures in the present study does not necessarily contradict the observed differences in objective cognitive performance. Instead, it may indicate that blood pressure-related differences in cognitive functioning are not equally perceived or reported by individuals themselves.

Several biological mechanisms may plausibly contribute to the association between hypertension and objective cognitive functioning. Chronic hypertension can adversely affect the cerebral vasculature and brain parenchyma and is an important risk factor for cerebral small vessel disease, a major vascular substrate of cognitive impairment and vascular dementia (23). Persistent blood pressure elevation may contribute to microvascular injury and structural alterations in the brain, potentially disrupting neural networks involved in cognitive functioning (32). More broadly, prolonged exposure to elevated blood pressure may affect cerebrovascular structure and function, cerebral perfusion, and the neurovascular unit, thereby increasing vulnerability to cognitive impairment (32). Importantly, emerging evidence suggests that the cognitive consequences of hypertension may depend not only on absolute blood pressure levels but also on factors such as blood pressure variability, duration of exposure, aging, and individual vascular vulnerability (32). These mechanisms provide biological plausibility for the present findings; however, because cerebral small vessel disease, neuroimaging markers, blood pressure variability, and cumulative blood pressure exposure were not directly assessed in our study, these pathways should be considered possible explanations rather than demonstrated mechanisms.

The present findings also have potential clinical implications. The significant difference in objective cognitive performance despite the absence of a corresponding difference in subjective cognitive failures suggests that relying exclusively on patients' perceived cognitive difficulties may not fully capture differences in cognitive functioning associated with blood pressure status. Objective cognitive assessment may therefore provide complementary information, particularly when cognitive changes are subtle or are not readily recognized by patients themselves. However, the present findings do not establish that routine cognitive screening should be universally implemented in all patients with hypertension; rather, they support greater attention to objective cognitive functioning in clinical and research assessments of hypertensive populations.

Several limitations should be considered when interpreting these findings. First, the cross-sectional design precludes determination of the temporal or causal relationship between blood pressure status and cognitive performance. Although objective cognitive performance differed across blood pressure groups, it cannot be determined whether differences in blood pressure preceded cognitive changes or whether other factors contributed to the observed association. Longitudinal studies are needed to clarify trajectories of cognitive change in relation to blood pressure over time. Second, blood pressure was assessed at a single time point, which may not adequately represent long-term blood pressure exposure, hypertension duration, or blood pressure variability. Repeated or ambulatory blood pressure measurements would provide a more comprehensive characterization of blood pressure exposure. Third, the blood pressure groups differed in educational level and socioeconomic status. Because education is closely related to cognitive performance and socioeconomic conditions may also influence cognitive health, these baseline differences may have contributed to the observed differences in objective cognitive performance and should be considered when interpreting the findings.

Future longitudinal studies should investigate whether differences in objective cognitive performance across blood pressure status groups persist or progress over time and whether they are influenced by cumulative blood pressure exposure, blood pressure variability, duration of hypertension, and antihypertensive treatment. Incorporating ambulatory blood pressure monitoring and neuroimaging measures may also help clarify the vascular mechanisms underlying cognitive differences in patients with hypertension.

Conclusion

In conclusion, the present study found that objective cognitive performance differed according to blood pressure status among patients with hypertension, whereas subjective cognitive failures did not differ significantly. These findings suggest that objective and subjective measures may provide complementary information regarding cognitive functioning in hypertensive populations. The observed association between blood pressure status and objective cognitive performance is consistent with previous evidence linking hypertension severity and cerebrovascular consequences of elevated blood pressure to cognitive functioning, although the relationship appears to be complex and potentially influenced by age, comorbidities, and the pattern and duration of blood pressure exposure. Given the cross-sectional design and the imbalance in educational and socioeconomic characteristics across groups, these findings should be interpreted as an association rather than a causal effect. Longitudinal studies using repeated blood pressure assessments and neuroimaging are warranted to clarify the temporal and biological pathways linking blood pressure and cognitive functioning.

Declarations

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) solely for language refinement and improvement of grammatical clarity. All scientific content, interpretations, and

conclusions were developed and reviewed by the authors, who take full responsibility for the accuracy and integrity of the manuscript.

Authors contributions

Gh.Kh performed the measurements. MTBS and M.K were involved in planning and supervising the work. MTBS processed the experimental data, performed the analysis, and drafted the manuscript. MTBS worked on the final manuscript. All authors commented on the manuscript.

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Clinical Trial Registration

Not applicable (cross-sectional study design).

Conflicts of Interest

All authors declare no conflicts of interest, financial or otherwise, related to this work.

Ethical Approval

This study was approved by the Research Ethics Committee of Golestan University of Medical Sciences (approval No. IR.GOUMS.REC.1403.432). Written informed consent was obtained from all participants before enrollment, and all procedures were conducted in accordance with the Declaration of Helsinki.

Informed Consent

All participants provided written informed consent before enrollment. The consent process included a detailed explanation of the study's purpose, procedures, potential risks, and benefits. For patients with limited literacy, verbal consent was obtained in the presence of an impartial witness, and simplified written summaries were provided.

Clinical trial number

not applicable

Confidentiality and Data Security

Participant data were anonymized using unique identification codes to protect privacy. Electronic records were stored on password-protected servers, and physical documents were kept in locked cabinets accessible only to the research team. Data will be retained for five years post-study completion, after which it will be securely destroyed.

Voluntary Participation and Withdrawal Rights

Participants were informed of their right to withdraw from the study at any time without affecting their clinical care. No financial incentives were provided to avoid coercion, though reimbursement for travel costs was offered.

AI Tool Disclosure

During the preparation of this work, the author(s) used AI Tool Disclosure: [BLINDED FOR REVIEW] (release date: 2024-07) solely to improve grammatical accuracy and enhance textual coherence. After using this tool, the author(s) reviewed and edited the content as needed and take full responsibility for the final manuscript.

Data availability

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to restrictions, e.g., their contents contain information that could compromise the privacy of research participants.

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