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A Longitudinal Evaluation of a Mind–Body Slow Deep Breathing Intervention for Blood Pressure Control in Older Adults with Hypertension

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A B S T R A C T

Introduction: Hypertension is highly prevalent among older adults and often remains inadequately controlled despite pharmacological treatment, particularly in community and primary care settings. Low-cost, non-pharmacological interventions that support long-term self-management are increasingly recommended. Slow deep breathing, a mind–body intervention targeting autonomic regulation, has shown potential to reduce blood pressure, but longitudinal evidence among older adults remains limited. **Objective:** This study aimed to examine the longitudinal association between a structured slow deep breathing intervention and changes in blood pressure and quality of life among older adults with hypertension. **Methods:** A longitudinal repeated-measures quasi-experimental study with a comparison group was conducted among community-dwelling adults aged ≥60 years with hypertension. Participants were allocated to either a slow deep breathing intervention group or a standard hypertension education group using a non-random allocation approach. The intervention consisted of guided slow deep breathing practiced daily for four weeks. Blood pressure and quality of life (WHOQOL-OLD) were assessed at baseline, week 4, and week 8. Linear mixed-effects models were used to evaluate group-by-time interactions while adjusting for baseline values and antihypertensive medication use. **Results:** Sixty-eight participants completed the study (intervention n = 34; comparison n = 34). Compared with the comparison group, the intervention group showed greater reductions in systolic (β = −6.82, 95% CI −10.23 to −3.41, $p < .001$) and diastolic blood pressure (β = −3.94, 95% CI −6.31 to −1.57, $p = .002$), along with greater improvements in quality of life (β = 3.26, 95% CI 1.54–4.98, $p < .001$). **Conclusion:** Participation in structured slow deep breathing was associated with improved blood pressure control and quality of life. Further randomized studies are needed to confirm effectiveness and causal relationships.

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1. INTRODUCTION

Hypertension remains a leading global public health challenge and a major contributor to cardiovascular morbidity and mortality, particularly among older adults. According to pooled global analyses, more than one billion adults worldwide live with hypertension, and control rates remain suboptimal despite the availability of effective pharmacological treatments (NCD Risk Factor Collaboration [NCD-RisC], 2021). Population aging further amplifies this burden, as advancing age is associated with increased arterial stiffness, altered autonomic regulation, and higher prevalence of multimorbidity, all of which complicate blood pressure (BP) management in later life (Carey & Whelton, 2021).

Older adults with hypertension often require long-term, multifaceted management strategies. Although antihypertensive medications are effective, real-world BP control remains limited due to factors such as polypharmacy, medication side effects, reduced adherence, and health system constraints, particularly in primary care and community settings (Carey & Whelton, 2021; NCD-RisC, 2021). These challenges highlight the importance of adjunct, non-pharmacological approaches that are safe, acceptable, and feasible for sustained use among older populations. Current international guidelines emphasize lifestyle and behavioral interventions, such as physical activity, dietary modification, and stress reduction, as essential components of comprehensive hypertension management (Carey & Whelton, 2021). However, traditional lifestyle programs may be difficult to implement consistently in older adults due to physical limitations, social barriers, or limited access to structured interventions. Consequently, there is increasing interest in mind–body approaches that require minimal resources and can be delivered flexibly in community or home-based settings.

Slow deep breathing is a core mind–body intervention that integrates controlled respiratory patterns with relaxation and attentional focus. Typically characterized by a reduced breathing rate (approximately six breaths per minute) and prolonged exhalation, slow deep breathing is hypothesized to enhance parasympathetic activity, attenuate sympathetic nervous system responses, and improve baroreflex sensitivity, thereby contributing to BP reduction (Tavoian & Craighead, 2023). From a practical perspective, slow deep breathing is attractive because it is low-cost, non-invasive, and does not require specialized equipment. These features make it particularly suitable for older adults and for implementation in primary care or community-based hypertension programs. Recent physiological studies further suggest that slow breathing may influence cardiovascular-related biological processes, including oxidative stress responses, supporting its plausibility as a BP-modulating intervention (Hunter et al., 2023).

Beyond its physiological effects, the potential benefits of slow deep breathing may also be understood through frameworks of autonomic regulation theory, psychophysiological stress models, and mind–body medicine. Autonomic regulation theory proposes that controlled breathing influences cardiovascular function by shifting autonomic balance toward greater parasympathetic activation and reduced sympathetic arousal, thereby promoting cardiovascular stability and lowering blood pressure. From a psychophysiological perspective, chronic stress contributes to sustained autonomic activation, elevated vascular resistance, and poorer cardiovascular outcomes, while breathing-based interventions may interrupt this stress response through enhanced emotional regulation and relaxation. Mind–body medicine frameworks further suggest that intentional

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breathing practices can improve self-awareness, perceived control, and psychological well-being, which may extend benefits beyond physiological outcomes to broader aspects of quality of life. For older adults, who often experience coexisting physical, emotional, and social challenges, these integrated mechanisms provide a conceptual basis for understanding how structured slow deep breathing may simultaneously support blood pressure regulation and enhance perceived well-being and daily functioning (Tavoian & Craighead, 2023; Hunter et al., 2023).

Growing evidence since 2019 supports the potential BP-lowering effects of breathing-based interventions, although findings vary across studies. A large network meta-analysis of non-pharmacological interventions for hypertension demonstrated that breathing-control and meditation-based approaches were associated with significant reductions in systolic and diastolic BP compared with usual care, albeit with smaller effect sizes than dietary or exercise interventions (Fu et al., 2020). These findings position breathing exercises as a complementary rather than standalone strategy within comprehensive BP management. More recent syntheses focusing specifically on breathing exercises reinforce this perspective. A systematic review and meta-analysis by Garg et al. (2023) reported modest but statistically significant BP reductions following structured breathing interventions, while also noting heterogeneity in intervention protocols, duration, and study quality. Similarly, a scoping review by Herawati et al. (2023) concluded that breathing exercises, including slow deep breathing are generally effective in reducing BP among individuals with hypertension, but emphasized substantial variability in delivery methods, supervision levels, and outcome assessment. An additional consideration in the literature is the distinction between device-guided and non–device-guided breathing interventions. While some trials using device-guided paced respiration report favorable outcomes, comparative evidence remains inconclusive regarding superiority over simpler, instructor-led or self-guided breathing techniques (Gonçalves et al., 2022). This uncertainty underscores the need for well-defined, reproducible breathing protocols that can be implemented without reliance on specialized devices, particularly in resource-limited or community settings.

Despite an expanding body of evidence, several non-premature and well-documented gaps remain in the literature. First, many studies on breathing-based BP interventions include broad adult samples, with relatively few investigations explicitly targeting older adults, a population with distinct physiological characteristics and care needs (NCD-RisC, 2021). Second, existing reviews consistently highlight heterogeneity in breathing protocols, including breathing rate, session length, intervention duration, and supervision, which limits comparability and translation into routine clinical practice (Garg et al., 2023; Herawati et al., 2023). This represents not an absence of evidence, but a lack of standardized, protocol-driven interventions tested in clearly defined populations. Third, while BP reduction is frequently reported, fewer studies examine the feasibility and applicability of slow deep breathing in real-world community or primary care contexts, where adherence and sustainability are critical for long-term BP control (Tavoian & Craighead, 2023). Addressing these gaps is essential to strengthen the evidence base supporting slow deep breathing as a practical adjunct to standard hypertension management in older adults.

In response to these gaps, the present study aims to evaluate the effect of a structured slow deep breathing intervention on blood pressure outcomes among older adults with hypertension. By focusing on an older population and applying a clearly defined breathing protocol, this study seeks

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to contribute robust, practice-relevant evidence to support the integration of mind–body breathing interventions into hypertension care.

2. METHODS

Study design

This study employed a longitudinal repeated-measures quasi-experimental design with a comparison group to evaluate the effects of a structured mind–body slow deep breathing intervention on blood pressure outcomes among older adults with hypertension. Repeated measurements were conducted at multiple time points to capture within-individual changes over time and to assess the sustainability of intervention effects. The study was implemented in a community-based primary care setting affiliated with a public primary health center. This design was selected to allow examination of temporal trajectories of blood pressure while maintaining feasibility in real-world community conditions, consistent with recommendations for evaluating behavioral and lifestyle interventions in chronic disease management (Unger et al., 2020; Sharman et al., 2025).

Sample

The target population comprised community-dwelling older adults aged 60 years and above with hypertension. Participants were eligible if they had a documented diagnosis of hypertension in their medical records or presented with elevated clinic blood pressure consistent with international guideline thresholds, were able to communicate in Bahasa Indonesia, were capable of following breathing instructions, and provided written informed consent. Individuals were excluded if they had experienced an acute cardiovascular event within the preceding three months, had unstable medical conditions requiring urgent treatment, severe cognitive impairment, advanced respiratory disease that could interfere with slow breathing practice, or participation in another structured mind–body or breathing program during the month prior to recruitment.

Participants were recruited using a consecutive sampling technique from community health registers and primary care lists. To minimize contamination between participants, allocation to intervention and comparison groups was conducted at the community or neighborhood level where feasible, reflecting pragmatic implementation conditions in community health programs. This approach allowed evaluation of the intervention while maintaining ecological validity in a real-world setting.

Sample size estimation was conducted using GPower software for longitudinal designs, based on repeated-measures analysis with between-group and within-group effects. The calculation assumed a two-sided alpha level of 0.05, statistical power of 0.80, a moderate effect size for changes in systolic blood pressure over time, and a conservative correlation among repeated measures. This approach followed established guidance for power analysis in repeated-measures and longitudinal health research using GPower (Kang, 2021). To accommodate anticipated attrition associated with longitudinal follow-up in older populations, the estimated minimum sample size was increased by approximately 15%.

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Intervention and comparison condition

Participants assigned to the intervention group received a structured slow deep breathing program designed as a mind–body breathing practice. The intervention emphasized controlled breathing with a reduced respiratory rate of approximately six breaths per minute and a prolonged exhalation phase, adjusted according to participant comfort. Each session lasted approximately 10–15 minutes and was practiced once to twice daily over a four-week period. Initial training was delivered through supervised demonstration and return-demonstration sessions conducted by trained personnel. Participants were provided with printed instructions and practice logs to support adherence and self-monitoring. Safety instructions were emphasized, and participants were advised to discontinue practice and report symptoms such as dizziness or discomfort.

To strengthen intervention fidelity, all personnel delivering the breathing intervention completed standardized training before study initiation and followed a structured intervention protocol. Training included demonstration procedures, participant instruction, safety monitoring, and adherence documentation. Fidelity was monitored through periodic observation using a standardized checklist and regular team meetings to ensure consistency of intervention delivery across sessions. Adherence was assessed using participant practice logs supplemented by weekly monitoring contacts conducted by research staff. Adherence was operationalized as completion of at least 80% of the prescribed breathing sessions during the four-week intervention period, and adherence rates were summarized descriptively.

The comparison group received standard hypertension education routinely provided in primary care settings, including advice on medication adherence, diet, and physical activity, without structured breathing training. This approach reflected usual care and aligned with international guideline recommendations for lifestyle counseling as part of hypertension management (Unger et al., 2020).

Instruments

Blood pressure served as the primary outcome and was measured using a validated automated upper-arm oscillometric device. Measurements followed standardized automated office blood pressure procedures, including appropriate cuff sizing, seated rest for at least five minutes, and repeated measurements to improve reliability. Three readings were obtained at one-minute intervals, and the mean of the final two readings was used for analysis. Interpretation of blood pressure values followed international hypertension guideline thresholds (Unger et al., 2020; Sharman et al., 2025).

Quality of life was assessed as a secondary outcome using the World Health Organization Quality of Life–Older Adults Module (WHOQOL-OLD). The WHOQOL-OLD was developed by the WHOQOL Group to assess quality of life specifically in older populations and consists of 24 items covering six domains: sensory abilities, autonomy, past–present–future activities, social participation, death and dying, and intimacy. Responses are rated on a Likert-type scale, and higher scores indicate better perceived quality of life. Contemporary validation studies support the reliability and construct validity of the WHOQOL-OLD across diverse settings (Anum et al., 2021). The Indonesian version of the WHOQOL-OLD has demonstrated good psychometric

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properties, with acceptable internal consistency and item reliability using Rasch modeling, and a reported Cronbach's alpha of 0.75 (Gondodiputro et al., 2021).

Study procedure

Ethical approval was obtained from an institutional review board prior to study initiation. Authorization to conduct the study was granted by local health authorities and community leaders. Eligible participants were identified through community and primary care registers and approached by trained research staff. After receiving detailed information regarding study objectives, procedures, potential risks, and benefits, participants who met eligibility criteria provided written informed consent.

Baseline assessment was conducted prior to intervention initiation and included collection of sociodemographic and clinical data, standardized blood pressure measurement, and administration of the WHOQOL-OLD questionnaire. Participants then entered the intervention or comparison condition according to group allocation. Follow-up assessments were conducted at multiple predefined time points, including immediately post-intervention and at subsequent follow-up intervals, to capture longitudinal changes in blood pressure and quality of life. During the intervention period, weekly monitoring contacts were conducted to reinforce correct breathing technique, review participant practice logs, assess adherence, and monitor adverse symptoms. To reduce reliance on self-report alone, adherence records were cross-checked during follow-up visits through brief participant verification and review of completed practice documentation.

Data analysis

Data were analyzed using longitudinal statistical techniques appropriate for repeated-measures designs. Descriptive statistics were used to summarize baseline characteristics. The primary analysis examined changes in blood pressure over time using **linear mixed-effects models**, which included fixed effects for group, time, and group-by-time interaction, and random intercepts to account for within-subject correlation across repeated measurements. This approach allowed inclusion of participants with incomplete follow-up data and provided robust estimates of intervention effects over time. Because participants were allocated at the community or neighborhood level to minimize contamination, potential clustering effects were considered in supplementary analyses. Community grouping was evaluated as an additional clustering variable within mixed-effects modeling to assess whether correlated responses within allocation units influenced parameter estimates. Robust standard errors were examined to account for residual clustering where appropriate. Secondary analyses of quality of life outcomes employed similar mixed-effects modeling strategies. As a complementary approach, generalized estimating equations were considered to assess population-averaged effects across time points. Sensitivity analyses using analysis of covariance were conducted with post-intervention blood pressure as the outcome and baseline blood pressure as a covariate to confirm the robustness of findings. Longitudinal analytic strategies followed contemporary recommendations for repeated-measures and pretest–posttest clinical studies (Zou, 2023; Jung et al., 2025). Missing data were handled using maximum likelihood estimation inherent in mixed models, with multiple imputation performed as a sensitivity analysis when appropriate. Statistical significance was defined as $p < .05$, and effect estimates were reported with 95% confidence intervals.

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Ethical Considerations

Ethical approval was obtained from an institutional review board prior to study initiation. Authorization to conduct the study was granted by local health authorities and community leaders.

3. RESULTS

A total of 78 older adults were screened for eligibility. Of these, 72 participants met the inclusion criteria and were enrolled in the study. Participants were allocated to the slow deep breathing intervention group (n = 36) and the comparison group (n = 36). During the follow-up period, four participants were lost to follow-up due to relocation or health-related reasons, resulting in a final analytic sample of 68 participants (intervention group n = 34; comparison group n = 34). All available data were included in the longitudinal analyses using mixed-effects modeling.

Intervention adherence was monitored using participant practice logs and weekly follow-up contacts. Among participants in the intervention group who completed follow-up, adherence to the prescribed breathing sessions was summarized descriptively. The mean adherence rate was [XX.X%], and [n (%)] participants completed at least 80% of the prescribed sessions. No intervention-related adverse events requiring discontinuation were reported. These findings support the feasibility and acceptability of the structured slow deep breathing protocol in this population.

Table 1 presents the baseline demographic and clinical characteristics of participants in the intervention and comparison groups. The mean age of participants was 67.4 ± 5.8 years, with the majority being female (61.8%). Most participants had been diagnosed with hypertension for more than five years and were receiving antihypertensive medication. No statistically significant differences were observed between groups at baseline for age, sex, education level, duration of hypertension, or baseline blood pressure, indicating adequate baseline comparability (Table 1).

Table 1. Baseline demographic and clinical characteristics of participants (N = 68)

Characteristic	Intervention (n = 34)	Comparison (n = 34)	p-value
Age, mean ± SD (years)	67.1 ± 5.6	67.8 ± 6.0	0.64
Female, n (%)	21 (61.8)	21 (61.8)	1.00
Primary education or less, n (%)	18 (52.9)	17 (50.0)	0.81
Duration of hypertension ≥ 5 years, n (%)	20 (58.8)	22 (64.7)	0.61
On antihypertensive medication, n (%)	29 (85.3)	30 (88.2)	0.72
Baseline systolic BP, mean ± SD (mmHg)	148.6 ± 10.9	147.9 ± 11.3	0.79
Baseline diastolic BP, mean ± SD (mmHg)	88.4 ± 7.2	87.9 ± 7.5	0.76

Mean systolic and diastolic blood pressure values at each measurement time point are presented in Table 2. In the intervention group, systolic and diastolic blood pressure showed a progressive decline from baseline to post-intervention and follow-up. In contrast, the comparison group demonstrated minimal change over time (Table 2).

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Table 2. Mean blood pressure values over time by study group

Outcome	Time point	Intervention (n = 34) mean ± SD	Comparison (n = 34) mean ± SD
Systolic BP (mmHg)	Baseline	148.6 ± 10.9	147.9 ± 11.3
	Week 4	138.2 ± 9.8	145.6 ± 10.7
	Week 8	134.9 ± 9.5	144.1 ± 10.5
Diastolic BP (mmHg)	Baseline	88.4 ± 7.2	87.9 ± 7.5
	Week 4	83.1 ± 6.6	86.8 ± 7.1
	Week 8	81.7 ± 6.3	86.1 ± 7.0

Linear mixed-effects models were used to evaluate group differences in blood pressure trajectories over time. A statistically significant group-by-time interaction was observed for systolic blood pressure, indicating that changes over time differed significantly between groups. After adjustment for baseline blood pressure and antihypertensive medication use, the intervention group demonstrated a greater reduction in systolic blood pressure compared with the comparison group. A similar pattern was observed for diastolic blood pressure (Table 3).

Table 3. Linear mixed-effects model results for blood pressure outcomes

Outcome	Fixed effect	β (SE)	95% CI	p-value	Estimated Cohen's d
Systolic BP	Group × Time	−6.82 (1.74)	−10.23 to −3.41	<0.001	0.89 (large)
Diastolic BP	Group × Time	−3.94 (1.21)	−6.31 to −1.57	0.002	0.67 (moderate)

Note. β values represent adjusted group-by-time interaction effects estimated using linear mixed-effects models controlling for baseline values and antihypertensive medication use. Effect sizes are presented as estimated standardized mean differences (Cohen's d) to facilitate interpretation of the magnitude of intervention-related changes. Cohen's d values were interpreted as small (0.20), moderate (0.50), and large (0.80).

Effect size estimates suggested that the intervention produced a large effect on systolic blood pressure reduction and a moderate effect on diastolic blood pressure reduction, indicating that the observed differences were not only statistically significant but also potentially meaningful in clinical practice.

Quality of life outcomes measured using the WHOQOL-OLD are presented in Table 4. Participants in the intervention group demonstrated significant improvements in overall WHOQOL-OLD scores over time, while changes in the comparison group were minimal (Table 4).

Table 4. WHOQOL-OLD total scores over time by group

Time point	Intervention (n = 34) mean ± SD	Comparison (n = 34) mean ± SD
Baseline	61.8 ± 7.9	62.4 ± 8.1
Week 4	66.9 ± 7.4	63.2 ± 8.0
Week 8	69.7 ± 7.1	63.8 ± 7.9

Mixed-effects analysis revealed a statistically significant group-by-time interaction for WHOQOL-OLD total scores. Participants in the intervention group experienced greater improvements in quality of life over time compared with those receiving standard care (Table 5).

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Table 5. Linear mixed-effects model results for WHOQOL-OLD scores

Fixed effect	β (SE)	95% CI	p-value	Estimated Cohen's d
Group × Time	3.26 (0.88)	1.54 to 4.98	<0.001	0.81large)

Note. β values represent adjusted group-by-time interaction effects estimated using linear mixed-effects models. Effect size was expressed as estimated Cohen's d to support interpretation of the practical magnitude of changes in quality-of-life outcomes. Interpretation thresholds followed conventional criteria: small (0.20), moderate (0.50), and large (0.80).

The observed effect size indicated a large improvement in quality of life among participants receiving the slow deep breathing intervention, suggesting benefits beyond physiological blood pressure outcomes.

4. DISCUSSION

This longitudinal repeated-measures study demonstrated that a structured mind–body slow deep breathing intervention was associated with significant improvements in blood pressure control among older adults with hypertension when compared with standard hypertension education. Participants in the intervention group exhibited a progressive reduction in both systolic and diastolic blood pressure across repeated follow-up assessments, whereas changes in the comparison group were minimal. These findings suggest that slow deep breathing may provide sustained physiological benefits when practiced consistently over time. The observed reductions in blood pressure are consistent with findings from recent systematic reviews and meta-analyses examining breathing-based interventions for hypertension. Garg et al. (2023) reported that structured breathing exercises were associated with significant reductions in systolic and diastolic blood pressure, with effect sizes comparable to those observed in the present study. Similarly, a scoping review by Herawati et al. (2023) concluded that slow breathing interventions are generally effective in lowering blood pressure among individuals with hypertension, although variability in intervention protocols and outcome measures was noted across studies.

When situated within the broader context of nonpharmacological hypertension management, the present findings align with a network meta-analysis by Fu et al. (2020), which demonstrated that breathing-control and meditation-based interventions contribute to blood pressure reduction, albeit with smaller effects than dietary modification or structured physical activity. Importantly, breathing interventions require fewer physical demands and resources, making them particularly suitable for older adults who may face barriers to more intensive lifestyle interventions.

The longitudinal design of the present study provides additional insight beyond cross-sectional or short-term trials by demonstrating that blood pressure improvements were maintained and continued to progress across repeated measurement points. This pattern is broadly consistent with previous evidence suggesting that regular slow deep breathing practice may contribute to favorable cardiovascular responses over time (Tavoian & Craighead, 2023). Several theoretical mechanisms have been proposed to explain these effects, including modulation of autonomic balance, increased parasympathetic activity, reduced sympathetic arousal, and improved baroreflex function. Such pathways may contribute to lower vascular resistance and improved blood pressure regulation and may be particularly relevant in older adults, who commonly

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experience age-related changes in autonomic and vascular function. However, these mechanisms remain hypothetical within the context of the present study because physiological mediators were not directly assessed. Measures such as heart rate variability, baroreflex sensitivity, autonomic indices, or stress-related biomarkers were not collected. Therefore, the observed blood pressure improvements should be interpreted as consistent with, but not confirmatory of, proposed autonomic and cardiovascular regulatory pathways. Future studies incorporating physiological assessments are needed to clarify the mechanisms through which slow deep breathing may influence blood pressure outcomes.

In addition to blood pressure improvement, participants in the intervention group demonstrated significant gains in quality of life as measured by the WHOQOL-OLD. This finding is consistent with the conceptual framework of mind–body interventions, which emphasize the interconnectedness of physiological regulation and psychological well-being. Improved quality of life may reflect reductions in stress, enhanced self-efficacy in disease management, and increased perception of control over health among older adults. The use of the WHOQOL-OLD strengthens the interpretation of these findings, as the instrument was specifically designed for older populations and has demonstrated robust psychometric properties in both international and Indonesian contexts (Anum et al., 2021; Gondodiputro et al., 2021). The observed improvement suggests that slow deep breathing may support not only cardiovascular outcomes but also broader aspects of well-being that are central to healthy aging.

Clinical implications

The findings of this study have important implications for hypertension management in primary care and community settings. Slow deep breathing is a low-cost, non-invasive, and easily teachable intervention that can be integrated into routine nursing care and health education programs. Given the high prevalence of hypertension among older adults and the challenges associated with long-term medication adherence, incorporating breathing-based interventions may enhance self-management and complement pharmacological treatment. From a practical perspective, slow deep breathing can be delivered by nurses, community health workers, or trained caregivers without the need for specialized equipment. The longitudinal improvement observed in this study suggests that ongoing reinforcement and follow-up may be key to maximizing benefits. Integrating breathing exercises into regular chronic disease monitoring visits may therefore represent a feasible strategy to improve blood pressure control and quality of life in older populations.

Study limitations

Several limitations should be considered when interpreting the results. First, the quasi-experimental design limits causal inference, as participants were not individually randomized. Although baseline characteristics were comparable and longitudinal mixed-effects models were used to account for within-subject changes, residual confounding cannot be entirely excluded. Second, the study was conducted in a single community-based primary care setting, which may limit generalizability to other regions or healthcare systems. Third, adherence to the breathing intervention was monitored through self-report and follow-up contacts, which may be subject to

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reporting bias. Objective measures of adherence were not available. Fourth, blood pressure was assessed using standardized automated office measurements; however, ambulatory or home blood pressure monitoring was not performed, which may have provided additional insight into day-to-day variability and nocturnal blood pressure patterns. Finally, although repeated measurements were conducted, longer follow-up periods are needed to determine the durability of intervention effects beyond the study timeframe.

5. CONCLUSION

This longitudinal repeated-measures study found that participation in a structured mind–body slow deep breathing intervention was associated with improvements in blood pressure control and quality of life among older adults with hypertension. These findings suggest that slow deep breathing may represent a feasible adjunctive approach to support hypertension management in community and primary care settings. However, interpretation should consider the quasi-experimental design and relatively short follow-up period, which limit causal inference and assessment of long-term sustainability. Future randomized multicenter studies with extended follow-up and implementation-focused outcomes are needed to confirm effectiveness, evaluate durability of benefits, and establish evidence before broad integration into routine hypertension care can be recommended.

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8. AUTHOR CONTRIBUTIONS

Conceptualization: AW, NN, MIT
Methodology: AW, MIT
Data collection: AW, NN
Data analysis and interpretation: AW, MIT
Writing—original draft preparation: AW
Writing—review and editing: NN, MIT
Supervision: AW, NN, MIT
All authors have read and approved the final version of the manuscript.

9. CONFLICT OF INTEREST DISCLOSURE

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

10. DATA AVAILABILITY STATEMENT

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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