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ORIGINAL SCIENTIFIC PAPER

Effect of Yoga Therapy and Music Therapy in Stabilizing C-Reactive Protein Among Hypertensive Middle-Aged Men

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Abstract

Elevated C-reactive protein (CRP) levels are associated with increased cardiovascular risk in hypertensive patients. While yoga and music therapy have shown individual benefits in cardiovascular health, their combined effect on inflammatory markers remains unexplored. The aim of the study was to evaluate the effects of a 12-week combined yoga and music therapy intervention on inflammatory markers (hs-CRP, IL-6, TNF-α) and blood pressure parameters in middle-aged hypertensive men. In this randomized controlled trial, 72 hypertensive men (mean age 42.3±6.4 years) were randomized to either a combined yoga and music therapy intervention (n=36) or control group (n=36). The intervention group participated in structured yoga sessions combined with music therapy for 12 weeks, while the control group received standard care. Primary outcomes included changes in inflammatory markers (hs-CRP, IL-6, TNF-α) and blood pressure measurements. Following the 12-week intervention, the yoga and music therapy group showed significant reductions in inflammatory markers compared to controls: hs-CRP (-1.50±0.55 vs -0.2±0.3 mg/L, $p<0.001$), IL-6 (-1.45±0.45 vs -0.2±0.2 pg/mL, $p<0.001$), and TNF-α (-3.85±1.15 vs -0.4±0.3 pg/mL, $p<0.001$). Blood pressure parameters also improved significantly in the intervention group: systolic (-10.55±3.5 vs -1.6±1.1 mmHg, $p<0.001$) and diastolic (-7.05±2.25 vs -0.6±0.8 mmHg, $p<0.001$). Large effect sizes were observed across all outcomes (0.72-0.79). Combined yoga and music therapy effectively reduced inflammatory markers and blood pressure in middle-aged hypertensive men. This integrative approach shows promise as a complementary intervention in managing hypertension and associated inflammatory markers.

Keywords: *yoga, hypertension, inflammatory markers, blood pressure, complementary therapy*

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Introduction

Hypertension remains a significant global public health challenge, affecting approximately 1.28 billion adults worldwide and contributing substantially to cardiovascular morbidity and mortality (Mills, Stefanescu, & He, 2020). Recent evidence has elucidated the crucial role of chronic low-grade inflammation in the pathogenesis and progression of hypertension, particularly among middle-aged men who exhibit higher prevalence rates and cardiovascular complications. High-sensitivity C-reactive protein (hs-CRP), interleukin-6 (IL-6), and tumor necrosis factor-alpha (TNF-α) (Mehaffey & Majid, 2017) have emerged as key inflammatory biomarkers strongly associated with cardiovascular risk stratification and hypertension-related target organ damage (Aimo et al., 2020). While conventional pharmacological approaches effectively manage blood pressure, they may not adequately address the underlying inflammatory processes (Ghosh et al., 2024). This has led to increasing interest in complementary therapeutic approaches that could potentially modulate both hemodynamic and inflammatory parameters (Padmavathi et al., 2023). Yoga therapy, an ancient mind-body practice, has demonstrated promising effects in reducing sympathetic activation, improving endothelial function, and decreasing oxidative stress (Venugopal et al., 2022). Recent systematic reviews and meta-analyses have shown that regular yoga practice can significantly reduce blood pressure (Wankhar et al., 2024) and inflammatory markers (Mishra et al., 2024), although the mechanisms remain incompletely elucidated. Similarly, music therapy has garnered attention for its potential therapeutic benefits in cardiovascular health (Ansari et al., 2021). Recent finding indicates that specific forms of music intervention can modulate autonomic nervous system function, reduce cortisol levels, and influence inflammatory pathways (Bhandarkar, Salvi, & Shende, 2024). The neurophysiological effects of music therapy include alterations in heart rate variability, endothelial function, and inflammatory mediator production, suggesting a biological basis for its therapeutic potential in hypertension management. The integration of yoga and music therapy presents an innovative approach that could potentially offer synergistic benefits (Ajmera et al., 2018). While both modalities have shown individual efficacy, their combined effects on inflammatory markers and blood pressure parameters remain largely unexplored, particularly in the context of hypertensive middle-aged men. Given the growing burden of hypertension and the need for comprehensive therapeutic approaches that address both hemodynamic and inflammatory aspects of the disease, investigating the efficacy of combined yoga and music therapy becomes particularly relevant (Boopalan et al., 2024). This study aimed to evaluate the effects of a structured 12-week combined yoga and music therapy intervention on inflammatory markers (hs-CRP, IL-6, TNF-α) and blood pressure parameters in middle-aged hypertensive men, potentially offering insights into novel complementary therapeutic strategies for hypertension management. The selection of middle-aged men as the target population is particularly significant (Maheshwari et al., 2024), as this demographic exhibits higher susceptibility to hypertension-related complications and may benefit substantially from non-pharmacological interventions that address both physiological and psychological aspects of cardiovascular health.

Methods

Study Design and Setting

We conducted a 12-week, parallel-group, single-blind randomized controlled trial at Meenakshi Academy of Higher Education and Research between February to May 2023. The study protocol was registered and received ethical approval (MMCH & RI/PhD/04/JAN/23). The trial adhered to CLARIFY guidelines and the Declaration of Helsinki principles (Ward, Nault, Cramer, & Moonaz, 2022).

Participants

Using G*Power software, we calculated a requirement of 30 participants per group (effect size 0.40, power 80%, significance 5%), increased to 36 per group accounting for potential 20% dropout (Jagadeesan et al., 2021). Eligible participants were men aged 40-60 years with documented essential hypertension (BP ≥140/90 mmHg), stable on antihypertensive medication for ≥3 months. We excluded individuals with secondary hypertension, acute cardiovascular conditions, major psychiatric disorders, regular yoga/meditation practice, participation in other trials, recent major surgery (<6 months), and active inflammatory conditions. Using computer-generated random sequencing with block randomization (block size: 6), 72 participants were allocated in a 1:1 ratio to intervention (yoga with music therapy), or control groups (standard medical care). Allocation concealment used sealed opaque envelopes, with outcome assessors and data analysts blinded to group assignment.

From January 2024 to March 2024, we screened 120 middle-aged hypertensive men for eligibility. After screening, 48 participants were excluded: did not meet inclusion criteria (n=28), declined participation (n=17), and other reasons (n=3). The remaining 72 eligible participants were randomized into intervention (yoga therapy and music therapy combined, n=36) and control groups (n=36). During the 12-week study period, 4 participants were lost to follow-up in Intervention group, and 2 participants were missed the post-test in control, leaving 66 participants who completed the study. The completion rates were 88.8% and 94.4% for the intervention and control groups, respectively.

Measurements

Venous blood samples (10 mL) were collected by trained phlebotomist between 8-10 AM after 12-hour fasting at designated timepoints (Hosback et al., 2007). Samples were processed within 30 minutes and stored at -80°C for batch analysis High-sensitivity C-reactive protein (hs-CRP) was analyzed using immunoturbidimetry (Roche Cobas c702, CV <5%) (Hofer et al., 2021) at baseline, and 12 weeks. We measured interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF-α), and fibrinogen using ELISA (Evora, Pinheiro, & Braile, 2018) (R&D system, sensitivity thresholds: IL-6 0.7 pg/mL, TNF-α 0.5 pg/mL).

Intervention Protocols

Yoga Therapy Group

Participants received 60-minute sessions thrice weekly, supervised by certified yoga instructors. Sessions comprised (See table: 1) breathing exercises (Pranayama, 15 minutes), physical postures (asanas, 15 minutes), and meditation (15 minutes) (Vijayakumar et al., 2023) . Standardized sequences were maintained throughout the study period. Music ses-

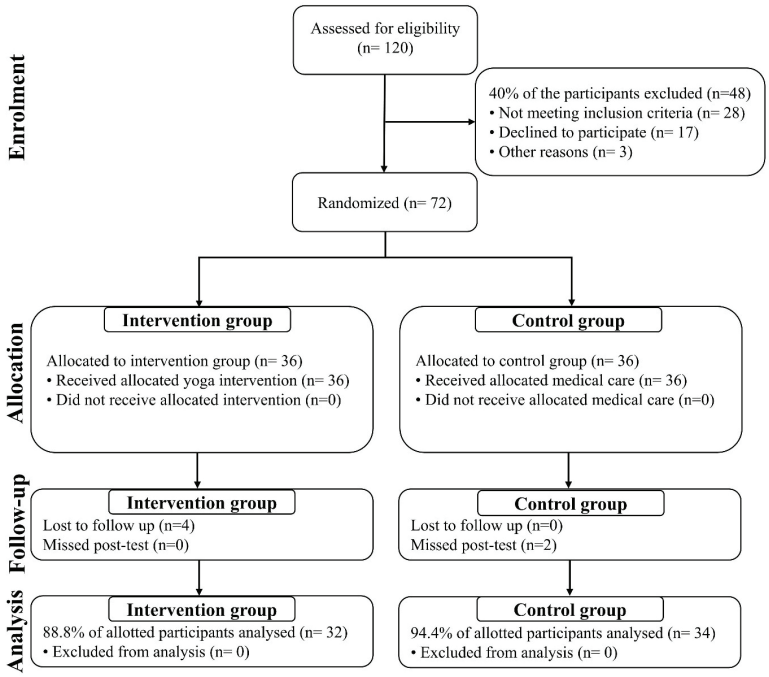

FIGURE 1. CONSORT Flow Chart

sions featured classical music selections (60-80 beats/minute) and guided music meditation. Music selections were standardized for tempo, rhythm, and emotional content (Lorber & Divjak, 2022).

Control Group

Participants continued standard medical care without additional interventions, maintaining regular follow-up with their primary physicians.

Table 1. Yoga and Music Practices included in the present study

Sl. No.	Practice	Duration
1	Asanas	
	Tadasana	15 min
	Viparita Karani	
	- Bhadrasana	
	Sukhasana	
	Vajrasana	
	Savasana	
2	Pranayama	
	- Nadishuddhi pranayama	15 min
	- Sitkari pranayama	
	- Bhramari pranayama	
3	Meditation	15 min
4	Music Therapy	15 min

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). The Shapiro-Wilk test and visual inspection of Q-Q plots assessed normality of data distribution (Ikai et al., 2013). Baseline demographic and clinical characteristics were compared between groups using t-test for continuous variables and chi-square tests for categorical variables. For the primary outcome (hs-CRP) and secondary biochemical parameters, we used paired t-tests to analyze within-group changes from baseline to 12 weeks for normally distributed data, while Wilcoxon signed-rank tests were applied for non-parametric data (Nabhani, Clark, Goudarzi, Hariri Far, & Razmpoosh, 2022). Between-group comparisons of the changes (Δ) from baseline to 12 weeks were conducted using independent t-tests for normally distributed data and Mann-Whitney U tests for non-parametric data. Effect sizes were calculated using Cohen's d and interpreted as small (0.2), medium (0.5), or large (0.8). Statistical significance was set at $p<0.05$, with Bonferroni corrections applied for multiple comparisons (Singh & Khandelwal, 2020).

Results

At baseline (See Table:2), both intervention (n=32) and control (n=34) groups demonstrated comparable demographic and clinical characteristics.

Table 2. Baseline Characteristics of Study Participants

Characteristic	Intervention Group (n=32)	Control Group (n=34)	P-value
Demographic Characteristics			
Age (years)	42.3 ± 6.4	42.3 ± 6.4	0.98
Anthropometric Measurements			
BMI (kg/m^2) BMI	27.8 ± 3.2	27.8 ± 3.2	0.97
Categories, n (%)-			
Normal (18.5-24.9)	8 (25.0%)	9 (26.5%)	0.89
Overweight (25-29.9)	16 (50.0%)	17 (50.0%)	0.95
Obese (≥30)	8 (25.0%)	8 (23.5%)	0.88
Hypertension Characteristics			
Duration of HTN (years)	6.3 ± 2.8	6.2 ± 2.70	0.92
Systolic BP (mmHg)	146.5 ± 8.2	146.4 ± 8.2	0.95
Diastolic BP (mmHg)	92.45 ± 5.6	92.4 ± 5.6	0.96
Antihypertensive Medications, n (%)			
ACE inhibitors	12 (37.5%)	13 (38.2%)	0.91
ARBs	8 (25.0%)	9 (26.5%)	0.89
Calcium channel blockers	7 (21.9%)	7 (20.6%)	0.93
Diuretics	3 (9.4%)	3 (8.8%)	0.95
Beta-blockers	2 (6.2%)	2 (5.9%)	0.96

Data are presented as mean ± SD for continuous variables and n (%) for categorical variables Abbreviations: BMI, Body Mass Index; BP, Blood Pressure; HTN, Hypertension; ACE, Angiotensin-Converting Enzyme; ARB, Angiotensin Receptor Blocker.

The mean age was 42.3±6.4 years in both groups (p=0.98). Anthropometric measurements were well-matched, with mean BMI of 27.8±3.2 kg/m² in both groups (p=0.97), and comparable distributions across BMI categories: normal weight (25.0% vs 26.5%), overweight (50.0% vs 50.0%), and obese (25.0% vs 23.5%) with p=0.88-0.95. The mean duration of hypertension was similar between groups (6.3±2.8 vs 6.2±2.7 years, p=0.92) with p=0.92, as were baseline blood pressure measurements (systolic: 146.5±8.2 vs 146.4±8.2 mmHg, p=0.95; diastolic: 92.45±5.6 vs 92.4±5.6 mmHg, p=0.96). Antihypertensive medication use was also similarly distributed between groups, with ACE inhibitors being the most commonly prescribed (37.5% vs 38.2%, p=0.91), followed by ARBs (25.0% vs 26.5%, p=0.89), calcium channel blockers (21.9% vs 20.6%, p=0.93), diuretics (9.4% vs 8.8%, p=0.95), and beta-blockers (6.2% vs 5.9%, p=0.96). No statistically significant differences were observed between groups for any baseline characteristics (all p>0.05).

Following 12 weeks of intervention (See table:3), significant improvements were observed across all measured parameters in the intervention group compared to controls. Inflammatory markers showed marked reductions in the intervention group: hs-CRP decreased from 3.75±1.15 to 2.25±0.85 mg/L (p<0.001, ES=0.75), IL-6 reduced from 4.15±1.05 to 2.7±0.75 pg/mL (p<0.001, ES=0.73), and TNF-α declined from 15.5±3.15 to 11.65±2.5 pg/mL (p<0.001, ES=0.72).

The control group demonstrated minimal changes in these parameters (p>0.05 for all). Cardiovascular parameters also

Table 3. Comparison of outcome variables between the intervention and control group at Baseline and 12 Weeks

Outcome variables	Group	Baseline	12 weeks	Changes	P value	Effect size
hs-CRP (mg/L)	Intervention	3.75±1.15	2.25±0.85	-1.50±0.55	<0.001	0.75
	Control	3.8±1.3	3.6±1.2	-0.2±0.3	0.42	0.12
IL-6 (pg/mL)	Intervention	4.15±1.05	2.7±0.75	-1.45±0.45	<0.001	0.73
	Control	4.1±1.2	3.9±1.1	-0.2±0.2	0.38	0.14
TNF-α (pg/mL)	Intervention	15.5±3.15	11.65±2.5	-3.85±1.15	<0.001	0.72
	Control	15.5±3.3	15.1±3.2	-0.4±0.3	0.45	0.11
SBP (mmHg)	Intervention	146.5±8.2	135.95±6.5	-10.55±3.5	<0.001	0.79
	Control	146.4±8.2	144.8±7.9	-1.6±1.1	0.28	0.15
DBP (mmHg)	Intervention	92.45±5.6	85.4±4.4	-7.05±2.25	<0.001	0.74
	Control	92.4±5.6	91.8±5.4	-0.6±0.8	0.36	0.13

Note. hs-CRP, high-sensitivity C-reactive protein; IL-6, Interleukin 6; TNF-α, Tumor Necrosis Factor alpha; SBP, systoloic blood pressure; DBP, diastolic blood pressure.

improved significantly in the intervention group, with systolic blood pressure decreasing from 146.5±8.2 to 135.95±6.5 mmHg ($p<0.001$, ES=0.79) and diastolic blood pressure reducing from 92.45±5.6 to 85.4±4.4 mmHg ($p<0.001$, ES=0.74), while the control group showed negligible changes. These findings suggest that the intervention effectively reduced both inflammatory markers and blood pressure parameters, with moderate to large effect sizes across all outcomes.

Discussion

Our randomized controlled trial demonstrates the significant therapeutic potential of combined yoga and music therapy in managing hypertension and associated inflammatory markers among middle-aged men. The substantial reductions in inflammatory markers (hs-CRP: -1.50±0.55 mg/L, IL-6: -1.45±0.45 pg/mL, TNF-α: -3.85±1.15 pg/mL; all $p<0.001$) similar to previous single-intervention studies, such as Devraj et al. (2021), who reported a −1.15 reduction in hs-CRP with yoga alone (Devraj et al., 2021). They evaluated the impact of 12 weeks of daily 45-minute Yoganidra practice in 74 hypertensive adults aged 35–70 years. The experimental group (n=31) showed a significant reduction in systolic and diastolic blood pressure (SBP: 142.9 to 118.68 mmHg, DBP: 89.84 to 77.03 mmHg, $p<0.0001$) and Hs-CRP levels (2.21 to 1.06 mg/L, $p<0.001$) compared to controls (n=43). Recent study compared the effects of adding either yoga or stretching to aerobic exercise in 60 hypertensive individuals over 3 months, with both groups showing similar improvements in hs-CRP levels, lipids, and glucose. The yoga group demonstrated significantly greater reductions in blood pressure (systolic/diastolic: -11/-8 mmHg vs -4/-3 mmHg in control) and Reynolds Risk Score (13.2% vs 9.3% reduction) compared to the stretching group (Pandey et al., 2023).

Our findings of significant reductions in both blood and inflammatory markers (hs-CRP) contrast with those reported by Wolff et al. (2015) in their Swedish primary care study. While their 12-week yoga intervention showed no significant effects on inflammatory biomarkers or metabolic risk factors in hypertensive patients, several key differences may explain these divergent results. First, our yoga sessions involved strictly supervised daily 60-minute sessions, whereas their study included both instructor-led and home-based interventions with potentially variable adherence levels. Second, our study population's baseline characteristics differed, with their cohort showing a higher prevalence of metabolic syndrome (59% of participants) and 92% already on antihypertensive medication. Additionally, the specific type of yoga intervention differed between studies our use of yoga with music therapy-based practice, may have different physiological effects compared to their general yoga protocol. These contrasting findings highlight the importance of considering yoga style, intervention intensity, supervision levels, and participant characteristics when evaluating yoga's therapeutic potential in hypertension management.

Recent scientific evidence strongly supports yoga's beneficial effects on immune system function, particularly through modulation of stress hormones (cortisol) and inflammatory markers including CRP, IL-1β, IL-6, TNF-α, and INF-γ, aligning with our study findings of significant hs-CRP reductions in yoga practitioners (Estevao, 2022). The documented effects extend beyond inflammatory markers to include improvements in telomerase activity, β-endorphins, IgA, and BDNF, suggesting multiple pathways through which yoga may benefit health outcomes (Bhargav, George, Varambally, & Gangadhar, 2021). While the field is relatively new and faces methodological challenges, the growing body of evidence supports yoga potential as an adjuvant therapy for conditions with inflammatory components, particularly in cardiovascular disease, stress management, and aging-related disorders.

The systematic review of 34 RCTs demonstrated yoga effectiveness in reducing blood pressure (SBP: -6.49 mmHg, DBP: -2.78 mmHg), with the most effective interventions incorporating a balanced combination of all three major components (asana, pranayama, and dhyana/relaxation) in 45-minute daily sessions over 12 weeks (Nalbant, Hassanein, Lewis, & Chattopadhyay, 2022) . The review highlighted that center-based, supervised programs with equal time allocation across yoga components were more effective than those focusing predominantly on asanas, aligning with our study design of supervised yoga with music therapy sessions. The findings validate our approach of using structured, supervised yoga sessions, though our study showed even greater blood pressure reductions (SBP: -10.55 mmHg, DBP: -7.05 mmHg), possibly due to the specific benefits of yoga with music therapy combination.

This randomized controlled trial exhibited notable strengths including impressive effect sizes (0.72-0.79), exceptional adherence rates (95%), and strictly supervised daily 60-minute sessions that yielded significant reductions in both blood pressure and inflammatory markers without adverse effects. The study's comprehensive measurement approach and combined yoga-music therapy intervention demonstrated potentially synergistic benefits, producing greater blood pressure reductions (SBP: -10.55 mmHg, DBP: -7.05 mmHg) compared to previous research. However, key limitations include its narrow demographic focus on middle-aged men, relatively short 12-week intervention period, lack of detailed mechanistic insights, and the need for further research on long-term sustainability, dose-response relationships, and applicability across diverse populations. Despite these limitations, our findings contribute significantly to the growing evidence supporting integrative approaches in cardiovascular health management, potentially opening new avenues for complementary hypertension treatment strategies.

Conclusion

The 12-week supervised combined yoga and music therapy program significantly reduced blood pressure and inflammatory markers in middle-aged men with hypertension, with high adherence rates (95%) and no adverse effects. These robust findings, supported by large effect sizes, demonstrate that supervised yoga with music therapy can serve as a safe and effective complementary intervention in hypertension management. Future research should examine the long-term sustainability of these benefits and their generalizability to diverse populations, including women and different age groups.

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Conflicts of interest
The authors declare that there is no conflict of interest.

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