Jurnal Keterapian Fisik
Vol. 11, No. 1, May 2026
https://doi.org/10.37341/jkf.v11i1.474

Original Research

Multimodal Acupuncture Enhances Autonomic Balance and Reduces Blood Pressure in Adults

Kadek Buja Harditya[1*], Anak Agung Istri Mas Padmiswari[1], Ida Ayu Suptika Strisanti[1], Komang Rosa Tri Anggaraeni[1]

[1]Bachelor of Applied Acupuncture and Herbal Medicine Study Program, Faculty of Health, Institute of Technology and Health Bali

ABSTRACT

Background: *Blood pressure regulation is influenced by autonomic nervous system balance, where increased sympathetic and reduced parasympathetic activity contribute to hypertension. Acupuncture may modulate autonomic function but combined somatic and auricular approaches remain underexplored. This study evaluated a multimodal acupuncture protocol combining Neiguan (PC6), auricular vagus, and Er Shen Men on autonomic function and blood pressure.*

Methods: *A randomized controlled trial with a pretest–posttest design was conducted in 60 adults aged 20–60 years, allocated into four groups: combination therapy, PC6 only, auricular vagus + Er Shen Men, and sham acupuncture. Interventions were applied twice weekly for four weeks. Outcomes included heart rate variability (SDNN, RMSSD, LF/HF ratio, and heart rate) and systolic and diastolic blood pressure. Data were analyzed using paired tests and ANOVA or Kruskal–Wallis tests with post hoc comparisons.*

Results: *The combination group showed significant improvements in SDNN, RMSSD, LF/HF ratio, and heart rate, along with reductions in systolic (−12.0 mmHg) and diastolic (−10.0 mmHg) blood pressure ($p < 0.001$). Single-intervention groups showed moderate changes, while the sham group showed minimal effects. Between-group differences were significant ($p < 0.05$), with greater improvements observed in the combination group.*

Conclusion: *Multimodal acupuncture is associated with improved autonomic function and reduced blood pressure, suggesting its potential as a non-pharmacological intervention for cardiovascular regulation.*

ARTICLE HISTORY
Received: December 07, 2025
Accepted: April 10, 2026

KEYWORDS
blood pressure; heart rate variability; multimodal acupuncture

CONTACT
Kadek Buja Harditya
✉
kadekbuja@gmail.com
Bachelor of Applied Acupuncture and Herbal Medicine Study Program, Faculty of Health, Institute of Technology and Health Bali
Jl. Tukad Balian No. 180, Denpasar, 80239, Indonesia

This article is an open access article licensed under Creative Commons Attribution 4.0 International License (CC BY 4.0)

Cite this as: Harditya, K. B., Padmiswari, A. A. I. M., Strisanti, I. A. S., & Anggaraeni, K. R. T. (2026). Multimodal Acupuncture Enhances Autonomic Balance and Reduces Blood Pressure in Adults. *Jurnal Keterapian Fisik, 11(1)*, 10-23. https://doi.org/10.37341/jkf.v11i1.474

INTRODUCTION

Blood pressure regulation is a physiological process that is highly influenced by the balance of autonomic nervous system activity, particularly through the interaction between sympathetic and parasympathetic tone. Autonomic imbalance, characterized by increased sympathetic activity alongside decreased parasympathetic activity, can lead to

elevated blood pressure and an increased risk of cardiovascular diseases (Karim et al., 2023; Valensi, 2021). One of the most reliable physiological parameters for non-invasive assessment of autonomic regulation is Heart Rate Variability (HRV), which is widely used to evaluate the balance between sympathetic and parasympathetic activity in both clinical and research settings (Grässler et al., 2021; Gullett et al., 2023; Shaffer et al., 2020). Blood pressure disturbances and autonomic dysfunction can arise from various factors, including stress, unhealthy lifestyle patterns, environmental exposures, and occupational factors that involve repetitive activity or poor ergonomic positions (Bonfiglioli et al., 2022). These factors can increase the risk of hypertension and further impair autonomic regulation.

Acupuncture, as a complementary therapeutic method, has been extensively studied and applied as a non-pharmacological intervention for various health conditions, including blood pressure regulation and cardiovascular disorders. Numerous studies have evaluated acupuncture as a modality capable of modulating autonomic nervous system activity. Acupuncture stimulation has been reported to influence autonomic regulation through neurohumoral mechanisms, activation of the nucleus tractus solitarius, and enhancement of vagal nerve activity (Li et al., 2022; Su et al., 2024; Ylikoski et al., 2020).

The Neiguan point (PC6) is widely recognized for its cardiovascular effects, including increasing parasympathetic tone and reducing sympathetic responses(Harditya, Anggaraeni, et al., 2023; Yue et al., 2025). Moreover, auricular vagus nerve stimulation has been shown to enhance vagal afferent activity and reduce blood pressure in individuals with mild hypertension (Kaniusas et al., 2020). Other studies indicate that Er Shen Men (Auricular Shenmen) exerts strong anxiolytic effects and can improve autonomic balance by enhancing parasympathetic activity (Hamvas et al., 2023). These findings reinforce the understanding that acupuncture, whether applied at somatic or auricular points, has the potential to serve as a non-pharmacological therapeutic approach for autonomic modulation.

Although the individual points have been studied separately, most previous research has not assessed the effectiveness of combining these three points as a multimodal approach. Prior studies suggest that single-point acupuncture may produce temporary effects on autonomic regulation, whereas combining somatic and auricular points may generate stronger and more sustained synergistic effects. This concept aligns with the principles of Jin's 3 Needles or the Integrative Neuromuscular Acupoint System (INMAS), in which the use of combined points aims not only to alleviate symptoms but also to restore physiological balance (Purwanto & Wahyu, 2021; Puspitaningrum et al., 2025). By analogy, a combination protocol involving PC6, auricular vagus, and Er Shen Men is expected to optimally enhance parasympathetic tone and reduce blood pressure more effectively.

Despite the therapeutic effects of PC6, auricular vagus, and Er Shen Men having been documented individually, prior research still has significant limitations. Most studies have focused solely on single-point stimulation, leaving the question unanswered as to whether combining these points could exert a stronger synergistic effect on parasympathetic tone and blood pressure reduction. Furthermore, multimodal stimulation protocols integrating somatic and auricular points remain scarcely investigated, even though physiologically such an approach may provide broader modulation along the cardiovagal pathways. Therefore, a significant research gap exists, namely the absence of comprehensive studies on a combined acupuncture protocol involving PC6, auricular vagus, and Er Shen Men for autonomic tone regulation as measured by HRV parameters.

Based on this gap, the present study offers novelty by evaluating a combined stimulation protocol of PC6, auricular vagus, and Er Shen Men as a multimodal approach, hypothesized to provide more optimal autonomic modulation than single-point stimulation. Conceptually, this combination is expected to enhance parasympathetic activity, improve autonomic regulation, and lower blood pressure through synergistic mechanisms between somatic and auricular modulation. The study aimed to determine whether a multimodal approach could enhance parasympathetic tone and reduce blood pressure more effectively than single-point stimulation or sham acupuncture. The findings of this study are anticipated to strengthen scientific evidence supporting acupuncture as a non-pharmacological intervention for blood pressure control and autonomic function improvement in adult populations.

MATERIALS AND METHOD

This study employed a randomized controlled trial (RCT) with a pretest–posttest control group design to evaluate the effectiveness of multimodal acupuncture on autonomic nervous system activity and blood pressure in adults with elevated blood pressure. The study was conducted at the Tulus Ayu Denpasar Clinic, Department of Acupuncture, from May to July 2025. All procedures were performed in a clinical setting adhering to standard sterility and safety protocols.

The study population consisted of adults aged 20–60 years with elevated blood pressure, ranging from prehypertension to stage 1 hypertension. Each group comprised 15 participants, and random allocation was applied to minimize selection bias. The study population consisted of adults aged 20–60 years with elevated blood pressure, ranging from prehypertension to stage 1 hypertension.

A total of 60 participants were recruited using purposive sampling based on predefined inclusion and exclusion criteria. The sample size (15 participants per group) was determined as a pilot and exploration study, considering feasibility, resource limitations, and effect size estimation, as well as reference to similar preliminary acupuncture studies (Singh et al., 2025). The inclusion criteria were adults aged 20–60 years, systolic blood pressure of 120–159 mmHg, diastolic blood pressure of 80–99 mmHg, and willingness to participate by providing written informed consent. The exclusion criteria included current use of antihypertensive medication, history of cardiovascular complications, pregnancy, neurological disorders, and any contraindications to acupuncture therapy.

The independent variable was the type of acupuncture intervention, while the dependent variables were autonomic nervous system activity and blood pressure. Participants were randomly allocated into four groups, each consisting of 15 participants, to minimize selection bias. Randomization was performed using a computer-generated random sequence prior to the intervention to ensure unbiased group assignment. Group A received multimodal acupuncture at Neiguan (PC6), Auricular Vagus, and Er Shen Men points. Group B received acupuncture at PC6 only. Group C received a combination of Auricular Vagus and Er Shen Men stimulation. Group D served as the control group receiving sham acupuncture. Participants were blinded to group allocation to reduce expectation bias.

Autonomic nervous system activity was assessed using Heart Rate Variability (HRV), while blood pressure was measured as the primary cardiovascular outcome. HRV was recorded using a validated Polar H10 heart rate monitor and analyzed with Kubios HRV software. Parameters included SDNN (standard deviation of normal-to-normal RR

intervals), RMSSD (root mean square of successive RR interval differences), LF/HF ratio, and average heart rate. Blood pressure was measured using a calibrated digital sphygmomanometer, with two readings taken per session and the average value used for analysis. All measurements were conducted under standardized conditions, including participant rest, posture, and measurement duration. The instruments used in this study have been validated in clinical and research settings for accuracy and reliability.

The intervention was administered twice weekly for four weeks, with each session lasting 20 minutes. For PC6 stimulation, sterile disposable stainless-steel acupuncture needles (0.25 × 25 mm) were inserted at a depth of 0.5–1 cun and manually stimulated to achieve deqi sensation, followed by electroacupuncture using a low-frequency stimulation of 2–10 Hz with a continuous waveform adjusted to patient tolerance. Auricular Vagus stimulation was performed using electroauricular stimulation at the cymba conchae to activate vagal afferent pathways. Er Shen Men was stimulated using auricular needles or manual pressure according to standardized auricular acupuncture techniques. All interventions were performed by licensed and certified acupuncture practitioners with formal training in traditional Chinese medicine and clinical acupuncture practice. A standardized protocol was followed to ensure consistency in needle selection, insertion techniques, stimulation parameters, and treatment duration across all participants.

The sham control group received superficial non-acupoint needling without electrical stimulation or manual manipulation intended to elicit deqi. The control condition was conducted in the same clinical environment and with the same session duration as the intervention groups. This control group is used to ensure that the observed effects are truly attributable to the acupuncture intervention administered.

Outcome assessors and data analysts were also blinded to group assignments; however, practitioner blinding was not feasible due to the nature of the intervention. Nevertheless, the researchers made efforts to minimize potential bias by following standard procedures throughout the intervention. The data collection process was conducted systematically and well-documented to ensure data quality. As a result, the validity and reliability of the study's findings were maintained.

Data analysis was performed using IBM SPSS Statistics version 26.0. Data normality was assessed using the Shapiro–Wilk test, and homogeneity of variance was evaluated using Levene's test. Within-group comparisons between pre- and post-intervention values were analyzed using paired t-tests for normally distributed data or Wilcoxon signed-rank tests for non-normally distributed data. Between-group comparisons were conducted using one-way analysis of variance (ANOVA) for parametric data or the Kruskal–Walli's test for non-parametric data. When significant differences were identified, post hoc analyses were performed using Tukey's Honestly Significant Difference (HSD) test for parametric data and Dunn's test with Bonferroni correction for non-parametric data. A p-value of less than 0.05 was considered statistically significant.

The study was approved by the Ethics Committee of the Institute of Technology and Health (ITEKES) Bali (Approval Number: 04.0163/KEP-ITEKES-BALI/III/2025). All participants provided written informed consent prior to participation, and the study was conducted in accordance with ethical principles for human research. The confidentiality of all participants' data and identities was also strictly maintained throughout the research process.

RESULTS

Table 1. Baseline Demographic Characteristics of Participants (n = 60)

Characteristic	Group A (n = 15)	Group B (n = 15)	Group C (n = 15)	Group D (n = 15)	Total (n = 60)	p-value
Age (years), mean ± SD	45.0 ± 10.0	46.0 ± 9.0	44.0 ± 11.0	45.0 ± 10.0	45.0 ± 10.0	0.910*
Age Range (years)	28–58	30–59	25–57	27–60	25–60	–
Sex, n (%)						0.870**
Male	8 (53.3%)	7 (46.7%)	9 (60.0%)	8 (53.3%)	32 (53.3%)	
Female	7 (46.7%)	8 (53.3%)	6 (40.0%)	7 (46.7%)	28 (46.7%)	

Note:
*One-Way ANOVA; **Chi-Square Test
Group A: Neiguan (PC6) + Auricular Vagus + Er Shen Men
Group B: Neiguan (PC6) only
Group C: Auricular Vagus + Er Shen Men
Group D: Sham Acupuncture

Table 1 summarizes the demographic characteristics of the 60 participants, who were equally distributed into four groups based on the intervention type. The mean age was comparable across groups, ranging from 44.0 to 46.0 years, with an overall mean of 45.0 ± 10.0 years, and no statistically significant difference was observed (p = 0.910). Age distribution was similar, ranging from 25 to 60 years. Sex distribution was also comparable among groups, with no statistically significant differences observed (p = 0.870). Overall, 32 participants (53.3%) were male and 28 (46.7%) were female.

Baseline clinical parameters, including systolic and diastolic blood pressure, heart rate, and heart rate variability indices (SDNN, RMSSD, and LF/HF ratio), were comparable across all groups, with no statistically significant differences observed (p > 0.05). These findings indicate that the groups were well balanced prior to the intervention. This indicates that there are no differences in baseline characteristics that could influence the study results.

Table 2. Systolic and Diastolic Blood Pressure (mmHg) Before and After Intervention (n = 60)

Variable	Pre-Test (Mean ± SD)	Post-Test (Mean ± SD)	Change (mmHg)	Within-group p-value	Between-group p-value
Systolic Blood Pressure					
Group A (n = 15)	138.0 ± 8.0	126.0 ± 7.0	−12.0	<0.001*	0.002**
Group B (n = 15)	137.0 ± 9.0	131.0 ± 8.0	−6.0	0.004*	
Group C (n = 15)	139.0 ± 7.0	129.0 ± 6.0	−10.0	<0.001*	
Group D (n = 15)	136.0 ± 8.0	135.0 ± 7.0	−1.0	0.320*	
Diastolic Blood Pressure					
Group A (n = 15)	88.0 ± 6.0	78.0 ± 5.0	−10.0	<0.001*	0.003**
Group B (n = 15)	87.0 ± 5.0	82.0 ± 6.0	−5.0	0.005*	

Variable	Pre-Test (Mean ± SD)	Post-Test (Mean ± SD)	Change (mmHg)	Within-group p-value	Between-group p-value
Group C (n = 15)	89.0 ± 6.0	80.0 ± 5.0	−9.0	<0.001*	
Group D (n = 15)	87.0 ± 6.0	86.0 ± 5.0	−1.0	0.280*	

Note:
*Paired t-tests; **One-Way ANOVA
Group A: Neiguan (PC6) + Auricular Vagus + Er Shen Men
Group B: Neiguan (PC6) only
Group C: Auricular Vagus + Er Shen Men
Group D: Sham Acupuncture

Table 2 presents the mean systolic blood pressure values before and after the intervention across all groups. Significant reductions were observed in Group A (−12.0 mmHg, $p < 0.001$), Group B (−6.0 mmHg, $p = 0.004$), and Group C (−10.0 mmHg, $p < 0.001$). In contrast, no statistically significant change was observed in Group D (−1.0 mmHg, $p = 0.320$). Between-group analysis using ANOVA demonstrated a statistically significant difference among groups ($p = 0.002$). The mean diastolic blood pressure values showed significant reductions in Group A (−10.0 mmHg, $p < 0.001$), Group B (−5.0 mmHg, $p = 0.005$), and Group C (−9.0 mmHg, $p < 0.001$), while no statistically significant change was observed in Group D (−1.0 mmHg, $p = 0.280$). Between-group analysis using ANOVA demonstrated a statistically significant difference among groups ($p = 0.003$).

Table 4. Standard Deviation of Normal-to-Normal intervals (SDNN) and Root Mean Square of Successive Differences (RMSSD) Before and After Intervention (n =60)

Variable	Pre-Test (Mean ± SD)	Post-Test (Mean ± SD)	Change (ms)	Within-group p-value	Between-group p-value
SDNN (millisecond/ms)					
Group A (n = 15)	32.0 ± 6.0	46.0 ± 7.0	+14.0	<0.001*	0.001**
Group B (n = 15)	31.0 ± 5.0	38.0 ± 6.0	+7.0	0.003*	
Group C (n = 15)	33.0 ± 6.0	45.0 ± 7.0	+12.0	<0.001*	
Group D (n = 15)	32.0 ± 5.0	33.0 ± 6.0	+1.0	0.340*	
RMSSD (millisecond/ms)					
Group A (n = 15)	28.0 ± 5.0	42.0 ± 6.0	+14.0	<0.001*	0.001**
Group B (n = 15)	27.0 ± 4.0	35.0 ± 5.0	+8.0	0.002*	
Group C (n = 15)	29.0 ± 5.0	41.0 ± 6.0	+12.0	<0.001*	
Group D (n = 15)	28.0 ± 4.0	29.0 ± 5.0	+1.0	0.310*	

Note:
*Paired t-tests; **One-Way ANOVA
Group A: Neiguan (PC6) + Auricular Vagus + Er Shen Men
Group B: Neiguan (PC6) only
Group C: Auricular Vagus + Er Shen Men
Group D: Sham Acupuncture

Table 4 presents the SDNN values before and after the intervention across all groups. Significant increases were observed in Group A (+14.0 ms, $p < 0.001$), Group B (+7.0 ms, $p = 0.003$), and Group C (+12.0 ms, $p < 0.001$), while no statistically significant change was observed in Group D (+1.0 ms, $p = 0.340$). Between-group analysis using ANOVA demonstrated a statistically significant difference among groups ($p = 0.001$). the RMSSD values before and after the intervention across all groups. Similarly, the RMSSD values before and after the intervention showed significant increases in Group A (+14.0 ms, $p < 0.001$), Group B (+8.0 ms, $p = 0.002$), and Group C (+12.0 ms, $p < 0.001$), whereas no statistically significant change was observed in Group D (+1.0 ms, $p = 0.310$). Between-group analysis using ANOVA also revealed a statistically significant difference among the groups ($p = 0.001$).

Table 5. Changes in Autonomic Nervous System Indicators (Low Frequency/High Frequency Ratio and Heart Rate) Before and After the Intervention (n = 60)

Group	Pre-Test (Mean ± SD)	Post-Test (Mean ± SD)	Change	Within-group p-value	Between-group p-value
Low Frequency (LF) /High Frequency Ratio (HF)					
Group A (n = 15)	2.5 ± 0.6	1.5 ± 0.5	−1.0	<0.001*	0.002**
Group B (n = 15)	2.4 ± 0.5	1.9 ± 0.6	−0.5	0.006*	
Group C (n = 15)	2.6 ± 0.6	1.7 ± 0.5	−0.9	<0.001*	
Group D (n = 15)	2.5 ± 0.5	2.4 ± 0.5	−0.1	0.280*	
Heart Rate (HR)					
Group A (n = 15)	78.0 ± 7.0	70.0 ± 6.0	−8.0	<0.001*	0.003**
Group B (n = 15)	77.0 ± 6.0	73.0 ± 6.0	−4.0	0.010*	
Group C (n = 15)	79.0 ± 7.0	71.0 ± 6.0	−8.0	<0.001*	
Group D (n = 15)	78.0 ± 6.0	77.0 ± 5.0	−1.0	0.320*	

Note:
* Wilcoxon signed-rank tests; ** the Kruskal–Wallis's test
Group A: Neiguan (PC6) + Auricular Vagus + Er Shen Men
Group B: Neiguan (PC6) only
Group C: Auricular Vagus + Er Shen Men
Group D: Sham Acupuncture

Table 5 presents the LF/HF ratio values before and after the intervention across all groups. Significant reductions were observed in Group A (−1.0, $p < 0.001$), Group B (−0.5, $p = 0.006$), and Group C (−0.9, $p < 0.001$), while no statistically significant change was observed in Group D (−0.1, $p = 0.280$). Between-group analysis using the Kruskal–Wallis's test demonstrated a statistically significant difference among groups ($p = 0.002$). Similarly, heart rate showed significant reductions in Group A (−8.0 bpm, $p < 0.001$), Group B (−4.0 bpm, $p = 0.010$), and Group C (−8.0 bpm, $p < 0.001$), whereas no statistically significant change was observed in Group D (−1.0 bpm, $p = 0.320$). Between-group analysis using ANOVA also indicated a statistically significant difference among the groups ($p = 0.003$).

Table 6. Summary of Post Hoc Pairwise Comparisons Across All Outcome Measures (n =60)

Comparison	SBP (p-value)	DBP (p-value)	SDNN (p-value)	LF/HF (p-value)	HR (p-value)	Interpretation
A vs B	0.045*	0.038*	0.021*	0.041*	0.048*	Group A showed significantly higher values than Group B
A vs C	0.412	0.521	0.356	0.438	0.998	No statistically significant difference between groups
A vs D	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	Group A showed significantly higher values than Group D
B vs C	0.083	0.091	0.072	0.095	0.052	No statistically significant difference between groups
B vs D	0.032*	0.041*	0.028*	0.047*	0.041*	Group B showed significantly higher values than Group D
C vs D	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	Group C showed significantly higher values than Group D

Note:
*p < 0.05 indicates statistical significance. Post hoc tests were performed using Tukey HSD for parametric data and Dunn's test with Bonferroni correction for non-parametric data.
SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; SDNN: Standard Deviation of NN intervals
LF/HF: Low-Frequency to High-Frequency Ratio; HR: Heart Rate
Group A: Neiguan (PC6) + Auricular Vagus + Er Shen Men; Group B: Neiguan (PC6) only; Group C: Auricular Vagus + Er Shen Men; Group D: Sham Acupuncture

Table 6 summarizes the results of post hoc analyses across all outcome measures revealed a highly consistent pattern of results. Group A demonstrated significantly greater improvements compared to Group B and Group D across all parameters, including systolic blood pressure, diastolic blood pressure, SDNN, LF/HF ratio, and heart rate (all $p < 0.05$). However, no statistically significant differences were observed between Group A and Group C across any outcome measures. Similarly, Group C showed significantly greater improvements compared to the sham group (Group D) across all variables ($p <$

0.001). No significant differences were found between Group B and Group C in any parameter. Group B also demonstrated statistically significant improvements compared to the sham group (Group D) across all outcomes ($p < 0.05$).

DISCUSSION

The results of this study indicate that combined stimulation of Neiguan (PC6), auricular vagus, and Er Shen Men produced the greatest improvements in autonomic function and blood pressure compared with single-point or sham interventions. The observed increases in SDNN and RMSSD, along with reductions in the LF/HF ratio, heart rate, and blood pressure, suggest enhanced parasympathetic activity and improved autonomic balance in the combination group. These findings support the hypothesis that a multimodal acupuncture approach provides more effective autonomic modulation than single-point stimulation and are consistent with previous studies demonstrating the role of acupuncture in regulating autonomic nervous system activity and heart rate variability (Hamvas et al., 2023; Li et al., 2022; Shaffer et al., 2020).

In addition, the post hoc analysis across all outcome measures demonstrated a highly consistent pattern of between-group differences. The combination group (Group A) showed significantly greater improvements compared to the PC6-only group (Group B) and the sham group (Group D) across all parameters, including blood pressure, heart rate variability indices, and heart rate ($p < 0.05$). However, no significant differences were observed between the combination group (Group A) and the auricular-only group (Group C), indicating comparable effects between these two interventions. Furthermore, Group C consistently demonstrated significantly better outcomes than the sham group ($p < 0.001$), while no significant differences were found between Groups B and C across all parameters. These findings suggest that auricular vagus-based stimulation may play a dominant role in mediating the observed autonomic and cardiovascular effects, while PC6 contributes additional but not superior benefits when used in combination.

The observed increases in SDNN and RMSSD, along with reductions in the LF/HF ratio, heart rate, and blood pressure, suggest enhanced parasympathetic activity and improved autonomic balance. These physiological changes indicate a shift toward vagal dominance and reduced sympathetic activity, which may explain the consistent improvements observed across cardiovascular and autonomic parameters. This suggests that the intervention administered has the potential to effectively improve overall autonomic nervous system regulations.

The superior outcomes observed in the combination group may be attributed to the synergistic effects of somatic and auricular stimulation. PC6 stimulation has been associated with modulation of autonomic responses and cardiovascular regulation, particularly through central autonomic pathways (Chang et al., 2022; Huang et al., 2023; Yue et al., 2025). Similarly, auricular vagus nerve stimulation has been shown to enhance vagal activity and improve heart rate variability, reflecting increased parasympathetic tone (Carandina et al., 2021; Konakoğlu et al., 2025).

In addition, Er Shen Men has been linked to stress reduction and autonomic regulation in both traditional and modern interpretations of auricular acupuncture (Rangon et al., 2023; Stanton, 2024). The integration of these stimulation sites may therefore contribute to broader and more robust modulation of autonomic function compared with single-point approaches. However, the present study did not directly assess neurophysiological pathways; thus, these mechanisms should be interpreted as plausible explanations rather than confirmed causal effects (Karemaker, 2022).

The significant reduction in the LF/HF ratio further indicates a shift in sympathovagal balance toward parasympathetic dominance. This finding is consistent with prior evidence suggesting that neuromodulation approaches, including electroacupuncture and auricular stimulation, can enhance vagal activity and improve autonomic balance (Armstrong et al., 2020; Ha et al., 2025; Hadaya & Ardell, 2020). In parallel, the observed reductions in systolic and diastolic blood pressure align with experimental and clinical findings showing that acupuncture at PC6 can exert antihypertensive effects through autonomic modulation and vascular regulation (Chang et al., 2022; Xin et al., 2020).

Compared with previous studies that primarily investigated single-point or single-modality acupuncture interventions, the present study demonstrates a more comprehensive approach by integrating both somatic and auricular stimulation within a single protocol. While earlier studies have reported improvements in autonomic function and cardiovascular parameters using individual acupuncture points, current evidence suggests that multimodal stimulation may produce more consistent and pronounced effects on autonomic regulation (Grässler et al., 2021; Shen et al., 2024). This supports the concept that targeting multiple regulatory pathways simultaneously may enhance therapeutic outcomes.

From a Traditional Chinese Medicine perspective, PC6 is known to regulate the Pericardium meridian and calm the Shen, which may contribute to cardiovascular and emotional stability. Auricular points associated with the vagus nerve and Shenmen are also traditionally linked to stress reduction and autonomic balance. These concepts align with modern findings demonstrating the involvement of the autonomic nervous system in mediating the effects of acupuncture (Guo et al., 2024; Li et al., 2022; Yue et al., 2025). Although these traditional concepts correspond with observed improvements in HRV and blood pressure, further research is needed to clarify the underlying mechanisms from a biomedical perspective.

The findings of this study have both theoretical and clinical implications. Theoretically, they support the integration of somatic and auricular acupuncture within a neuromodulation framework. Clinically, multimodal acupuncture may serve as a promising non-pharmacological intervention for improving autonomic balance and managing elevated blood pressure. These findings also reinforce the notion that complementary therapy approaches can play a role in holistically improving patients' health. Furthermore, these interventions can serve as a safe and effective alternative in clinical practice to reduce reliance on pharmacological therapies.

Nevertheless, several limitations should be considered. First, the relatively short intervention duration may not fully capture long-term effects. Second, the study population consisted of adults with mild blood pressure elevation, which may limit generalizability to patients with more severe hypertension. Third, neurophysiological mechanisms were not directly measured, and interpretations were primarily based on HRV parameters. Future studies are recommended to include longer follow-up periods, larger sample sizes, and objective neurobiological measures to further elucidate the mechanisms underlying these effects.

CONCLUSION

This study demonstrates that multimodal acupuncture combining Neiguan (PC6), auricular vagus, and Er Shen Men produces superior effects on blood pressure and autonomic function compared with single-point or sham interventions. Improvements in

heart rate variability indicate enhanced parasympathetic activity and better autonomic balance. Post hoc analysis suggests that auricular vagus stimulation plays a dominant role, while PC6 provides complementary effects. These findings support the potential of multimodal acupuncture as a non-pharmacological approach for cardiovascular and autonomic regulation. Further studies with larger samples and longer follow-up are required to confirm these findings and elucidate the underlying mechanisms.

ACKNOWLEDGEMENTS

The authors would like to express their sincere gratitude to the Tulus Ayu Denpasar Clinic, Department of Acupuncture, for providing the clinical facilities and support necessary to conduct this study. Appreciation is also extended to the participants for their time and cooperation, and to the technical staff for their assistance in HRV measurements and blood pressure assessments. Special thanks are given to the Institute of Technology and Health (ITEKES) Bali for ethical oversight and guidance throughout the research process.

DECLARATION OF USE OF AI IN SCIENTIFIC WRITING

AI tools were used solely for grammar and language editing. The authors take full responsibility for the content and integrity of the manuscript.

CONFLICT OF INTERESTS

The authors affirm that they have no competing financial or non-financial interests that may have influenced the outcomes of this study.

REFERENCES

Armstrong, K., Gokal, R., & Todorsky, W. (2020). Neuromodulating influence of two electroacupuncture treatments on heart rate variability, stress, and vagal activity. *The Journal of Alternative and Complementary Medicine*, *26*(10), 928–936. https://doi.org/10.1089/acm.2019.0267

Bonfiglioli, R., Caraballo-Arias, Y., & Salmen-Navarro, A. (2022). Epidemiology of work-related musculoskeletal disorders. *Current Opinion in Epidemiology and Public Health*, *1*(1), 18–24. https://doi.org/10.1097/PXH.0000000000000003

Carandina, A., Rodrigues, G. D., Di Francesco, P., Filtz, A., Bellocchi, C., Furlan, L., Carugo, S., Montano, N., & Tobaldini, E. (2021). Effects of transcutaneous auricular vagus nerve stimulation on cardiovascular autonomic control in health and disease. *Autonomic Neuroscience*, *236*, 102893. https://doi.org/10.1016/j.autneu.2021.102893

Chang, Y.-C., Chen, C.-M., Lay, I.-S., Lee, Y.-C., & Tu, C.-H. (2022). The dosage effect of laser acupuncture at pc6 (neiguan) on heart rate variability: A pilot study. *Life*, *12*(12), 1951. https://doi.org/10.3390/life12121951

Grässler, B., Thielmann, B., Böckelmann, I., & Hökelmann, A. (2021). Effects of different exercise interventions on heart rate variability and cardiovascular health factors in older adults: A systematic review. *European Review of Aging and Physical Activity*, *18*(1), 24. https://doi.org/10.1186/s11556-021-00278-6

Gullett, N., Zajkowska, Z., Walsh, A., Harper, R., & Mondelli, V. (2023). Heart rate variability (HRV) as a way to understand associations between the autonomic nervous system (ANS) and affective states: A critical review of the literature. *International Journal of Psychophysiology*, *192*, 35–42. https://doi.org/10.1016/j.ijpsycho.2023.08.001

Guo, K., Lu, Y., Wang, X., Duan, Y., Li, H., Gao, F., & Wang, J. (2024). Multi-level exploration of auricular acupuncture: From traditional Chinese medicine theory to modern medical application. *Frontiers in Neuroscience*, *18*. https://doi.org/10.3389/fnins.2024.1426618

Ha, S., Choi, S., Jung, Y., Lee, S., & Park, W. (2025). Effects of tc vns and multimodal stimulation on heart rate variability and stress regulation. *MedRxiv*, https://doi.org/10.1101/2025.06.22.25329895

Hadaya, J., & Ardell, J. L. (2020). Autonomic modulation for cardiovascular disease. *Frontiers in Physiology*, *11*. https://doi.org/10.3389/fphys.2020.617459

Hamvas, Sz., Hegyi, P., Kiss, Sz., Lohner, Sz., McQueen, D., & Havasi, M. (2023). Acupuncture increases parasympathetic tone, modulating HRV − Systematic review and meta-analysis. *Complementary Therapies in Medicine*, *72*, 102905. https://doi.org/10.1016/j.ctim.2022.102905

Harditya, K. B., Anggaraeni, K. R. T., Sari, N. M. C. C., & Wahyuningsih, N. L. G. N. S. (2023). Clinical manifestation of differentiation syndrome diagnosis in hypertension. *Jurnal Kesehatan*, *12*(2), 280–279. https://doi.org/10.46815/jk.v12i2.175

Huang, J., Yan, J., Wang, T., & Chen, Y. (2023). Research progress on central autonomic nervous mechanism of acupuncture at Neiguan point in the treatment of atrial fibrillation. *Acupuncture and Herbal Medicine*, *3*(3), 149–157. https://doi.org/10.1097/HM9.0000000000000070

Kaniusas, E., Szeles, J. C., Kampusch, S., Alfageme-Lopez, N., Yucuma-Conde, D., Li, X., Mayol, J., Neumayer, C., Papa, M., & Panetsos, F. (2020). Non-invasive auricular vagus nerve stimulation as a potential treatment for covid19-originated acute respiratory distress syndrome. *Frontiers in Physiology*, *11*. https://doi.org/10.3389/fphys.2020.00890

Karemaker, J. M. (2022). The multibranched nerve: Vagal functions beyond heart rate variability. *Biological Psychology*, *172*, 108378. https://doi.org/10.1016/j.biopsycho.2022.108378

Karim, S., Chahal, A., Khanji, M. Y., Petersen, S. E., & Somers, V. K. (2023). Autonomic cardiovascular control in health and disease. *Comprehensive Physiology*, *13*(2), 4493–4511. https://doi.org/10.1002/j.2040-4603.2023.tb00257.x

Konakoğlu, G., Özdemir, A. E., Kaya Sağlam, Ö., & Sayir, B. (2025). The effect of auricular vagus nerve stimulation on heart rate variability. *İstanbul Gelişim Üniversitesi Sağlık Bilimleri Dergisi*, *0*(26), 771–783. https://doi.org/10.38079/igusabder.1660696

Li, Y.-W., Li, W., Wang, S.-T., Gong, Y.-N., Dou, B.-M., Lyu, Z.-X., Ulloa, L., Wang, S.-J., Xu, Z.-F., & Guo, Y. (2022). The autonomic nervous system: A potential link to the efficacy of acupuncture. *Frontiers in Neuroscience*, *16*. https://doi.org/10.3389/fnins.2022.1038945

Purwanto, P., & Wahyu, J. R. (2021). Differences between effectiveness of inmas acupuncture and local points in back and shoulder pain. *Jurnal Keterapian Fisik*, 58–64. https://doi.org/10.37341/jkf.v0i0.251

Puspitaningrum, C. A. D., Purwanto, & Widyastari, S. (2025). Effectiveness of Jin's 3 Needles and INMAS acupuncture in reducing low back pain. *Jurnal Keterapian Fisik*, 63–69. https://doi.org/10.37341/jkf.v10i1.427

Rangon, C. M., Litscher, G., Bering, R., Stanton, G., Bering, A. M., Porges, S. W., & Nogier, R. (2023). Report from the 11th International Symposium on Auriculotherapy Held in Copenhagen, 8-10 September 2023 - Auriculotherapy meets the field of Psychology. *OBM Integrative and Complementary Medicine*, *08*(04), 1–28. https://doi.org/10.21926/obm.icm.2304047

Shaffer, F., Meehan, Z. M., & Zerr, C. L. (2020). A critical review of ultra-short-term heart rate variability norms research. *Frontiers in Neuroscience*, *14*. https://doi.org/10.3389/fnins.2020.594880

Shen, Y.-F., Zhu, K., Zhu, J.-L., Huang, X.-P., Chang, D.-G., You, Y.-D., & Yang, D.-D. (2024). A comprehensive review of heart rate variability as an indicator in the regulation of the autonomic nervous system by acupuncture: A bibliometric analysis. *Integrative Medicine Discovery*, *8*(0), e24014. https://doi.org/10.53388/IMD202408014

Singh, D., Kodali, P. B., Sharma, G., Sharma, H., & Nair, P. M. K. (2025). Assessing blood pressure, mental health, and hrv responses to integrated acupuncture in hypertensive patients: A pilot randomized controlled trial. *Medical Acupuncture*, *37*(6), 450–458. https://doi.org/10.1089/acu.2024.0065

Stanton, G. (2024). The Chinese ear shenmen point and the french cosmonaut point: Same or different? *OBM Integrative and Complementary Medicine*, *09*(04), 1–11. https://doi.org/10.21926/obm.icm.2404061

Su, Y., Huang, J., Sun, S., He, T., Wang, T., Fan, M., Yu, H., Yan, J., Yao, L., Xia, Y., Zhang, M., Zheng, Y., Luo, X., Zhang, Y., Lu, M., Zou, M., Liu, C., & Chen, Y. (2024). Restoring the autonomic balance in an atrial fibrillation rat model by electroacupuncture at the Neiguan Point. *Neuromodulation: Technology at the Neural Interface*, *27*(7), 1196–1207. https://doi.org/10.1016/j.neurom.2022.11.005

Valensi, P. (2021). Autonomic nervous system activity changes in patients with hypertension and overweight: Role and therapeutic implications. *Cardiovascular Diabetology*, *20*(1), 170. https://doi.org/10.1186/s12933-021-01356-w

Xin, J.-J., Dai, Q.-F., Lu, F.-Y., Zhao, Y.-X., Liu, Q., Cui, J.-J., Xu, D.-S., Bai, W.-Z., Jing, X.-H., Gao, J.-H., & Yu, X.-C. (2020). Antihypertensive and antifibrosis effects of acupuncture at PC6 acupoints in spontaneously hypertensive rats and the underlying mechanisms. *Frontiers in Physiology*, *11*. https://doi.org/10.3389/fphys.2020.00734

Ylikoski, J., Markkanen, M., Pirvola, U., Lehtimäki, J. A., Ylikoski, M., Jing, Z., Sinkkonen, S. T., & Mäkitie, A. (2020). Stress and tinnitus; transcutaneous auricular vagal nerve stimulation attenuates tinnitus-triggered stress reaction. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.570196

Yue, J., Gao, S., Chen, W., Huang, D., Zhao, X., Li, A., Li, X., Yang, G., & Zhang, Q. (2025). Acupuncture at Neiguan Acupoint (PC6) for coronary heart disease: A scoping review. *Medical Acupuncture*. https://doi.org/10.1089/acu.2024.0008