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ORIGINAL RESEARCH

The Rehabilitation Efficacy of the Novel Metronomic Breathing Technique for Gerontic Patients After Percutaneous Coronary Intervention for Acute Myocardial Infarction—A Pilot Study

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Background: The respiratory rehabilitation technique is a crucial component of early cardiac recovery in geriatric patients with acute myocardial infarction (AMI). This study primarily investigated the effectiveness of a novel respiratory rehabilitation technique, metronomic breathing (MB), on geriatric patients after percutaneous coronary intervention for AMI and compliance with home-based rehabilitation compared to traditional respiratory rehabilitation.

Methods: From June 2022 to March 2023, 75 acute myocardial infarction (AMI) patients admitted to the Shanghai Tenth People's Hospital Cardiovascular Department were consecutively enrolled. Ultimately, 46 patients completed the follow-up in this study—26 in the MB group and 20 in the control group—who underwent the novel MB technique and conventional abdominal breathing training. The primary endpoint of the study was left ventricular function measured by noninvasive hemodynamics three months after discharge. The secondary endpoints were compliance and quality of life after three months of home rehabilitation.

Results: After the intervention, several cardiac functional parameters (SV, SVI, CO, CI, LCW, and LCWI), myocardial contractility parameters (VI), and systemic vascular resistance parameters (SVR and SVRI) were significantly greater in the MB group than in the preintervention group ($P < 0.05$). Furthermore, post-treatment, the MB group exhibited greater SV, SVI, CO, CI, and VI; lower SVR, SVRI, and SBP; and a lower readmission rate three months later than did the control group. The SF-36 scores after three months of MB intervention, PE, BP, GH, VT, SF, RE, and MH, were all significantly greater than those before treatment ($P < 0.05$). Moreover, the MB group displayed greater compliance with home-based cardiac rehabilitation ($P < 0.05$).

Conclusion: Compared to conventional respiratory rehabilitation training methods, short-term metronomic respiratory therapy is more effective for reducing systemic vascular resistance, enhancing left ventricular ejection function, enhancing quality of life, and increasing home-based rehabilitation compliance in geriatric patients following AMI with PCI.

Keywords: metronomic breathing, MB, acute myocardial infarction, AMI, cardiac rehabilitation, efficacy, gerontal patients

Introduction

Acute myocardial infarction (AMI) is a common and critical cardiovascular condition in cardiology, and its incidence and mortality rates are increasing worldwide.[1,2] Patients with AMI often exhibit an imbalance in autonomic nervous system activity characterized by increased sympathetic nervous system activity and suppression of the vagus nervous system.[3] AMI gerontal patients continue to experience overactive autonomic nervous system dysfunction after percutaneous coronary intervention (PCI), increasing the risk of adverse outcomes. Therefore, early cardiac rehabilitation post-PCI is of paramount importance.

Cardiac rehabilitation can effectively reduce the risk of cardiovascular-related complications. Long-term, regular cardiac rehabilitation exercises have decreased all-cause mortality by 15–30%.[4] Respiratory rehabilitation is an integral component of cardiac rehabilitation, contributing to improving geriatric patient outcomes and mitigating complications associated with bed

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rest. It also plays a regulatory role in heart function and autonomic nerve regulatory function.[5] Conventional abdominal breathing (AB) training involves respiratory activity in specific body positions to enhance respiratory muscle function and decrease energy expenditure during breathing.[6] In recent years, a new respiratory technique called metronomic breathing (MB), which is based on the principles of music therapy and combines traditional respiratory exercises with cardiac rehabilitation, was introduced in China in 2020 by the German biophysicist Karl-Heinz Röber. Research suggests that MB can be beneficial for elderly patients with cardiopulmonary conditions, contributing to the improvement of breathing patterns, enhancement of blood oxygen saturation, and alleviation of autonomic nervous system disorders.[7–9]

However, there is relatively little clinical treatment and research on early respiratory training to improve cardiovascular function in frontal patients with AMI post-PCI. Therefore, this study strongly emphasizes the effectiveness of MB training compared to conventional AB respiratory training methods in the rehabilitation of post-PCI patients following AMI. Additionally, this study aimed to analyze geriatric patients' compliance with home-based rehabilitation.

Method

Study Design and Patients

This study is a prospective randomized controlled trial. Figure 1 depicts the follow-up research process based on the standardized trial reporting criteria.[10] The study continuously enrolled a total of 75 patients who were diagnosed with AMI post-PCI and who were scheduled to undergo early cardiac rehabilitation at the Department of Cardiology of Shanghai Tenth People's Hospital between June 2022 and March 2023. The exclusion criteria for patients were as follows: acute respiratory distress syndrome (ARDS); acute episode of COPD; uncontrolled pulmonary infection; acute heart failure; acute pulmonary embolism; acute myocarditis/pericarditis; severe arrhythmia (degree II or III atrioventricular block, atrial flutter, or atrial fibrillation); and sternotomy, rib fracture, thoracic deformity, or other neurological diseases that may affect respiratory

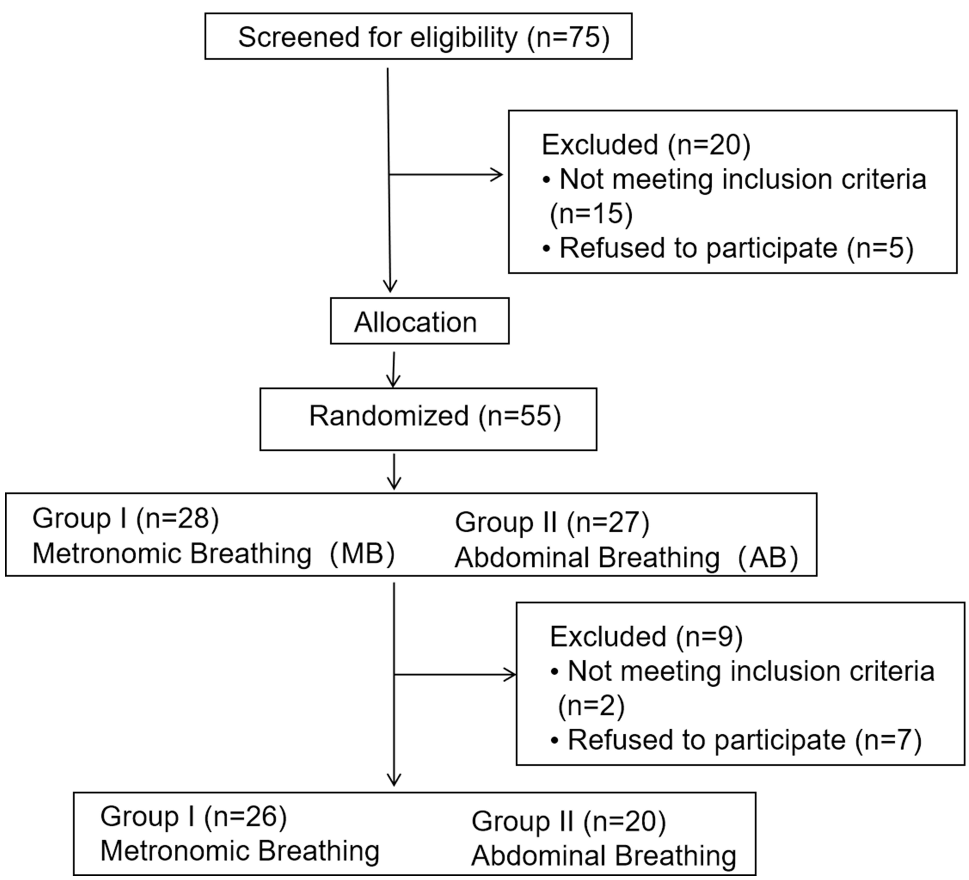

Figure 1 Patient recruitment flow chart.

muscles. Among these patients, 20 did not meet the inclusion criteria, and 5 declined to participate in the treatment. Therefore, 55 patients were included and randomly assigned to two groups. The control group received conventional AB training, while the experimental group received novel MB training. During the follow-up period, 9 patients declined further participation. Ultimately, 46 patients completed the follow-up in this study, with 26 in the MB group and 20 in the control group.

Randomization and Blinding

The randomization process was executed by a third-party statistician utilizing the random number table method. After providing informed consent, patients were randomly assigned to either the AB group or the MB group and subsequently admitted to separate wards. Prior to the commencement of the trial, all researchers underwent comprehensive training to ensure uniformity and consistency in the execution of the study procedures. The randomization process and administration of questionnaires were overseen by two physicians who were not directly involved in the trial. Furthermore, the music operators responsible for the MB group were entirely distinct from those involved in data collection and therapeutic interventions for patients in the AB group.

Abdominal Breathing Group

The control group received conventional AB training once a day, which involved guidance on pursed-lip breathing strategies and active expiration and body positioning strategies. The subjects were placed at a 45-degree incline, maintaining a straight back, with their palms facing upward, with their eyes closed, and with a focus on the breathing rhythm. They were instructed to inhale through the nose as much as possible, hold their breath for 3 seconds, and then exhale like blowing a whistle through the mouth. The breathing ratio was maintained at 1:2, and the intervention lasted 5 minutes.

Metronomic Breathing Group

In the experimental group, participants received the MB intervention once a day. The subjects were positioned at a 45-degree tilt with their backs straight, palms facing up, eyes closed, and directed to focus on their breathing. Guided by a specific musical rhythm and synchronized to a predetermined tempo, participants were instructed to inhale deeply and slowly through the nose, allowing the diaphragm to descend and the abdomen to expand. Subsequently, they were guided to elevate their collarbones to expand the ribcage, adjusting the inhalation duration until the lungs were fully inflated. This process was repeated with a rhythm of five seconds of nasal inhalation followed by five seconds of oral exhalation, constituting the therapeutic intervention for the last 5 minutes of the session.

Clinical Variable Data Collection

Data were collected for clinical analysis according to the data presented in hospital records. Blood samples and echocardiographic variables were collected within 12 hours of admission.

Noninvasive Hemodynamic Monitoring

Noninvasive hemodynamic monitoring was performed using the BioZ-2011 bioimpedance hemodynamic monitoring device manufactured by Medean Medical Equipment Co., Ltd., in Shenzhen, China.[11] The monitor used a 70 kHz and 2.5 mA current via the tetrapolar system of four signal sensors, two of which were placed in the neck above the bilateral clavicle, and the other two sensors were placed in the bilateral chest in the plane of the xiphoid tip. Each pair of sensors was 180° apart at the top and bottom of the thorax. As the current passed through the external electrode of each sensor, the sensor was connected to the chest for axial voltage measurements. This algorithm allows the calculation of hemodynamic parameters based on changes in aortic blood volume and flow velocity, resulting in changes in thoracic bioimpedance.[12] These parameters included the stroke volume (SV), stroke volume index (SVI), cardiac output (CO), cardiac output index (CI), left cardiac work (LCW), left cardiac work index (LCMI), acceleration index (ACI), velocity index (VI), systemic vascular resistance (SVR), systemic vascular resistance index (SVRI), heart rate (HR), and on-demand measurements of systolic blood pressure (SBP) and diastolic blood pressure (DBP).

Follow-Up and Outcomes

The primary endpoint of the study was left ventricular function measured by noninvasive hemodynamics three months after discharge. The secondary endpoints were compliance and quality of life after three months of home rehabilitation. The initial noninvasive hemodynamic measurements and SF-36 questionnaire assessments were subsequently conducted in AMI patients following PCI after receiving AB and MB respiratory rehabilitation interventions during hospitalization and continuing with home-based rehabilitation postdischarge. The rehabilitation intervention was administered at least five days a week, with each session lasting five minutes, and the treatment course spanned three months (13 weeks). Patients were followed up three months later, during which a second round of noninvasive hemodynamic measurements and SF-36 assessments were conducted during outpatient visits.

Compliance with Home Rehabilitation

In this study, patients were required to upload daily videos or pictures to their accounts as part of their home rehabilitation regimen. Compliance with home rehabilitation was defined as uploading data on 80% or more of the planned intervention days, with a minimum of 52 sessions. A patient's family rehabilitation compliance was considered poor if it was recorded for fewer than 52 days, indicating incomplete treatment. Conversely, if the patient completed 52 days or more, the patient was deemed to have good home rehabilitation compliance, reflecting adherence to the treatment plan. At the end of the study, the number of people who had completed rehabilitation at home was counted.

Data Analysis

In this pilot study, normality and homogeneity of variance in the dataset were evaluated utilizing either the Kolmogorov–Smirnov test or the Shapiro–Wilk test. Continuous variables were summarized using descriptive statistics, specifically reporting the mean along with its corresponding standard deviation (mean ± SD). Group comparisons between the experimental and control cohorts were conducted employing Student's t test, considering the assumption of normally distributed data. The paired-sample t test was utilized, enabling comparisons before and after intervention within each group. Categorical variables within both the experimental and control groups are expressed as frequencies and percentages (n (%)) and were subjected to the chi-square test for analysis. A P value < 0.05 was considered to indicate statistical significance. Statistical analysis was conducted using SPSS version 20.0.

Results

Participant Baseline Characteristics

Table 1 summarizes the baseline parameters and clinical indicators for the two groups of patients. The mean age of the patients was 60.12±12.10 years in the MB group and 62.30±10.71 years in the control group. There were no significant differences (P > 0.05) observed between the MB group and the control group in terms of cardiovascular disease-related risk factors (drinking, smoking, hypertension, CKD, diabetes mellitus), cardiac ultrasound indicators (LVDD, LVDS, LVEF), medication use (aspirin, statins, ACEI/ARB, CCB, β-blockers) or blood biochemical indicators (ALT, creatinine, CHOL, TG, HDL-C, LDL, TnT, CKMB, BNP). Table 2 shows the baseline hemodynamic parameters and the SF-36 score. Similarly, there were no significant differences in the hemodynamic parameters (SV, SVI, CO, CI, VI, ACI, TFC, SVR, SVRI, LCW, and LCWI) or quality of life (SF-36 score) between the two groups before treatment. The above results indicate no significant baseline heterogeneity among the enrolled patients.

Comparison of Hemodynamic Indices Before and After Surgery in the Two Groups

Table 3 displays the changes in the hemodynamic parameters before and after the intervention in the two groups of patients. Posttreatment cardiac function parameters (SV, SVI, CO, CI, LCW, and LCWI), myocardial contractility parameters (VI), and systemic vascular resistance parameters (SVR and SVRI) were greater in the MB group than in the preintervention group. These differences were statistically significant (P < 0.05). Blood pressure and heart rate did not significantly differ among the

Table 1 Baseline Characteristics of All Patients

Variables	MB	Control	*P*
Number	26	20	
Age, years	60.12±12.10	62.30±10.71	0.527
Male			
Man(%)	20 (76.9)	15 (75.0)	0.880
Blood pressure			
SBP	123.08±20.20	126.80±18.29	0.522
DBP	71.19±10.33	70.60±12.63	0.862
H.R.	72.31±10.03	71.75±10.06	0.853
BMI	25.93±4.05	26.05±2.89	0.909
Risk factors			
Drinking(%)	3 (11.5)	2 (10.0)	0.868
Smoking(%)	19 (73.1)	14 (70.0)	0.819
Hypertension(%)	19 (73.1)	17 (85.0)	0.324
CKD(%)	5 (19.2)	2 (10.0)	0.379
Diabetes mellitus(%)	17 (65.4)	14 (70.0)	0.740
Echocardiogram			
LVDD	46.81±5.52	46.20±5.49	0.712
LVDS	31.27±6.64	31.10±5.78	0.928
LVEF	52.58±8.96	48.90±9.11	0.178
Biochemical			
ALT(U/L)	29.75±16.66	31.69±18.59	0.712
Creatinine(umol/L)	81.27±39.82	75.67±25.19	0.585
CHOL (mmol/L)	4.88±1.20	4.25±0.88	0.056
TG (mmol/L)	2.11±1.22	1.81±0.84	0.352
HDL-C (mmol/L)	0.94±0.15	0.83±0.14	0.011
LDL (mmol/L)	3.10±1.00	2.76±0.85	0.223
HS-TNT (ng/mL)	1.01±2.15	1.59±2.46	0.401
CKMB (U/L)	33.52±48.38	57.64±81.22	0.249
BNP (pg/mL)	1519.82±1874.04	952.78±998.60	0.227
Medications			
Aspirin(%)	24 (92.3)	19 (95.0)	0.711
Statins(%)	23 (88.5)	17 (85.0)	0.731
ACEI/ARB(%)	18 (69.2)	11 (55.0)	0.322
CCB(%)	2 (7.7)	1 (5.0)	0.711
β-Blocker(%)	21 (80.8)	12 (60.0)	0.121

Notes: Continuous variables were expressed as mean ± standard deviation (SD) and compared using Student's *t*-test. Categorical variables were expressed as frequencies and percentages (n (%)) and subjected to the chi-square test for analysis. P-value < 0.05 was considered statistically significant.

Abbreviations: SBP, Systolic blood pressure; DBP, Diastolic blood pressure; HR, Heart rate; CKD, Chronic kidney disease; LVDD, Left ventricular end-diastolic dimension; LVDS, Left ventricular end-systolic dimension LVEF, Left ventricular ejection fraction ALT, Alanine aminotransferase Chol, Cholesterol TG, Triglyceride; ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin II receptor blocker.

groups. On the other hand, compared to the MB group, the control group showed some improvements in hemodynamic parameters before and after the intervention. However, these differences were not statistically significant (P > 0.05).

Comparison of Treatment Effects Between the Two Groups After Three Months

Compared with the control group, after the intervention, the MB group exhibited significant increases in SV, SVI, CO, CI, and VI (Figure 2A-D and G) and significant decreases in SVR, SVRI, and SBP (Figure 2I-K) (P < 0.05). Although the MB group

Table 2 Baseline Parameters of Hemodynamics and SF-36 Scores

Variables	MB	Control	*P*
Number	26	20	
Hemodynamics			
SV	63.31±14.05	60.5±18.24	0.590
SVI	34.08±6.31	33.65±9.09	0.852
CO	4.52±0.89	4.23±1.08	0.318
CI	2.43±0.36	2.36±0.57	0.588
VI	39.62±10.31	40.05±15.64	0.910
ACI	74.88±21.69	69.95±30.83	0.527
SVR	1441.81±369.35	1581.70±452.36	0.254
SVRI	2658.08±632.42	2816.50±752.09	0.442
LCW	5.26±1.44	5.03±1.76	0.624
LCWI	2.81±0.57	2.79±0.92	0.927
The SF-36 scores			
PF	37.88±8.62	39.50±7.05	0.500
RP	60.58±14.44	61.25±15.12	0.879
BP	49.19±9.32	46.60±7.70	0.319
GH	51.27±6.60	51.30±8.49	0.989
VT	58.27±7.61	60.00±7.07	0.435
SF	56.73±8.83	60.63±13.00	0.258
RE	61.49±22.50	63.28±21.36	0.786
MH	58.62±8.31	58.85±7.62	0.922

Notes: Continuous variables were expressed as mean ± standard deviation (SD) and compared using Student's *t*-test. P-value < 0.05 was considered statistically significant.
Abbreviations: SV, Stroke volume; SVI, Stroke volume index; CO, Cardiac output; CI, Cardiac output index; LCW, Left Cardiac Work; LCMI, Left Cardiac Work index; ACI, Acceleration index; VI, Velocity index; SVR, Systemic Vascular Resistance; SVRI, Systemic Vascular Resistance index; SBP, Systolic blood pressure; DBP, Diastolic blood pressure; HR, Heart rate; PF, Physical Functioning; RP, Role-Physical; BP, Bodily Pain; GH, General Health; VT, Vitality; SF, Social Functioning; RE, Role-Emotional; MH, Mental Health.

Table 3 Comparison of Hemodynamic Indices Before and After in Two Groups

Variable	MB Group		*P*	Control Group		*P*
	Pre-Treatment	Post-Treatment		Pre-Treatment	Post-Treatment	
SV	63.31±14.05	74.73±13.77	0.005	60.5±18.24	62.95±17.62	0.668
SVI	34.08±6.31	40.19±5.91	0.001	33.65±9.09	35.05±8.90	0.625
CO	4.52±0.89	5.25±1.02	0.008	4.23±1.08	4.40±1.09	0.604
CI	2.43±0.36	2.82±0.43	0.001	2.36±0.57	2.46±0.55	0.576
VI	39.62±10.31	49.65±13.39	0.004	40.05±15.64	40.25±1.54	0.966
ACI	74.88±21.69	88.08±26.14	0.053	69.95±30.83	74.00±28.30	0.668
SVR	1441.81±369.35	1234.35±288.43	0.028	1581.70±452.36	1510.70±393.09	0.599
SVRI	2658.08±632.42	2278.96±506.07	0.021	2816.50±752.09	2688.15±647.44	0.564
LCW	5.26±1.44	6.13±1.64	0.013	5.03±1.76	5.20±1.79	0.757
LCWI	2.81±0.57	3.27±0.70	0.014	2.79±0.92	2.90±0.91	0.707
SBP	123.08±20.20	115.92±15.16	0.155	126.80±18.29	126.40±16.14	0.942
DBP	71.19±10.33	68.96±8.46	0.398	70.60±12.63	69.70±9.74	0.802
HR	72.31±10.03	70.92±10.44	0.628	71.75±10.06	71.30±9.73	0.886

Notes: Paired t-tests were used pre and post treatment. Data are expressed as Mean ± SD. P-value < 0.05 was considered statistically significant.

had greater LCW, LCWI, and ACI, no significant differences were detected (P > 0.05) (Figure 2E, F and H). Furthermore, there were no significant changes in HR or DBP for either group of patients after the intervention (Figure 2L and M).

Comparison of Compliance and Readmission Results After Three Months in the Two Groups

The follow-up methods are discussed in detail in the Methods section. Compared to those in the control group, patients in the MB group were more likely to engage in home-based cardiac rehabilitation and exhibited better compliance, and these differences were statistically significant (P = 0.046). There were no significant differences in the number of hospital readmissions within three months for the patients (P = 0.220). (Supplementary Table 1).

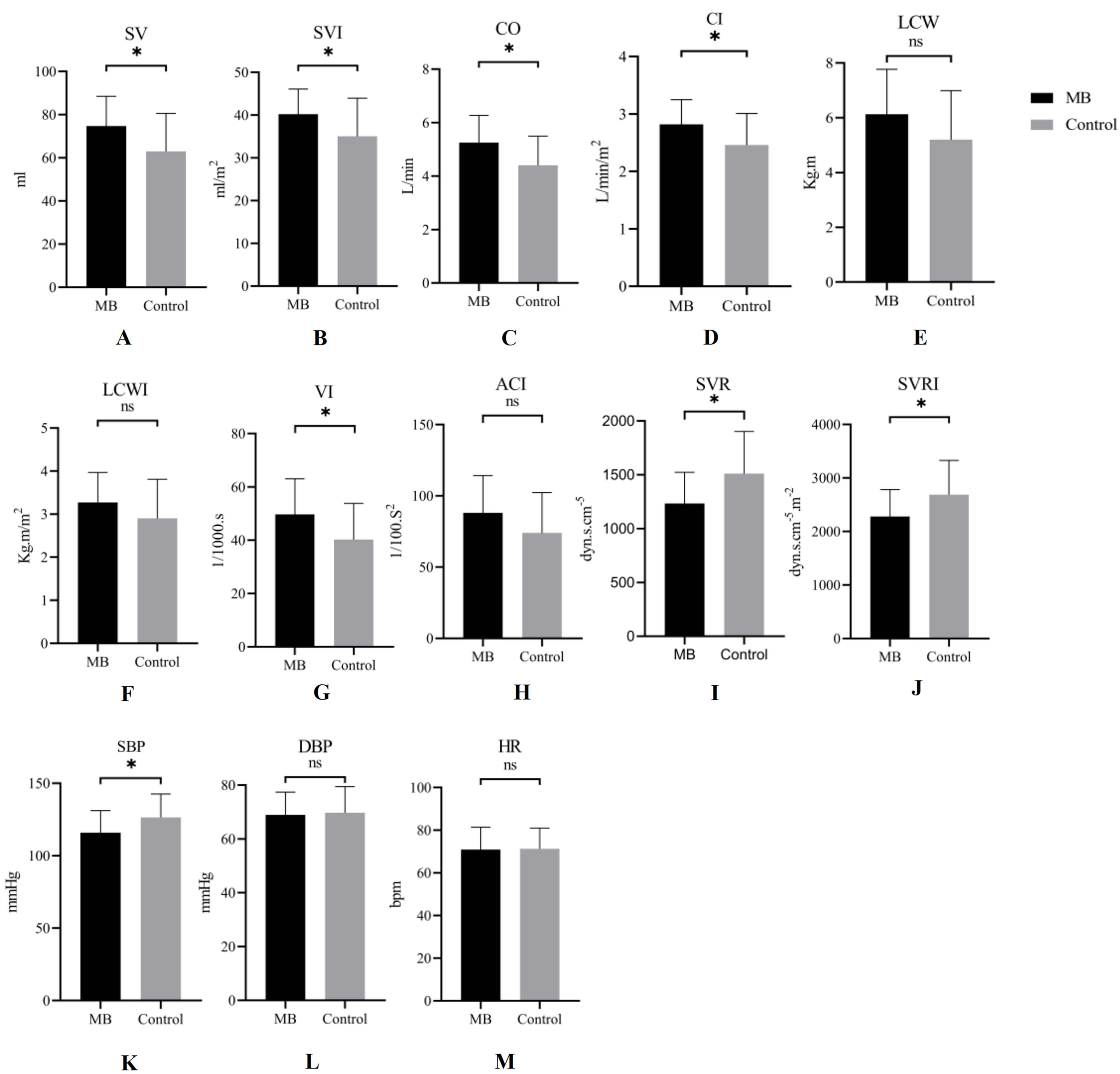

Figure 2 Comparison of treatment effects between the two groups after three months. Compared to the control group, the MB group exhibited significant increases in SV, SVI, CO, CI, and VI (**A-D** and **G**) and significant decreases in SVR, SVRI, and SBP (**I-K**) (P < 0.05). Although the MB group had greater LCW, LCWI, and ACI, no significant differences were detected (P > 0.05) (**E, F** and **H**). Furthermore, there were no significant changes in HR or DBP for either group of patients after the intervention (**L** and **M**). The data are expressed as the mean ± SD. *: P < 0.05, Ns: P > 0.05.

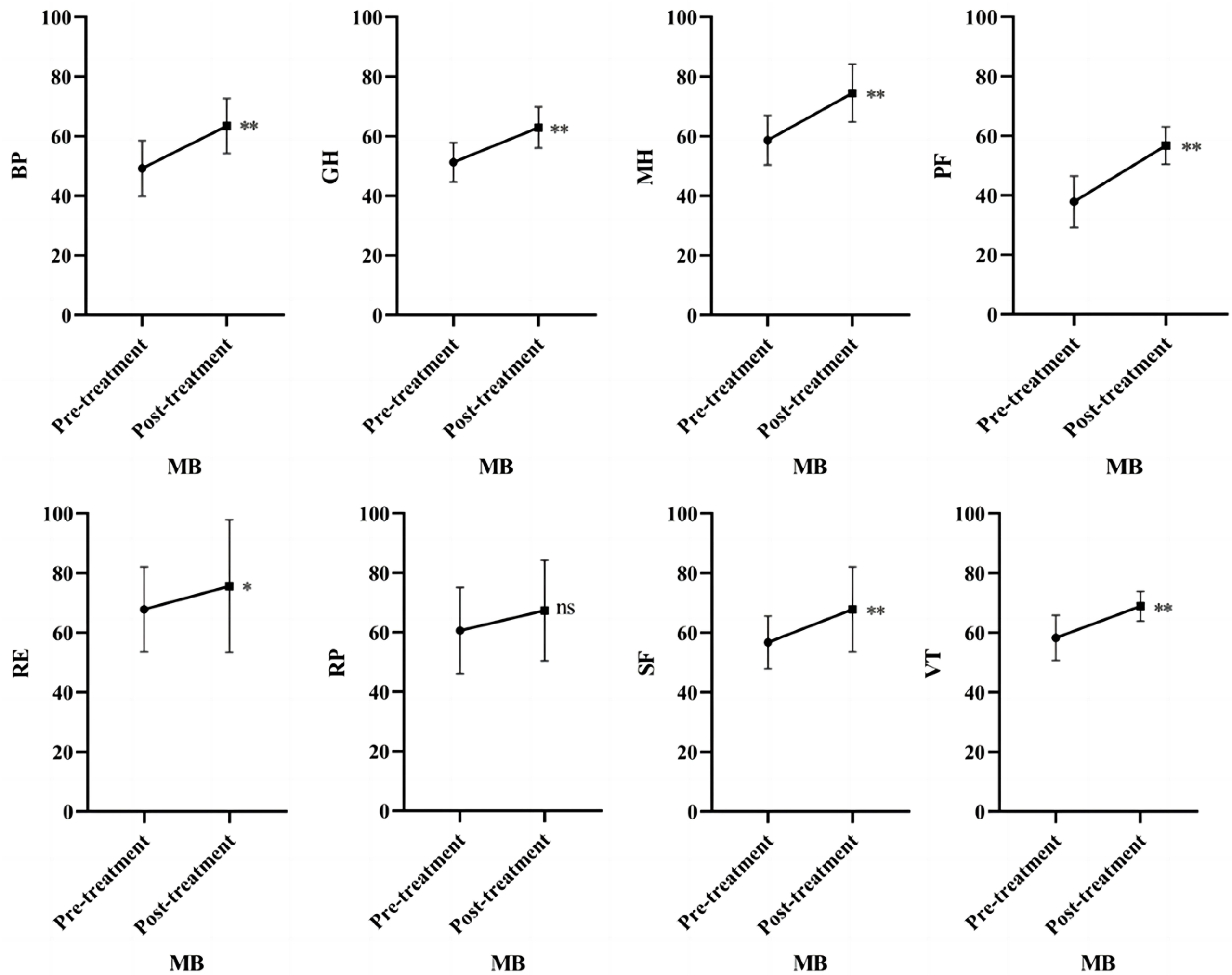

Figure 3 Comparison of SF-36 scores after three months in the MB group. SF-36 scores after three months of MB rehabilitation intervention, PF, BP, GH, VT, SF, RE, and MH, were all significantly greater than those before treatment (P <0.05) (Figure 3). Although the SF-36 score increased more in the RP group than in the pretreatment group, the difference was not statistically significant (P> 0.05) (Figure 3). The data are expressed as the means ± SDs. *: P < 0.05, **: P < 0.005, Ns: P > 0.05.

Comparison of Quality of Life (SF-36 Score) After Three Months in the MB Group

The SF-36 score was used to assess the impact of patients on their quality of life through a 3-month home-measured MB rehabilitation intervention (Figure 3). The results showed that the quality of life of the MB group improved significantly after three months of MB rehabilitation intervention. SF-36 scores after three months of MB rehabilitation intervention, PF, BP, GH, VT, SF, RE, and MH, were all significantly greater than those before treatment. P <0.001 vs P <0.001 vs P = 0.002 vs P <0.001 vs P = 0.001 vs P = 0.027 vs P <0.001. Although RP increased more after treatment than before treatment, the difference was not significant (P=0.13).

Discussion

Our study demonstrated that novel cardiac rehabilitation training using the MB technique significantly improved left ventricular function and hemodynamic parameters in geriatric patients post-PCI for AMI. Furthermore, the MB technique shows superior therapeutic effects compared to traditional conventional AB exercises. Gerontal patients exhibit better compliance with home-based treatment and improved quality of life and physical functioning after discharge.

Respiratory rehabilitation is an essential component of cardiac rehabilitation for geriatric patients.[6] Ischemic heart disease can lead to decreased sensitivity to pressure reflexes and excessive sympathetic nervous system activity in patients while inhibiting parasympathetic nervous system activity.[13] Respiratory movements can induce optimal activation of the parasympathetic nervous system through stimulation of the Hering–Breuer reflex, which can reduce the respiratory rate[14] and improve cardiac vagal tone.[15] MB is a novel approach to cardiac rehabilitation that has evolved from music therapy.[16] Music therapy can effectively relieve gerontic patients' anxiety and reduce their respiratory rate. MB involves using the respiratory system to influence the cardiovascular system's performance. During inhalation, increased venous and lymphatic return enhances ventricular filling, leading to heightened myocardial contractility.

This study revealed that MB therapy resulted in significant improvements in various geriatric patient cardiac function parameters (SV, SVI, CO, CI, LCW, and LCWI), myocardial contractility parameters (VI), and systemic vascular resistance parameters (SVR and SVRI) after treatment. These improvements influence the left ventricular end-diastolic volume, myocardial contractility, and heart rate. Myocardial injury and ischemia trigger sympathetic input, increasing oxygen consumption and the risk of ventricular arrhythmia. In this context, MB training balances autonomic nervous system function by activating the parasympathetic nervous system.[17] It has a positive effect on the effects of the heart itself. Numerous studies have also shown that MB safeguards the cardiovascular health of geriatric patients and enhances physical vitality.[18,19] The same experimental results were found by Damisela et al and Jones et al[20,21] The blood pressure and respiratory reflexes induced by MBs have a profound effect on peripheral vascular resistance. Studies have shown that MB significantly lowers systolic and diastolic blood pressure in hypertensive patients.[22] This is particularly true in the young hypertensive population.[23] However, this study revealed no significant changes in patient heart rate or blood pressure with MB, which may be attributed to respiratory training requiring long-term adherence to improve patient blood pressure slowly.[24]

MB offers significant advantages over traditional AB training. Studies indicate that while AB interventions often require longer periods and staged instructions for benefits,[25] MB therapy is more effective in the short term. Additionally, music-guided MB rhythmic breathing exercises increase vagal tone reflexes, reducing premature ventricular contractions (PVCs) and contributing to cardiac function restoration and hemodynamic stability.[26] This therapy helps establish synchronized autonomous breathing rhythms, aiding long-term cardiopulmonary rehabilitation in gerontal patients.[27] Moreover, music helps alleviate treatment fears and improves adherence to home rehabilitation plans,[28,29] resulting in higher compliance rates in the MB group than in the control group.

A large number of studies have shown that gerontal patients with cardiovascular diseases generally have a decline in quality of life.[30] We used the SF-36 scale to assess quality of life early after and three months after discharge.[31,32] Related studies have shown that patients with cardiovascular disease have different degrees of health decline in all eight dimensions.[33] Regular MB helps patients with cardiovascular disease in all fields achieve corresponding improvements[33] and improve their quality of life.[34,35] Our results also revealed that three months of home MB can more effectively improve quality of life in terms of physical functioning.

However, this study has certain limitations. First, this study's relatively small overall sample size and single-center design require further research with larger and multicenter studies to validate our experimental results. Second, considering the different coronary artery narrowing and severity in post-PCI patients with AMI, future experiments should include more subgroups for a detailed analysis of the patient population and treatment effects of MB. The third limitation is that noninvasive hemodynamic monitoring, as a noninvasive assessment method, inherently carries unavoidable systematic errors. There is a lack of precision and specificity for detecting subtle differences between the MB and AB groups accurately. Therefore, in subsequent experiments, we plan to incorporate invasive hemodynamic monitoring methods to validate the results, ensuring greater authenticity and accuracy of the experimental outcomes.

Conclusion

Our research has demonstrated that MB is more effective than conventional voluntary deep breathing exercises in improving systemic vascular resistance, enhancing hemodynamics, increasing left ventricular ejection function, enhancing quality of life and improving compliance with home-based rehabilitation in post-PCI gerontal patients with AMI. The significant potential of MB could serve as a practical approach to expand cardiac rehabilitation therapies for early post-PCI recovery, promoting functional recovery and overall well-being in gerontal patients with AMI.

Data Sharing Statement

The raw data supporting the conclusions of this article will be made available by the authors without undue reservation.

Ethics Statement

This study was registered at ClinicalTrials.gov (NCT NCT05935436), approved by the local ethics committee of Shanghai Tenth People's Hospital, and conformed to the Declaration of Helsinki and its later amendments.

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Author Contributions

All authors contributed significantly to the study conception, study design, data acquisition, analysis and interpretation, and drafting of the article. The authors participated in revising and critically reviewing the article and provided final approval of the version to be published. All authors have agreed on the journal submission and have committed to being accountable for all aspects of the work.

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Disclosure

The authors declare that the research was conducted without any commercial or financial relationships that could be construed as potential conflicts of interest.

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