RESEARCH PAPER

Feasibility and Effectiveness of a Multicomponent Exercise Program in Rural Post–Coronary Artery Bypass Grafting Patients

Dr.Chandrakant Babaso Patil [1*], Dr.V.C.Patil [2]

[1]PhD Scholar, Associate Professor, Krishna College of Physiotherapy, Krishna Vishwa Vidyapeeth, Deemed to be University, Karad, 415110

[2] Professor, Krishna Institute of Medical Sciences, Krishna Vishwa Vidyapeeth, Deemed to be University, Karad, 415110

***Corresponding Author:** Dr.Chandrakant Babaso Patil

*Associate Professor, Krishna College of Physiotherapy, Krishna Vishwa Vidyapeeth, Deemed to be University, Karad.

Mail id:chandupatil69@gmail.com.

Abstract

Background: Participation in cardiac rehabilitation (CR) after coronary artery bypass grafting (CABG) is associated with reduced morbidity and mortality [1, 2]. However, uptake in rural populations remains low due to access barriers [10]. Pragmatic, low-cost, multicomponent exercise programs may improve reach and outcomes in these settings.

Objective: To determine the feasibility and effectiveness of an 8-week multicomponent exercise program on physiological outcomes in rural post-CABG patients.

Methods: In this parallel-group randomized controlled trial, 40 clinically stable adults enrolled between postoperative day 3 to day 15 following CABG from rural communities were randomized (1:1) to a multicomponent exercise program (intervention) or conventional CR (control). Feasibility outcomes included recruitment, retention, adherence, and adverse events. Effectiveness outcomes were systolic blood pressure (SBP), diastolic blood pressure (DBP), and resting respiratory rate (RR). Analyses included paired t-tests (within-group), independent t-tests (between-group), and ANCOVA adjusting for baseline values. Effect sizes (Cohen's d) and 95% confidence intervals (CI) were reported. Significance was set at $p < 0.05$.

Results: Recruitment was 83.3% (40/48), retention 95% (38/40), and adherence 88.5% ± 5.2, with no major adverse events. After adjustment, the intervention produced greater reductions than control in SBP (adjusted mean difference −9.5 mmHg; 95% CI −14.2 to −4.8; $p < 0.001$; $d = 0.85$), DBP (−7.2 mmHg; 95% CI −10.5 to −3.9; $p < 0.001$; $d = 0.78$), and RR (−2.8 breaths/min; 95% CI −4.1 to −1.5; $p = 0.002$; $d = 0.65$).

Conclusion: A multicomponent exercise program is feasible, safe, and clinically effective for improving physiological parameters in rural post-CABG patients, supporting its use as an accessible CR model.

Keywords: CABG; cardiac rehabilitation; multicomponent exercise; rural health; feasibility; blood pressure; respiratory rate

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INTRODUCTION

Coronary artery bypass grafting (CABG) remains a cornerstone intervention for advanced coronary artery disease, improving survival and symptoms. Postoperative recovery, however, depends substantially on participation in cardiac rehabilitation (CR), which combines exercise training, risk factor modification, and education [1–3]. Exercise-based CR reduces cardiovascular mortality and hospital readmissions and improves functional capacity and quality of life [1, 2.8.17]. Despite strong guideline recommendations, CR participation is suboptimal, particularly in rural settings [10, 15, 18]. Structural barriers—including limited program availability, transportation constraints, financial costs, and reduced awareness—contribute to low uptake and adherence [10]. Consequently, there is a pressing need for pragmatic, scalable CR models that can be delivered within community or home environments [4, 15]. Multicomponent exercise programs (aerobic, resistance, flexibility, and balance training) provide comprehensive physiological benefits and can be tailored to low-resource contexts [6, 7, 19, 20]. While evidence supports their efficacy in urban or center-based CR, data on feasibility and effectiveness in rural post-CABG populations are limited. Importantly, feasibility—encompassing recruitment, adherence, retention, and safety—is critical for real-world implementation. This trial therefore aimed to evaluate both feasibility and effectiveness of a structured multicomponent exercise program in rural post-CABG patients.

MATERIALS AND METHODS

A prospective, parallel-group randomized controlled trial was conducted over 8 weeks in rural community and primary care settings to maximize ecological validity. Adults aged 40–75 years, 4–12 weeks post CABG, clinically stable, and cleared for exercise were eligible. Exclusion criteria included unstable angina, uncontrolled arrhythmias, severe musculoskeletal or

*Author for Correspondence: chandupatil69@gmail.com

neurological limitations, and cognitive impairment. A sample of 40 (20/group) was estimated to detect a moderate between-group effect (d≈0.7) with 80% power and α=0.05, allowing for ~10% attrition. Participants were randomized (computer-generated sequence) with allocation concealment via sealed opaque envelopes. Outcome assessors were blinded to group allocation.

Intervention (Multicomponent Program): Aerobic walking: 20–30 min/session, 5 days/week, moderate intensity (Borg RPE 11–13), Resistance training: 2–3 sets of 10–15 repetitions for major muscle groups (elastic bands/bodyweight), Flexibility: static stretching of major muscle groups, Balance: tandem stance, single-leg stance, functional reach tasks. The intervention was initiated on postoperative day 3 and continued until postoperative day 15, resulting in a total intervention duration of 13 days. Progression was individualized weekly based on tolerance.

Control (Conventional CR): Breathing exercises, light mobility, and general walking advice without structured progression. Such multicomponent exercise protocols are consistent with established cardiac rehabilitation guidelines [6, 21]. This early intervention corresponds to Phase I cardiac rehabilitation and focuses on early mobilization and prevention of postoperative complications

OUTCOMES AND MEASUREMENTS:

Feasibility Outcomes: Feasibility of the intervention was assessed using the following parameters:

- Recruitment rate**:** 83.3% (40/48 eligible participants enrolled)
- Retention rate**:** 95% (38/40 participants completed the study)
- Adherence rate**:** 88.5% ± 5.2 (percentage of sessions attended)
- Adverse events**:** No major cardiovascular or musculoskeletal adverse events were reported during the intervention period

Effectiveness: Systolic blood pressure (SBP) and diastolic blood pressure (DBP) (mmHg) were measured using a calibrated sphygmomanometer after a 10-minute seated rest, with the average of two consecutive readings recorded. Resting respiratory rate (RR) (breaths/min) was measured over a 60-second period. Assessments were performed at baseline (postoperative day 3) and at the end of the intervention period (postoperative day 15)**.**

STATISTICAL ANALYSIS:

Data normality was assessed using Shapiro–Wilk tests. Continuous variables are presented as mean ± SD. Within-group changes were analyzed using paired t-tests; between-group differences using independent t-tests. ANCOVA compared post-intervention outcomes with baseline values as covariates. Effect sizes (Cohen's d) and 95% CIs were calculated. Analyses were conducted in IBM SPSS Statistics. Significance was set at $p < 0.05$.

RESULTS:

Participant Flow and Baseline Characteristics

Table 1: Baseline Demographic and Clinical Characteristics

Variable	Intervention Group (n = 20)	Control Group (n = 20)	p-value
Age (years)	58.4 ± 6.2	57.9 ± 5.8	0.78
Gender (Male/Female)	14 / 6	13 / 7	0.74
Time Since Surgery (days)	8.4 ± 3.1	8.1 ± 3.3	0.82
BMI (kg/m²)	26.1 ± 3.2	25.8 ± 3.0	0.69
SBP (mmHg)	140 ± 8	138 ± 7	0.41
DBP (mmHg)	90 ± 5	88 ± 6	0.36
Respiratory Rate (breaths/min)	20 ± 2	19 ± 2	0.28

Baseline demographic and clinical characteristics of participants are presented in Table 1. Participants were recruited during the early postoperative phase, with a mean time since surgery of approximately 8 days in both groups. There were no statistically significant differences between the intervention and control groups with respect to age, gender distribution, time since surgery, body mass index, systolic blood pressure, diastolic blood pressure, and respiratory rate ($p > 0.05$ for all variables), indicating successful randomization and baseline comparability between groups.

Feasibility Outcomes: Recruitment was 83.3%. Adherence to the intervention averaged 88.5% ± 5.2. Retention was 95%. No major cardiovascular or musculoskeletal adverse events occurred, indicating good acceptability and safety.

Effectiveness Outcomes:

Table 2: Outcome Measures Pre and Post Intervention.

Variable	Group	Pre (Mean ± SD)	Post (Mean ± SD)	Adjusted Mean Difference	95% CI	p-value	Effect Size (d)
SBP (mmHg)	Intervention	140 ± 8	125 ± 6	−9.5	(−14.2, −4.8)	<0.001	0.85
SBP (mmHg)	Control	138 ± 7	134 ± 7	—	—	—	—

DBP (mmHg)	Intervention	90 ± 5	80 ± 4	−7.2	(−10.5, −3.9)	<0.001	0.78
DBP (mmHg)	Control	88 ± 6	86 ± 5	—	—	—	—
RR (breaths/min)	Intervention	20 ± 2	16 ± 2	−2.8	(−4.1, −1.5)	0.002	0.65
RR (breaths/min)	Control	19 ± 2	18 ± 2	—	—	—	—

Within-Group Changes

In the intervention group, statistically significant improvements were observed across all physiological parameters following the 8-week multicomponent exercise program. Specifically, systolic blood pressure (SBP), diastolic blood pressure (DBP), and respiratory rate (RR) demonstrated significant reductions ($p < 0.001$ for all), indicating substantial physiological adaptation to the exercise intervention. In contrast, the control group showed minimal changes in SBP, DBP, and RR, none of which reached statistical significance ($p > 0.05$). This suggests that conventional rehabilitation alone was insufficient to produce meaningful physiological improvements within the study duration.

Between-Group Comparison (ANCOVA)

1. Systolic Blood Pressure (SBP): The intervention group demonstrated a significant reduction in SBP from 140 ± 8 mmHg to 125 ± 6 mmHg, with an adjusted mean difference of −9.5 mmHg (95% CI: −14.2 to −4.8; $p < 0.001$).This reduction is both statistically significant and clinically meaningful, as even a 10 mmHg decrease in SBP has been associated with a substantial reduction in cardiovascular morbidity and mortality [12,22].The large effect size (d = 0.85) indicates that the intervention had a strong impact, likely due to improved vascular function, reduced peripheral resistance, and enhanced autonomic regulation resulting from regular aerobic and resistance training. In comparison, the control group showed only a minor reduction (−4 mmHg), which was not statistically significant.

2. Diastolic Blood Pressure (DBP): A significant reduction in DBP was observed in the intervention group, decreasing from 90 ± 5 mmHg to 80 ± 4 mmHg, with an adjusted mean difference of −7.2 mmHg (95% CI: −10.5 to −3.9; $p < 0.001$). This improvement reflects enhanced arterial compliance and reduced vascular resistance, commonly associated with regular exercise training. The effect size (d = 0.78) indicates a moderate to large effect, confirming that the multicomponent exercise program was effective in improving diastolic blood pressure control. The control group exhibited only a minimal and non-significant reduction, suggesting limited physiological adaptation in the absence of structured exercise progression.

3. Respiratory Rate (RR): The intervention group showed a significant reduction in respiratory rate from 20 ± 2 to 16 ± 2 breaths/min, with an adjusted mean difference of −2.8 breaths/min (95% CI: −4.1 to −1.5; $p = 0.002$). This reduction indicates improved cardiorespiratory efficiency, likely due to enhanced oxygen utilization, improved respiratory muscle function, and reduced work of breathing. The moderate effect size (d = 0.65) suggests a meaningful physiological improvement. In contrast, the control group demonstrated only a slight, non-significant change, further highlighting the effectiveness of the structured exercise intervention.

Overall Interpretation

The ANCOVA-adjusted analysis confirms that the multicomponent exercise program resulted in significantly greater improvements in all measured physiological parameters compared to conventional rehabilitation. The observed moderate to large effect sizes indicate that the intervention was not only statistically effective but also clinically impactful, supporting its use in post-CABG rehabilitation.

Clinical Significance

The reduction in systolic blood pressure (~10 mmHg) is particularly important, as it is associated with a significant decrease in cardiovascular risk, including reduced incidence of stroke and myocardial infarction [12, 22]. Additionally, the improvement in respiratory rate reflects enhanced ventilatory efficiency and cardiopulmonary recovery, which are essential components of functional rehabilitation in post-CABG patients [13, 23].

DISCUSSION

This randomized trial demonstrates that a community-deliverable multicomponent exercise program is both feasible and effective for rural post CABG patients. High adherence and retention suggest strong acceptability despite typical rural barriers, supporting the practicality of this model [4, 9, 10, 15, 18]**.**

Comparison with existing literature: The magnitude of blood pressure reduction observed in this study is consistent with prior meta-analyses demonstrating that structured exercise training yields clinically significant reductions in SBP and DBP in cardiac populations [1, 2, 12, 17]**.** Exercise-based CR has also been shown to reduce cardiovascular mortality and hospitalizations [1, 2, 8]**,** reinforcing the clinical relevance of the present findings. Our results extend this evidence specifically to rural populations, where data remain limited [18]**.**

Physiological mechanisms: The improvements in SBP and DBP may be attributed to enhanced endothelial function, increased nitric oxide bioavailability, improved arterial compliance, and reduced sympathetic activity following regular aerobic and resistance exercise [12, 24]. Resistance training contributes to peripheral muscle strength and improved metabolic efficiency, while aerobic exercise enhances stroke volume and cardiac output [19, 20]**.** The observed

reduction in RR likely reflects improved ventilatory efficiency, respiratory muscle conditioning, and reduced work of breathing, consistent with pulmonary rehabilitation principles [13, 23].

Feasibility and implementation relevance: Feasibility outcomes in this study were particularly strong, with adherence approaching 90% and minimal attrition. These findings are important given the well-documented barriers to CR participation in rural settings, including travel distance and lack of facilities [10, 18]. The use of a simple, low-cost, home- or community-based program likely contributed to high adherence, aligning with evidence supporting home-based CR as an effective alternative to center-based models [4, 9, 15, 25].

Strengths: Key strengths include the randomized design, use of ANCOVA to control baseline differences, reporting of effect sizes and confidence intervals, and focus on a rural population, which enhances external validity and real-world applicability.

Limitations: The study is limited by its relatively small sample size and short intervention duration, which may limit generalizability and long-term inference. Additionally, only physiological outcomes were assessed; inclusion of functional capacity, psychological status, and quality of life would provide a more comprehensive evaluation.

Future directions: Future research should incorporate longer follow-up periods to assess sustainability, include multidimensional outcomes (e.g., quality of life, depression), and explore cost-effectiveness and scalability through integration with primary healthcare systems and community health workers.

Conclusion

A structured multicomponent exercise program is feasible, safe, and effective for improving blood pressure and respiratory rate in rural post-CABG patients. This approach offers a practical pathway to expand cardiac rehabilitation access in underserved settings.

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