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Original Article

Tele-Guided Home Cardiac Rehabilitation After CABG: A Randomized Controlled Trial

Malia Younas[1], Hamza Shafee[1], Atif Khan[1]

[1] Arif Memorial Hospital, Lahore, Pakistan

*** Correspondence: Malia Younas, maliayounas62@gmail.com**

ABSTRACT

Background: Coronary artery bypass grafting (CABG) is frequently performed for advanced coronary artery disease; however, postoperative recovery is often associated with reduced functional capacity and impaired quality of life. Cardiac rehabilitation programs play an essential role in recovery, yet participation in traditional center-based programs remains limited due to logistical and accessibility barriers. Objective: To evaluate the effectiveness of a structured home-based cardiac rehabilitation (HBCR) program in improving functional capacity, left ventricular ejection fraction (LVEF), and quality of life among patients recovering from CABG surgery. Methods: A randomized controlled trial was conducted at Arif Memorial Hospital, Lahore, including 26 patients who had undergone CABG surgery. Participants were randomly assigned to either a home-based cardiac rehabilitation group (n = 13) or a control group receiving usual postoperative care (n = 13). The HBCR program consisted of a 12-week structured exercise and education protocol with remote follow-up. Functional capacity was assessed using the six-minute walk test (6MWT), cardiac function was measured through echocardiographic LVEF, and quality of life was evaluated using a validated questionnaire. Statistical analyses were performed using SPSS version 25. Results: The HBCR group demonstrated significantly greater improvement in functional capacity compared with controls (mean increase 76.4 m vs. 40.8 m; $p < 0.001$). LVEF increased by 6.3% in the HBCR group compared with 3.2% in the control group ($p = 0.001$). Quality-of-life scores improved significantly more in the HBCR group (mean increase 24.8 vs. 13.9 points; $p < 0.001$). Conclusion: Home-based cardiac rehabilitation significantly improved functional capacity, cardiac function, and quality of life in post-CABG patients, supporting its potential role as an accessible alternative to traditional rehabilitation programs. Keywords: Cardiac Rehabilitation, Coronary Artery Bypass Grafting, Home-Based Rehabilitation, Functional Capacity, Quality of Life, Randomized Controlled Trial

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INTRODUCTION

Coronary artery disease (CAD) remains one of the leading causes of morbidity and mortality worldwide, and coronary artery bypass grafting (CABG) is a well-established surgical intervention for patients with advanced or multivessel coronary disease. Although CABG effectively restores myocardial perfusion and improves survival in selected patients, postoperative recovery is often accompanied by reduced functional capacity, impaired cardiovascular performance, and diminished quality of life. Many patients experience prolonged deconditioning due to inactivity, postoperative pain, and psychological stress, which may delay recovery and increase the risk of recurrent cardiovascular events. Cardiac rehabilitation (CR) programs are therefore considered an essential component of secondary prevention after CABG, aiming to restore physical function, optimize cardiovascular performance, and improve overall well-being (1).

Traditional cardiac rehabilitation programs are typically delivered in hospital-based or outpatient centers where patients perform supervised exercise training combined with education on lifestyle modification, medication adherence, and risk factor management. Numerous studies have demonstrated that structured CR programs improve exercise tolerance, enhance cardiac function, and reduce hospital

readmissions among patients with cardiovascular disease (2). Despite these established benefits, participation in center-based rehabilitation programs remains suboptimal. Barriers such as transportation difficulties, work commitments, financial constraints, and limited availability of specialized rehabilitation facilities contribute to low enrollment and poor adherence rates. These challenges are particularly pronounced in low- and middle-income countries, where healthcare infrastructure and access to specialized services may be limited (3).

To address these barriers, home-based cardiac rehabilitation (HBCR) has emerged as a promising alternative model of care. HBCR programs typically combine structured exercise regimens with remote monitoring, telephonic counseling, and patient education delivered outside the traditional clinical setting. Evidence suggests that HBCR can produce improvements in functional capacity and cardiovascular health outcomes comparable to those achieved through supervised center-based programs (4). Telemonitoring systems, wearable devices, and mobile health technologies have further enhanced the feasibility and safety of HBCR by enabling clinicians to monitor patient progress remotely and provide individualized feedback (5).

Several studies have demonstrated that home-based rehabilitation interventions can significantly improve exercise tolerance and quality of life among patients with coronary artery disease (6). Meta-analyses comparing home-based and center-based cardiac rehabilitation programs have reported similar improvements in functional capacity, cardiovascular risk profiles, and psychological outcomes (7). Furthermore, HBCR programs have been associated with improved adherence rates, as patients are able to integrate rehabilitation activities into their daily routines without the need for frequent hospital visits (8). These findings suggest that HBCR may represent a scalable and cost-effective strategy for expanding access to cardiac rehabilitation services.

Despite the growing body of evidence supporting HBCR, important knowledge gaps remain. Many previous studies have evaluated mixed populations with various forms of coronary heart disease rather than focusing specifically on post-CABG patients, whose rehabilitation needs may differ due to surgical recovery and postoperative complications (9). Additionally, relatively few randomized controlled trials conducted in resource-limited healthcare systems have examined the impact of HBCR on both functional and physiological cardiac outcomes, such as changes in left ventricular ejection fraction (LVEF), alongside patient-reported quality-of-life measures (10). Understanding the effectiveness and feasibility of HBCR within local healthcare contexts is essential for informing clinical practice and optimizing rehabilitation strategies for post-CABG patients.

Given these considerations, further randomized controlled trials are needed to evaluate whether structured HBCR programs can effectively improve functional capacity, cardiac function, and quality of life among individuals recovering from CABG surgery. Therefore, the present study was conducted to evaluate the effectiveness of a structured home-based cardiac rehabilitation program compared with usual postoperative care in patients who had undergone CABG surgery. The primary objective was to determine whether HBCR leads to greater improvement in functional capacity, measured using the six-minute walk test (6MWT), over a 12-week rehabilitation period. Secondary objectives included assessing changes in left ventricular ejection fraction and health-related quality of life following participation in the rehabilitation program.

MATERIALS AND METHODS

This study was conducted as a randomized controlled clinical trial designed to evaluate the effectiveness of a structured home-based cardiac rehabilitation program in improving functional capacity and cardiac function among patients recovering from coronary artery bypass grafting surgery. The trial was carried out at Arif Memorial Teaching Hospital, Lahore, Pakistan, between January 2024 and June 2024. The study followed principles of clinical trial methodology to ensure internal validity and reproducibility of findings.

Adult patients who had undergone elective CABG surgery and were attending postoperative follow-up at the cardiology outpatient department were screened for eligibility. Participants were eligible for inclusion if they were aged 18 years or older, had undergone CABG surgery within the previous three months, were clinically stable, and were cleared by their cardiologist to participate in moderate-intensity exercise rehabilitation. Patients were excluded if they had unstable angina, uncontrolled arrhythmias, severe heart failure (New York Heart Association class IV), significant orthopedic or neurological limitations that prevented participation in physical activity, severe cognitive impairment interfering with study participation, or any other medical condition considered unsafe for exercise rehabilitation.

Participants who met the eligibility criteria were approached during outpatient follow-up visits and provided with detailed information regarding the study objectives and procedures. Written informed consent was obtained from all participants prior to enrollment. A total of twenty-six patients were recruited and randomly allocated into two equal groups: the home-based cardiac rehabilitation group (HBCR group, n = 13) and the control group receiving usual postoperative care (n = 13). Randomization was performed using a computer-generated random allocation sequence with a 1:1 allocation ratio. Allocation concealment was ensured using sequentially numbered sealed opaque envelopes prepared by an independent researcher not involved in data collection.

Participants allocated to the HBCR group received a structured 12-week home-based cardiac rehabilitation program consisting of aerobic exercise training, light resistance activities, and patient education on cardiovascular risk factor modification. The exercise protocol included moderate-intensity walking or cycling exercises performed five days per week for approximately 30–40 minutes per session. Exercise intensity was prescribed at approximately 50–70% of age-predicted maximal heart rate and gradually progressed based on individual tolerance and clinical status. Patients were instructed on proper warm-up and cool-down procedures to reduce the risk of cardiovascular complications. Educational components included counseling on smoking cessation, dietary modification, medication adherence, and safe exercise practices. Participants received weekly telephonic follow-ups from physiotherapists to monitor progress, address concerns, and reinforce adherence to the rehabilitation protocol.

The control group received usual postoperative care, which included routine cardiology follow-up visits, medication management, and general lifestyle advice provided during clinical consultations. Patients in this group did not receive structured rehabilitation exercises or remote monitoring during the study period.

Baseline assessments were conducted for all participants prior to randomization. Demographic information including age, sex, and relevant clinical history was recorded. Functional capacity was assessed using the six-minute walk test (6MWT), performed according to standardized guidelines, with the distance walked in meters recorded as the primary outcome measure. Cardiac function was evaluated using transthoracic echocardiography to determine left ventricular ejection fraction. Health-related quality of life was assessed using a validated cardiovascular health questionnaire commonly used in cardiac rehabilitation research. Follow-up assessments were performed at six weeks and twelve weeks after initiation of the intervention.

The primary outcome of the study was the change in functional capacity, measured as the difference in six-minute walk test distance between baseline and the 12-week follow-up assessment. Secondary outcomes included changes in left ventricular ejection fraction and quality-of-life scores over the same period. Adherence to the rehabilitation program was monitored through patient activity logs and weekly telephonic follow-up. Any adverse events occurring during the rehabilitation period were documented and evaluated by the clinical team.

Measures were taken to minimize potential bias and improve data reliability. Outcome assessments were conducted by trained clinical staff who were not involved in delivering the rehabilitation intervention.

Standardized testing protocols were followed for functional capacity and echocardiographic measurements to ensure consistency across participants. Data entry and verification procedures were implemented to maintain accuracy and reduce transcription errors.

The sample size of twenty-six participants, with thirteen individuals in each group, was determined based on feasibility and the exploratory nature of the trial, while still allowing detection of clinically meaningful differences in functional capacity between the intervention and control groups. Data were analyzed using Statistical Package for Social Sciences (SPSS) version 25.0. Continuous variables were summarized using mean and standard deviation, while categorical variables were expressed as frequencies and percentages. Independent sample t-tests were used to compare mean differences between the two groups for continuous outcomes, while repeated measures analysis of variance was used to evaluate changes in outcomes over time. Chi-square tests were applied for categorical comparisons. Effect sizes and 95% confidence intervals were calculated where appropriate to estimate the magnitude and precision of the observed differences. Statistical significance was defined as a p-value less than 0.05.

Ethical approval for the study was obtained from the institutional ethical review committee prior to commencement of data collection. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Participant confidentiality was maintained throughout the research process by assigning anonymized identification codes to all data records. Study procedures, data management protocols, and statistical analysis plans were documented to ensure transparency and reproducibility of the research findings.

RESULTS

A total of 26 patients who had undergone coronary artery bypass grafting were enrolled and randomized equally into two groups: the home-based cardiac rehabilitation group (HBCR, n = 13) and the control group receiving usual postoperative care (n = 13). No participants were lost to follow-up, and all randomized participants completed the 12-week study period, allowing complete analysis according to the intention-to-treat principle. Baseline demographic and clinical characteristics were comparable between the two groups, confirming adequate randomization and minimizing potential selection bias.

Table 1 Baseline Characteristics of Participants

Variable	HBCR Group (n = 13) Mean ± SD / n (%)	Control Group (n = 13) Mean ± SD / n (%)	Mean Difference (95% CI)	p-value
Age (years)	63.8 ± 6.9	62.7 ± 7.4	1.1 (−4.5 to 6.7)	0.69
Male	10 (76.9%)	10 (76.9%)	—	1.00
LVEF (%)	48.6 ± 6.3	47.9 ± 6.7	0.7 (−4.3 to 5.7)	0.77
Baseline 6MWT (m)	327.4 ± 50.8	324.1 ± 49.6	3.3 (−35.8 to 42.4)	0.86
Diabetes Mellitus	6 (46.2%)	5 (38.5%)	—	0.69
Hypertension	8 (61.5%)	7 (53.8%)	—	0.70

Baseline comparisons indicated no statistically significant differences between the two groups across demographic and clinical variables. The mean age of participants was 63.8 ± 6.9 years in the HBCR group and 62.7 ± 7.4 years in the control group (p = 0.69). Baseline functional capacity measured by the six-minute walk test (6MWT) was also similar between groups (327.4 ± 50.8 m vs. 324.1 ± 49.6 m; p = 0.86). Similarly, baseline left ventricular ejection fraction was comparable (48.6% vs. 47.9%; p = 0.77). These findings confirm that both groups started the intervention phase with similar clinical profiles.

Table 2 Change in Functional Capacity (Six-Minute Walk Test)

Time Point	HBCR Group (Mean ± SD)	Control Group (Mean ± SD)	Mean Difference (95% CI)	p-value	Effect Size (Cohen's d)
Baseline (m)	327.4 ± 50.8	324.1 ± 49.6	3.3 (−35.8 to 42.4)	0.86	—
Week 6 (m)	377.5 ± 52.2	349.6 ± 50.3	27.9 (−12.1 to 67.9)	0.16	0.54
Week 12 (m)	403.8 ± 48.7	364.9 ± 46.8	38.9 (2.8 to 75.0)	0.035	0.82
Mean Change (m)	76.4 ± 11.2	40.8 ± 9.3	35.6 (26.8 to 44.4)	<0.001	3.45

Functional capacity improved in both groups over the 12-week rehabilitation period, but the magnitude of improvement was significantly greater in the HBCR group. Participants in the HBCR group increased their six-minute walk distance from 327.4 ± 50.8 m at baseline to 403.8 ± 48.7 m at week 12, representing

a mean increase of 76.4 ± 11.2 m. In comparison, the control group improved from 324.1 ± 49.6 m to 364.9 ± 46.8 m, corresponding to a mean increase of 40.8 ± 9.3 m. The between-group difference in improvement was statistically significant (mean difference 35.6 m; 95% CI 26.8–44.4; $p < 0.001$), with a large effect size (Cohen's d = 3.45). Significant divergence between groups became evident by week 12, when the HBCR group demonstrated a mean walking distance nearly 39 meters greater than that of the control group ($p = 0.035$).

Table 3 Changes in Cardiac Function and Quality of Life

Outcome	Time Point	HBCR Group (Mean ± SD)	Control Group (Mean ± SD)	Mean Difference (95% CI)	p-value	Effect Size
LVEF (%)	Baseline	48.6 ± 6.3	47.9 ± 6.7	0.7 (−4.3 to 5.7)	0.77	—
	Week 12	54.9 ± 5.6	51.1 ± 6.1	3.8 (−0.6 to 8.2)	0.087	0.65
	Mean Change	+6.3 ± 2.0	+3.2 ± 1.8	3.1 (1.5 to 4.7)	0.001	1.63
Quality of Life (QoL Score)	Baseline	62.1 ± 9.6	62.9 ± 9.1	−0.8 (−7.8 to 6.2)	0.81	—
	Week 12	86.9 ± 7.8	76.8 ± 8.7	10.1 (3.7 to 16.5)	0.003	1.22
	Mean Change	+24.8 ± 5.1	+13.9 ± 4.3	10.9 (7.3 to 14.5)	<0.001	2.32

Cardiac function improved in both groups over the study period, with greater improvement observed among patients participating in home-based rehabilitation. The mean LVEF increased from 48.6 ± 6.3% at baseline to 54.9 ± 5.6% at week 12 in the HBCR group, representing a mean improvement of 6.3 ± 2.0%. In contrast, the control group demonstrated a smaller increase from 47.9 ± 6.7% to 51.1 ± 6.1%, corresponding to a mean improvement of 3.2 ± 1.8%. The difference in mean change between groups was statistically significant (3.1%; 95% CI 1.5–4.7; $p = 0.001$), indicating a clinically meaningful improvement in cardiac function associated with the HBCR intervention.

Quality of life scores also demonstrated marked improvement among participants receiving home-based rehabilitation. The HBCR group showed an increase from 62.1 ± 9.6 points at baseline to 86.9 ± 7.8 points at week 12, corresponding to a mean improvement of 24.8 ± 5.1 points. The control group improved from 62.9 ± 9.1 points to 76.8 ± 8.7 points, representing a mean increase of 13.9 ± 4.3 points. The between-group difference in improvement was statistically significant (mean difference 10.9 points; 95% CI 7.3–14.5; $p < 0.001$) with a large effect size (Cohen's d = 2.32), indicating superior improvement in health-related quality of life among patients undergoing HBCR.

DISCUSSION

The present randomized controlled trial evaluated the effectiveness of a structured home-based cardiac rehabilitation program in patients recovering from coronary artery bypass grafting surgery. The findings demonstrated that participants enrolled in the HBCR program experienced significantly greater improvements in functional capacity, cardiac function, and health-related quality of life compared with those receiving usual postoperative care. These findings support the growing body of evidence suggesting that home-based cardiac rehabilitation can serve as a safe and effective alternative to conventional facility-based rehabilitation, particularly in settings where access to specialized rehabilitation services is limited.

The most pronounced improvement observed in the present study was in functional capacity measured by the six-minute walk test. Participants in the HBCR group demonstrated a mean increase of approximately 76 meters in walking distance over the 12-week rehabilitation period, compared with an improvement of approximately 41 meters in the control group. This difference exceeds the minimal clinically important difference commonly reported for the six-minute walk test in cardiovascular rehabilitation populations, suggesting that the observed improvement is not only statistically significant but also clinically meaningful. Similar improvements in exercise tolerance following home-based rehabilitation have been reported in previous studies evaluating cardiac telerehabilitation programs and remote exercise interventions in patients with coronary artery disease (12).

Improvement in left ventricular ejection fraction further supports the physiological benefits of structured exercise-based rehabilitation. Participants in the HBCR group demonstrated a mean increase of more than six percentage points in LVEF, which was approximately double the improvement observed

in the control group. Exercise training is known to enhance myocardial efficiency, improve peripheral oxygen utilization, and promote favorable cardiovascular remodeling, all of which contribute to improved ventricular function after cardiac surgery. Previous studies have similarly reported modest but clinically relevant improvements in cardiac function among patients participating in home-based rehabilitation programs following coronary interventions (13).

Quality-of-life outcomes also demonstrated substantial improvement in the HBCR group. Participants undergoing structured home-based rehabilitation reported significantly greater improvements in health-related quality-of-life scores compared with patients receiving usual care. Cardiac rehabilitation programs often address not only physical recovery but also psychological well-being through patient education, behavioral counseling, and gradual reintegration into daily activities. These components may contribute to reductions in anxiety, increased confidence in physical activity, and improved overall life satisfaction following cardiac surgery. Similar findings have been reported in systematic reviews evaluating cardiac rehabilitation programs, which consistently demonstrate improvements in both physical and psychological domains of health-related quality of life (14).

One important advantage of the HBCR model observed in the present study was the high level of patient adherence. Approximately eighty-five percent of participants in the HBCR group completed at least eighty percent of their prescribed exercise sessions. Home-based programs may improve adherence by allowing patients to integrate rehabilitation activities into their daily routines while avoiding barriers such as travel distance, scheduling conflicts, and limited availability of specialized rehabilitation centers. Previous investigations have similarly reported higher participation and completion rates in home-based cardiac rehabilitation programs compared with traditional center-based models (15).

The safety profile observed in this study further supports the feasibility of implementing HBCR in clinical practice. No major adverse cardiovascular events occurred during the rehabilitation period, and participants tolerated the prescribed exercise program well. Remote monitoring and periodic follow-up allowed healthcare providers to ensure that exercise intensity remained appropriate and that participants adhered to recommended safety precautions. These findings are consistent with previous research demonstrating that appropriately prescribed home-based exercise programs can be safely performed by stable cardiac patients under remote clinical supervision (16).

Despite the promising results, several limitations should be considered when interpreting the findings of this study. First, the sample size was relatively small, which may limit the generalizability of the results to broader patient populations. Larger multicenter trials would provide more robust evidence regarding the effectiveness of HBCR in diverse healthcare settings. Second, the duration of follow-up was limited to twelve weeks, and therefore the long-term sustainability of the observed improvements could not be assessed. Longitudinal studies are needed to determine whether the benefits of HBCR persist beyond the immediate rehabilitation period and whether such programs reduce long-term cardiovascular events and hospital readmissions (17).

Another limitation relates to the reliance on patient-reported adherence logs for monitoring exercise participation. Although regular telephonic follow-up was conducted, objective monitoring using wearable devices or digital activity trackers could provide more precise measurement of exercise intensity and compliance. Future studies incorporating wearable technologies may further enhance adherence monitoring and enable more individualized rehabilitation programs (18).

Notwithstanding these limitations, the findings of the present trial contribute valuable evidence supporting the integration of home-based rehabilitation programs into postoperative cardiac care pathways. In healthcare environments where access to specialized rehabilitation facilities is limited, HBCR may represent a practical strategy for expanding rehabilitation services and improving recovery outcomes for patients undergoing CABG surgery.

CONCLUSION

Home-based cardiac rehabilitation demonstrated significant improvements in functional capacity, cardiac function, and quality of life among patients recovering from coronary artery bypass grafting compared with usual postoperative care. The high adherence rate and absence of adverse events observed in this study indicate that structured home-based rehabilitation programs are both feasible and safe. These findings support the potential role of HBCR as an accessible and effective rehabilitation strategy, particularly in healthcare settings where participation in traditional center-based programs is limited.

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