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Effectiveness of Aerobic Exercise-Based Phase II Cardiac Rehabilitation on Functional Capacity and Quality of Life After CABG; A Randomized Controlled Trial

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ABSTRACT:

Background: Cardiac rehabilitation usually incorporates exercises as central to recovery after coronary artery bypass grafting (CABG). However, locally generated evidence from outpatient physiotherapy based Phase-II cardiac rehabilitation services in Pakistan remains limited.

Objective: To determine whether a structured aerobic exercise cardiac rehabilitation program improves functional capacity and quality of life compared to usual cardiac rehabilitation in clinically stable post-CABG patients.

Methodology: This study was a two arm randomized controlled trial enrolling 30 participants aged 40-75 years with left ventricular ejection fraction of 35%-44%. Participants were randomized to aerobic exercise training group (n=15) or usual care group (n=15). The intervention was delivered three times per week and comprised of warm-up, progressive aerobic training at 40%-60% of heart rate reserve as well as Borg rating of perceived exertion 11-14 and cool-down with symptom and haemodynamic monitoring. Outcomes were assessed at baseline and end of week 10. Primary analysis used ANCOVA for post intervention adjusted for baseline 6 Minute Walk Test (6MWT) for functional capacity and SF-36 for quality of life.

Results: Baseline 6MWT distance was similar between groups. At the end of week 10, the adjusted between-group difference favored aerobic training by 61.14 m (95% CI 51.60-70.68; $p<0.001$; partial $\eta^2=0.865$). SF-36 domain scores also favored aerobic training across all domains, and all domain level comparisons survived Holm-Bonferroni correction with partial η^2 range 0.339–0.592.

Conclusions: These preliminary findings suggest that a moderate intensity, physiotherapist supervised aerobic exercise program may improve functional capacity and quality of life after CABG.

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INTRODUCTION

Cardiovascular disease continues to be the leading cause of mortality worldwide and coronary artery disease continues to account for a large segment of premature deaths, disability and health system burden, especially in low and middle income countries (World Health Organization, 2025; Martin et al., 2025). Coronary artery bypass grafting (CABG) is a well known revascularisation therapy for patients with complex or multivessel coronary artery disease. However, surgical revascularisation does not by itself restore cardiorespiratory endurance, skeletal muscle conditioning, confidence in physical activity performance or health related quality of life (HRQoL). These domains are pivotal to physiotherapy care and to Phase II cardiac rehabilitation (CR); where exercise prescription, symptom monitoring, patient education and self-management support are practiced to convert surgical survival into functional rehabilitation.

Patients recovering from CABG ususally experience reduced exercise tolerance, postoperative muscular and cardiopulmonary deconditioning, pain induced movement restriction, fatigue, anxiety about exertion and delayed return to daily living activities. Previous evidence syntheses focused on CABG show that CR improves cardiopulmonary and functional outcomes positively, including peak oxygen uptake and 6 minute walk test (MWT) distance, although included trials vary greatly in timing, frequency, intensity, duration, supervision and outcome selection (Miao et al., 2023; Moneruzzaman et al., 2023). Randomized studies have also suggested that structured physical training plans after CABG can improve early functional recovery, heart-rate recovery and quality-of-life outcomes compared with less structured usual care but the protocols used across different clinical settings remain heterogeneous (Hirschhorn et al., 2012; Hojskov et al., 2016; Shan et al., 2022; Wu et al., 2006). Therefore, locally feasible and clearly described aerobic CR protocols remain necessary, especially in outpatient settings where resources and referral pathways are poor.

Moderate intensity aerobic exercise training is commonly recommended for clinically stable cardiac patients as it can produce functional improvements while maintaining an acceptable to good safety margin when delivered with warm-up, cool-down, blood pressure and heart-rate monitoring, proper symptom surveillance and perceived exertion regulation. Current CR guidance supports prescribing aerobic exercise around 40%-60% of heart rate reserve for moderate intensity along with Borg ratings for perceived exertion at 12-14; broader clinical standards in available literature frequently use Borg RPE 11-14, 20-60 minutes of aerobic work and at least three weekly sessions (Brown et al., 2024; Mytinger et al., 2020). A 10 week program delivered three times per week was therefore selected to provide repeated supervised exposure, gradual progression and a clinically realistic dose within routine outpatient Phase II CR.

Functional capacity and HRQoL are appropriate patient centered endpoints for post CABG rehabilitation because they focus walking endurance, activity confidence, physical fatigue, social participation and perceived recovery. The 6MWT is a practical, low cost measure of submaximal functional capacity, with standardised administration guidance and well established responsiveness in outpatient CR populations (ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories, 2002; Bellet et al., 2012). The SF-36 focuses physical and mental health domains and has been commonly used in Pakistani CABG cohorts and cardiac rehabilitation studies; for Urdu speaking populations, Urdu RAND SF-36 adaptation has reported as acceptable psychometric properties; although it was validated outside a cardiac disease sample and therefore requires cautious interpretation in this population (Amjad et al., 2022; Barolia et al., 2012).

In Pakistan, CR remains underdeveloped correlate to national burden of coronary artery disease (CAD) and evidence from structured Phase II outpatient rehabilitation programs is very limited. Existing local and regional studies have usually examined mixed CAD populations, inpatient protocols or less precisely described rehabilitation exposure, leaving a gap regarding whether a physiotherapist supervised, structured moderate intensity aerobic exercise program can improve functional capacity and HRQoL after CABG using feasible clinical outcomes. Accordingly, primary objective of this randomized controlled trial was to determine whether a structured 10 week aerobic exercise program delivering three sessions per week improves post intervention 6MWT distance at the end of week 10 compared with usual care control among post CABG patients who were receiving outpatient Phase II CR in Karachi. The secondary objective was to examine changes in SF-36 HRQoL domains at week 10 completion. It was hypothesised that the aerobic exercise group would demonstrate greater 6MWT distance and better SF-36 domain scores than usual care group.

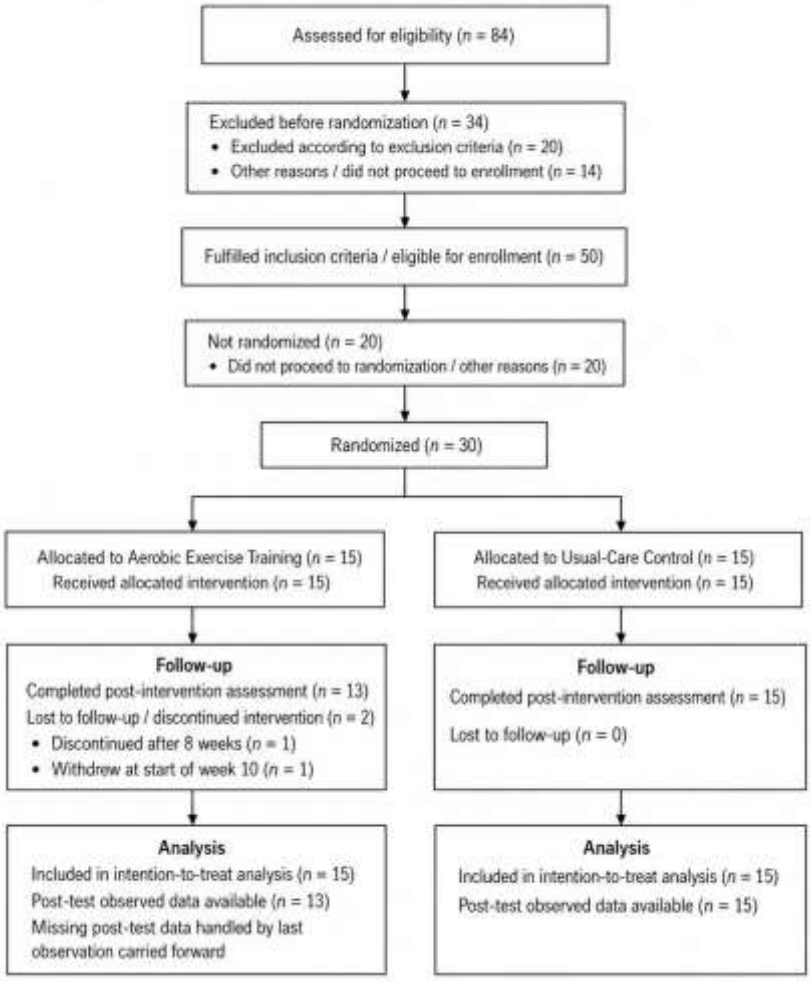
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MATERIALS AND METHODS

Study design and setting

This research study was a two-arm, parallel group randomized controlled trial comparing structured aerobic exercise training with usual care control during outpatient Phase II CR. The study was conducted in cardiac rehabilitation section of Body Experts in Karachi, Pakistan. It provided supervised post CABG cardiac rehabilitation. Reporting was revised to align with CONSORT guidance for parallel group trials, including explicit reporting of allocation, outcomes, participant flow, missing data and harms (Schulz et al., 2010; Moher et al., 2010).

Figure 1. CONSORT flow diagram of participant flow through the trial



Ethical consideration

Ethical approval was obtained from Ethical Review Board of Body Experts, Karachi having approval reference B.E/ERB-07/11/25 dated 3rd November 2025. All participants provided written informed consent before enrolment and study procedures followed the Declaration of Helsinki.

Participants

Participants were recruited from outpatient CR services using consecutive clinic-based sampling during the recruitment period, starting from 15th November 2025 till 15th February 2026. Potentially eligible patients were screened by trained rehabilitation team and entered only after cardiologist clearance for supervised exercise.

Inclusion criteria were: men or women aged 40-75 years; documented CABG after coronary artery disease, with or without preceding uncomplicated anterior or inferior myocardial infarction; clinically stable status for outpatient Phase II CR; left ventricular ejection fraction (LVEF) 35% to 44%; ability to perform 6MWT; willingness to attend a 10 week program three times per week and baseline completion of the 6MWT and SF-36.

Exclusion criteria were unstable angina or angina at rest, decompensated heart failure, uncontrolled arrhythmia, active condition of pericarditis, carditis or endocarditis, severe peripheral arterial disease limiting walking, moderate to severe orthopedic or neurological limitation, severe arthritis in any lower limb joint, severe diabetic neuropathy, concurrent clinical instability or inability to attend intervention schedule.

Sample size

The sample size for the trial was calculated as a priori using G*Power 3.1. The primary outcome was functional capacity measured by 6MWT. Because the study compared two groups at two assessment points, calculation was based on the F-test family using a repeated measures ANOVA framework for the group-time effects. Assumptions were a medium effect size (f=0.54), level of significance at alpha=0.05, power at 0.80, two groups, two repeated measurements, correlation among repeated measures at 0.60 and non-sphericity correction epsilon was 1.0. The calculated minimum sample size was 26 participants. To allow for attrition within routine outpatient cardiac rehabilitation, four additional participants were recruited, giving a final target sample of 30 participants (15 per group). Effect size assumption was informed by previous post CABG and cardiac rehabilitation evidence reporting clinically meaningful moderate to large improvements in functional capacity after structured exercise rehabilitation (Miao et al., 2023; Shan et al., 2022).

Randomization, allocation concealment and blinding

After baseline assessment, eligible participants were randomized in a 1:1 ratio to aerobic exercise training or usual care control using sequentially numbered opaque sealed envelopes prepared before recruitment. Envelopes were opened only after eligibility confirmation, informed consent and completion of baseline assessments. Outcome assessment was performed by an assessor who was not involved in intervention delivery.

Intervention Group (Group A)

The aerobic exercise group received supervised aerobic exercises for 10 weeks, three sessions per week, for a maximum of 30 planned sessions. Each session comprised of a standard structure: warm-up for 5 to 10 minutes, aerobic conditioning for 25-40 minutes as tolerated and a cool-down of 5 to 10 minutes. Aerobic exercises included treadmill or corridor walking alternatively for 15-20 minutes and stationary cycling for 15-20 minutes after walking. Exercise intensity was prescribed primarily using moderate intensity heart rate reserve (40%-60% HRR). Additionally, Borg rating of perceived exertion on 6-20 scale was used as a concurrent clinical monitoring and adjustment tool, with the target maintained between RPE 11-14. HRR provided an objective intensity target, whereas RPE and symptoms were used to individualize day to day progression where heart rate response was expected to be affected by medication, fatigue, anxiety or abnormal chronotropic response. HRR was calculated using the Karvonen method: target HR = resting HR + prescribed intensity x (maximum HR - resting HR).

Progression was gradual and symptom limited. First two weeks emphasised tolerance and familiarisation at RPE 11-12 with 15-20 minutes of aerobic work. Next two weeks (3-4) progressed duration toward 25-30 minutes taking RPE at 11-13. Weeks 5-6 consolidated continuous aerobic exercise using walking and stationary cycling. Weeks 7-8 introduced simple moderate intervals when tolerated, such as 2-3 minutes faster walking alternated with 2-3 minutes easier recovery, while keeping overall effort within RPE 11-14. Last two weeks (9-10) aimed for 35 to 40 minutes of aerobic conditioning at RPE 11-14 when clinically tolerated. Exercise was to be reduced or stopped if participants developed chest pain, excessive dyspnoea, dizziness, abnormal blood pressure response, presyncope, or any clinician determined safety concern.

Usual care control Group (Group B)

The usual care group were subjected to routine Phase II cardiac rehabilitation three times weekly for 10 weeks, giving the same nominal contact schedule as aerobic group. Each usual care session lasted approximately 30-40 minutes and included symptom review, resting heart-rate and blood-pressure monitoring, education on medication adherence, diet, risk-factor

modification, stress management, breathing exercises, range of motion exercises, stretching and light non progressive walking or mobility activity (10-15 minutes maximum) according to local centre practice.

Outcome measures

The pre-specified primary outcome was functional capacity measured by 6MWT distance at the end of week 10. The 6MWT was administered according to American Thoracic Society guidance on a 30-metre flat indoor corridor. One test was performed at each assessment point; no familiarisation trial was conducted because the measure was embedded in routine outpatient CR workflow. But standardized instructions and encouragement were used consistently throughout walking during test performance. Participants were instructed to walk as far as possible for six minutes, turning around marked endpoints without running. Standardized encouragement was provided at each minute and total distance walked in metres was recorded. Heart rate, blood pressure, oxygen saturation, Borg RPE and other symptoms were monitored before and immediately after the test.

HRQoL was measured using the English SF-36 version 2 questionnaire. The questionnaire was interviewer-administered when required to support completion by participants with limited literacy or difficulty completing forms independently. Responses were scored according to SF-36 scoring procedures, with items recoded where necessary and transformed to 0-100 domain scores; higher scores indicated better perceived health status.

Adherence, adverse events and missing data

Adherence was recorded using attendance logs and summarized as sessions attended out of 30 prescribed sessions and as mean sessions attended per group. Missing data were handled using an intention-to-treat (ITT) approach with last observation carried forward imputation. Adverse events were recorded from session logs and classified by type, timing and seriousness. Minor events included fatigue, transient dizziness, abnormal blood-pressure response, angina symptoms or arrhythmia symptoms not requiring hospitalization. Serious adverse events were considered as events causing death, hospital admission, syncope/fall with injury or urgent medical intervention.

Statistical analysis

Data were analyzed using SPSS version 25.0. Continuous variables were summarized as mean and standard deviation when approximately normally distributed. Categorical variables were summarized as frequency and percentage. All randomized participants were included in ITT analysis. For two aerobic-group participants without week 10 post-test data, last observation carried forward imputation was used. Medication changes were not entered as covariates because they were not part of the prespecified statistical model. The primary analysis used ANCOVA with week-10 6MWT distance as the dependent variable, treatment group as the fixed factor and baseline 6MWT distance as the covariate. Secondary outcomes; SF-36 domains; were analyzed using parallel baseline adjusted ANCOVA models. Because eight SF-36 domains were tested, Holm-Bonferroni correction was applied to control family-wise error rate. Effect sizes were reported as partial eta squared and interpreted cautiously because estimates from small samples are sometimes unstable.

RESULTS

Thirty participants were randomized, with 15 allocated to Group A (Aerobic exercise group) and 15 to Group B (Usual care control group). In Group A, 13 participants completed week 10 post intervention assessments. Two participants discontinued before post testing; one after completion of week 8 (6 sessions missed) and one at beginning of week 10 (3sessions missed). Both were retained in ITT analysis using last observation carried forward imputation. In addition, two aerobic group participants missed two sessions each at different levels but completed the study. All 15 usual-care participants participated assessment at completion of week 10. Therefore, the analysis included all 30 randomized participants after imputation for missing Group A week-10 observations.

Baseline age, weight and BMI were similar between groups with insignificant variations between groups (Table 1).

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Table 1. Baseline demographic and clinical characteristics

Variable	Aerobic Exercises (n=15)	Usual care (n=15)	p value
Age, years	57.13 ± 4.05	56.20 ± 3.67	0.514
Weight, kg	82.00 ± 15.93	77.27 ± 18.27	0.456
BMI, kg/m2	31.50 ± 5.56	30.23 ± 5.85	0.549
Time elapsed since CABG, days	5.13 ± 1.05	5.83 ± 1.15	0.093
LVEF, %	48.63 ±7.34	47.94 ±8.55	0.814
Diabetes mellitus, n (%)	9(60)	10(66.6)	1.000
Hypertension, n (%)	12(80)	12(80)	1.000
Dyslipidaemia, n (%)	14(93.3)	15(100)	1.000
Current smoker, n (%)	6(40)	5(33.3)	1.000
Antiplatelet therapy, n (%)	14(93.3)	14(93.3)	1.000
Beta-blocker therapy, n (%)	13(86.6)	14(93.3)	1.000
Statin therapy, n (%)	15(100)	15(100)	1.000
ACE inhibitor/ARB, n (%)	11(73.3)	10(66.6)	1.000

LVEF = left ventricular ejection fraction; ACE = angiotensin-converting enzyme; ARB = angiotensin receptor blocker.

Baseline 6MWT distance was similar between groups. After 10 weeks, the aerobic group improved from 334.00 ± 11.13 m to 412.87 ± 13.86 m, whereas the usual-care group improved from 331.33 ± 24.11 m to 348.80 ± 31.12 m. (Figure 1) The within-group change was +78.87 m in the aerobic group and +17.47 m in the control group. In the ANCOVA model adjusted for baseline 6MWT, the adjusted post-intervention difference was 61.14 m in favor of aerobic training (95% CI 51.60-70.68; $p<0.001$). This exceeded commonly cited minimal important changes for walking performance in cardiopulmonary populations, although the exact threshold can vary by population and baseline severity. (Table 2)

Table 2. Primary outcome: 6-minute walk test (ANCOVA Results)

Measure	Aerobic training	Usual care	Between-group effect
Baseline, mean ± SD	334.00 ± 11.13	331.33 ± 24.11	
Week 10, mean ± SD	412.87 ± 13.86	348.80 ± 31.12	
Within-group change	+78.87	+17.47	
Adjusted week-10 mean (SE)	411.40 (3.29)	350.26 (3.29)	
Adjusted mean difference			61.14 m
95% CI			51.60 to 70.68
p value			<0.001
Effect size			η^2=0.865

SD: Standard Deviation

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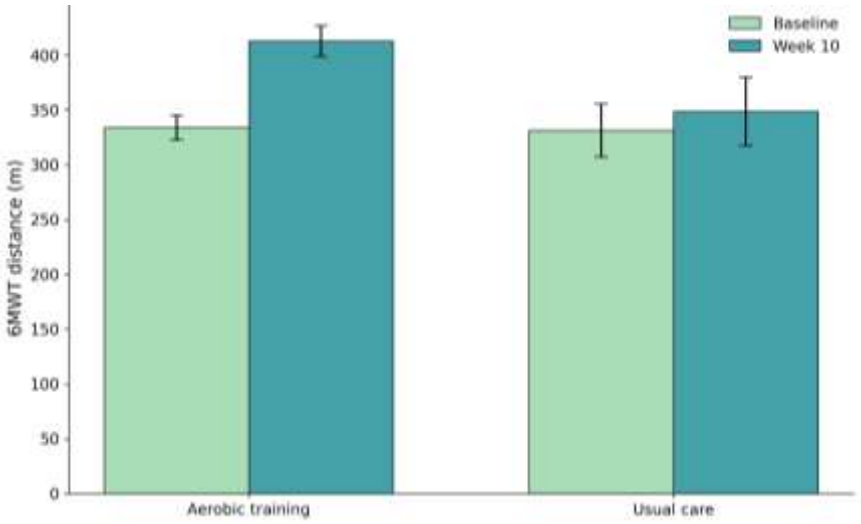


Figure 1: 6 Minute Walk Test (6MWT) at Pre and Post Intervention

All SF-36 domains showed larger baseline-to-week-10 improvement in the aerobic group than in the usual-care group (Table 3). The adjusted between-group differences favored aerobic training across physical functioning, role-physical, role-emotional, energy/fatigue, emotional well-being, social functioning, pain and general health. (Figure 2) Using a conservative generic interpretation in which 5 points is often treated as a minimal clinically important difference for SF-36 summary or domain-level interpretation, the adjusted between-group differences exceeded this value in all domains. Because SF-36 domains were secondary/exploratory and correlated, interpretation should emphasize the consistent direction of effects rather than individual domain claims.

Table 3. SF-36 domain scores, within-group changes and baseline-adjusted effects (ANCOVA Results)

Domain	Aerobic pre	Aerobic post	Aerobic change	Control pre	Control post	Control change	Adjusted MD	95% CI	p value	partial η^2
Physical functioning	52.33 ± 7.04	82.00 ± 6.76	+29.67	54.73 ± 5.50	67.60 ± 7.73	+12.87	15.00	9.49-20.51	<0.001	0.536
Role-physical	54.33 ± 7.29	85.00 ± 5.00	+30.67	57.80 ± 10.1	77.67 ± 9.42	+19.87	9.09	4.35-13.82	0.001	0.365
Role-emotional	55.67 ± 6.23	82.33 ± 4.17	+26.66	55.00 ± 10.0	74.33 ± 7.53	+19.33	7.77	3.68-11.85	0.001	0.361
Energy/fatigue	54.67 ± 6.67	85.00 ± 6.27	+30.33	55.47 ± 5.76	76.33 ± 5.16	+20.86	8.91	4.78-13.05	<0.001	0.420
Emotional well-being	47.60 ± 4.82	81.33 ± 5.81	+33.73	50.13 ± 7.58	75.33 ± 5.16	+25.20	7.14	3.48-10.80	<0.001	0.372
Social functioning	50.00 ± 8.66	78.00 ± 4.14	+28.00	50.67 ± 7.76	72.20 ± 5.77	+21.53	6.01	2.69-9.32	0.001	0.339
Pain	51.67 ± 6.45	84.33 ± 4.58	+32.66	50.00 ± 6.27	77.33 ± 5.30	+27.33	6.31	3.08-9.55	<0.001	0.373
General health	49.00 ± 5.73	83.33 ± 5.23	+34.33	49.67 ± 6.40	72.33 ± 5.30	+22.66	11.23	7.55-14.92	<0.001	0.592

Note. MD = mean difference.

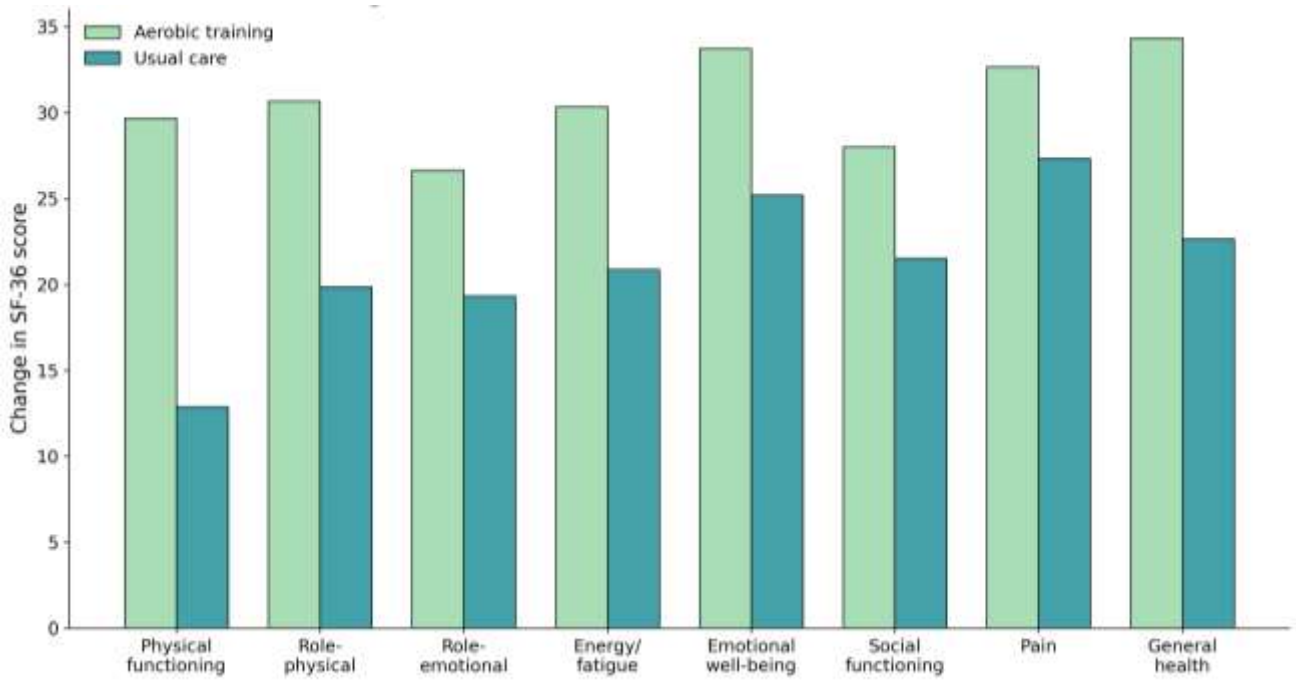


Figure 2: Changes in SF-36 domains across both groups from Pre to Post Intervention

Holm-Bonferroni correction was applied to the eight SF-36 domain tests. The observed p values were ordered from smallest to largest and compared sequentially with adjusted alpha thresholds. All eight comparisons remained statistically significant after correction (Table 4).

Table 4: Holm-Bonferroni correction for SF-36 domain comparisons

Ordered comparison	P value	Holm threshold	Survives correction
Physical functioning	<0.001	0.00625	Yes
Energy/fatigue	<0.001	0.00714	Yes
Emotional well-being	<0.001	0.00833	Yes
Pain	<0.001	0.01000	Yes
General health	<0.001	0.01250	Yes
Role-physical	0.001	0.01667	Yes
Role-emotional	0.001	0.02500	Yes
Social functioning	0.001	0.05000	Yes

Adherence and safety

Attendance was high in both groups. The aerobic group attended 437 of 450 prescribed sessions, corresponding to 29.13 ± 0.75 sessions per participant. The usual-care group attended 440 of 450 prescribed sessions, corresponding to 29.33 ± 0.68 sessions per participant. In the aerobic group, the most commonly recorded minor events were transient fatigue after sessions, abnormal blood-pressure responses during sessions and dizziness usually immediately after sessions. Less frequent events included chest pain/angina symptoms and arrhythmia symptoms during sessions. No falls, syncope, intercurrent hospitalization or serious adverse events were reported in the aerobic group. Group B adverse-event details should be inserted from centre logs before final submission.

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DISCUSSION

This small, randomized trial generated a preliminary evidence that a structured, physiotherapist supervised aerobic exercise program delivered during outpatient Phase II CR may improve functional capacity as well as HRQoL after CABG. The primary outcome duly favored aerobic training, with an adjusted between group difference of 61.14 m in 6MWT. This direction of effect is consistent with previous evidence that physical exercise based CR improves functional capacity in coronary heart disease and post CABG populations (Anderson et al., 2016; Dibben et al., 2021; Miao et al., 2023; Moneruzzaman et al., 2023, Mehmood et al., 2025). This finding is also clinically relevant because 6MWT is responsive to outpatient CR and predicts submaximal walking endurance required for daily activities (Agarwala & Salzman, 2020; Bellet et al., 2012). In small samples, effect size estimates can be found unstable and inflated by restricted variability, baseline homogeneity or strong protocol adherence; hence, the point estimate should be considered as preliminary rather than definitive evidence of aerobic program efficacy (Schulz et al., 2010). Similarly, findings are mostly consistent with systematic reviews and clinical studies showing that post CABG CR improves cardiopulmonary as well as functional outcomes. It has been reported that CR after CABG improves peak oxygen uptake, 6MWT distance and resting heart rate (Miao et al., 2023). While others concluded that exercise based therapy after CABG can improve functional as well as exercise capacity among inpatient and outpatient settings (Moneruzzaman et al., 2023). Individual controlled studies have also reported benefits of structured post CABG exercise/rehabilitation on functional capacity, heart rate recovery and quality of life outcomes compared with less structured CR (Hirschhorn et al., 2012; Hojskov et al., 2016; Shan et al., 2022; Wu et al., 2006). The present trial adds a local outpatient rehabilitation perspective by using a simple but structured moderate intensity protocol that can be delivered within physiotherapy based Phase II CR in Karachi. However, because the trial was small and local, it may be interpreted as not a high level definitive evidence but a preliminary evidence for CR scaling without replication in larger multicentre studies. The aerobic exercise dose used in this trial was clinically plausible and aligned with CR prescription principles. A frequency of three sessions per week, progression from shorter tolerance building sessions toward 35 to 40 minutes of aerobic work and intensity regulation using 40% to 60% HRR as well as Borg RPE 11-14 reflect moderate intensity training commonly used in supervised CR (Brown et al., 2024; Mytinger et al., 2020). This approach is particularly relevant for patients with lower LVEF, beta-blocker use or post-surgical apprehension, where symptom limited progression and RPE based monitoring may improve safety and confidence (Brown et al., 2024; Thomas et al., 2019). The program also comprised of warm up and cool-down phases, which are highly important for haemodynamic stability and symptom monitoring in cardiac disease populations (Brown et al., 2024). Mechanisms behind observed functional improvement were not directly measured and should, therefore, be interpreted as plausible explanations rather than demonstrated effects. Moderate intensity aerobic exercises may improve submaximal performance through central as well as peripheral adaptations, including improved stroke volume response, endothelial functionality, autonomic regulation mechanisms, skeletal muscle oxidative capacity building and oxygen extraction; mechanisms described in CR and exercise based coronary disease literature (Anderson et al., 2016; Brown et al., 2024; Dibben et al., 2021). In present trial, however, no cardiopulmonary exercise testing, endothelial markers, autonomic markers or muscle oxidative measures were included. The only supported conclusion is that the aerobic protocol was associated with improved functional capacity and quality of life scores at the end of week 10. SF-36 results also favored aerobic group across all eight domains. The changes were largest in physical functioning and general health; with good concurrent improvements in role limitations, fatigue, pain, social functioning and emotional well being. These findings are clinically coherent because improved walking tolerance and supervised exposure to safe exertion can reduce effort intolerance and fear of activity, while education and routine contact may support perceived recovery. The SF-36 was originally developed to capture broad physical and mental health constructs and it has been used in CABG and revascularization quality of life research (Barolia et al., 2012; Pačarić et al., 2020; Takousi et al., 2016; Ware & Sherbourne, 1992). Using a conservative generic threshold of approximately 5 points for interpreting SF-36 changes as Minimum Clinically Identifiable Difference (MCID), all adjusted between group differences exceeded this level. Therefore, the SF-36 findings should be framed as adding a good supportive evidence of broad HRQoL improvement (Patafi et al., 2025; Norman et al., 2003). The study also has practical relevance for rehabilitation services in Pakistan. Post CABG patients often require structured progression after hospital discharge but CR implementation can be limited by workforce deficiencies, referral inconsistency, affordability, transport issues and patient awareness, particularly in low and middle income settings (Mamataz et al., 2022; Samad & Hanif, 2023). A protocol based on walking/cycling, RPE and HRR is feasible for outpatient physiotherapy departments because it does not require sophisticated cardiopulmonary exercise equipment for every patient.

Even so, service level recommendations should be cautious. This trial supports further testing of structured aerobic CR in local settings; it does not by itself establish scalability, cost-effectiveness, safety across higher-risk patients or long-term maintenance (Brown et al., 2024; Thomas et al., 2019).

LIMITATIONS

There are some limitations which require explicit acknowledgement. First, the sample was small and the single city recruitment frame limits external validity. Second, the trial was not prospectively registered in a public registry, which may be taken as a limit to reporting transparency. Third, two aerobic group participants discontinued before post testing and required LOCF imputation; therefore, the results remain sensitive to missing data assumptions. Fourth, although adherence was high, the sample size was too small to examine dose response relationships between attendance and outcomes. Fifth, SF-36 was administered in English with interviewer support when needed rather than through a validated local language version, which may affect cultural and linguistic measurement validity. Finally, physiological mechanisms such as endothelial function, autonomic balance and skeletal muscle oxidative capacity were not measured directly.

CONCLUSIONS

It can be concluded that a 10 week physiotherapist supervised aerobic exercise program delivered three times per week may produce greater improvement in functional capacity and health related quality of life than usual care cardiac rehabilitation among clinically stable post CABG patients. Because of some limitations already mentioned, the findings should be interpreted as exploratory preliminary evidence rather than definitive proof of effectiveness.

FUTURE RECOMMENDATIONS

Future research should prioritise following principal limitations directly arising from this trial: first, adequately powered with large sample size multicentre RCTs with prospective registration should be conducted; second, pragmatic comparison of standardised centre based, home based and hybrid CR models to improve access while preserving safety should be carried out; third, longer term follow-up assessing maintenance of functional gains, HRQoL, rehospitalization, return to work and cost effectiveness should be included in further studies; fourth, studies with SF-36 validated in local language translation should be incorporated and finally, physiological mechanisms eg muscle oxidative capacity, autonomic balance, endothelial functionality and others should be included to measurements.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY

Data is available on demand from the corresponding author.

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