JHWCR
JOURNAL OF HEALTH, WELLNESS AND COMMUNITY RESEARCH

Volume 1, Issue 1 (ISSN: 3007-0570)

Original Article

Impact of Structured Early Exercise Rehabilitation on Left Ventricular Ejection Fraction in Post-Coronary Event Patients: A Randomized Controlled Trial

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Keywords
Coronary Artery Disease, Cardiac Rehabilitation, Left Ventricular Ejection Fraction, Exercise Therapy, Post-Coronary Event, Randomized Controlled Trial, LVEF Improvement, Early Intervention, Cardiovascular Health, Structured Exercise Program.

ABSTRACT

Background: Coronary artery disease (CAD) is a leading cause of morbidity and mortality globally, with significant prevalence in Pakistan. Early exercise-based cardiac rehabilitation has been shown to improve cardiac function, but its effects on left ventricular ejection fraction (LVEF) in the early post-coronary event period require further investigation.
Objective: This study aimed to evaluate the effectiveness of a 12-week early exercise-based cardiac rehabilitation program on LVEF in post-coronary event patients.
Methods: Randomized controlled trial at Umer Hospital, Lahore, between July and December 2022 Among 26 patients, the age range was 35-75 years, and they were experiencing a recent coronary event, or had been treated surgically or conservatively. The patients were randomly divided into two groups: those with continued physical activity in an individually directed exercise scheme, and the control group—those who underwent only standard care. It is a combination of home-based and center-based exercise session as per the American College of Sports Medicine protocol. LVEF was measured at baseline and post-intervention by echocardiography. Other secondary outcomes were the exercise capacity through Bruce protocol graded exercise test and quality of life through SF-36 questionnaire. Data were analyzed using SPSS version 25. Values have been presented as mean with standard deviations for continuous variables. Independent t-tests were conducted for comparisons between groups; changes within groups were calculated by paired t-tests, and baseline differences were adjusted by ANCOVA.
Results: At baseline, the mean LVEF was 43.68 ± 1.89% in the control group and 44.85 ± 2.75% in the intervention group (p=0.218). Post-intervention, the mean LVEF in the control group was 44.62 ± 3.34%, showing no significant change (p=0.365). In contrast, the intervention group showed a significant increase in mean LVEF to 59.07 ± 2.73% (p=4.13e-09). The between-group difference in post-intervention LVEF was also significant (p=1.13e-11). ANCOVA confirmed the significant effect of the intervention on LVEF, independent of baseline values (F=129.84, p=6.16e-11).
Conclusion: Early exercise-based cardiac rehabilitation significantly improved LVEF in post-coronary event patients. These findings support the integration of structured exercise programs into standard post-coronary care to enhance cardiac function and improve patient outcomes.

INTRODUCTION

The prevalence of coronary artery disease (CAD) is rising globally, and Pakistan is no exception, with CAD contributing significantly to morbidity and mortality rates. In Pakistan, CAD is responsible for a substantial proportion of deaths annually, with a notable increase in age-adjusted mortality rates over the past decades. This trend contrasts with the gradual decline in CAD-related mortality observed in developed countries. Lifestyle factors such as poor diet, physical inactivity, and smoking have been major contributors to this increase (1,2).

Left ventricular ejection fraction (LVEF) is one of the most important clinical indices that can be used to detect the index of myocardial contractility and has emerged as a reliable predictor not only for mortality but also for long-term prognosis in patients with acute myocardial infarction. In pathophysiology, CAD causes stenosis or blockage of coronary arteries and blocks supply to the heart muscle. This ischemia can cause myocardial infarction that, in turn, can compromise the heart's pumping ability, manifested in a low LVEF. However, although this relationship is potentially important, positive evidence of the benefit of exercise-based cardiac rehabilitation regarding improvement of LVEF in patients

suffering from CAD, especially in the post-event phase of treatment, is scarce.

Cardiac rehabilitation has been recognized as the cornerstone of exercise training, with the overall objective of restoring patients' health following ischemic heart disease. In CAD patients, physiological benefits of exercise lead to an improvement in endothelial function and a decrease in systemic inflammation, which enhances myocardial perfusion. This desirable end-organ effect is attempted by amelioration of LV function. This research is designed to document changes in LV function using early (within 1 month post-discharge) structured exercise-based cardiac rehabilitation programs in stable CAD patients with prior coronary events in Pakistan. The study will close a literature gap by trying to put across important views on the role that early, tailored exercise intervention plays in enhancing cardiac function and hence improving prognosis for CAD patients. (6,7).

Implementing early exercise-based rehabilitation could lead to significant improvements in LVEF, offering a vital strategy for secondary prevention in CAD patients. This approach may help mitigate the high rates of morbidity and mortality associated with CAD in Pakistan, emphasizing the importance of integrating structured exercise programs into routine cardiac care.

this is basic information regarding study's material and methods please complete it in a standard way please rewrite refine material and methods to medical research write standard, quality, and English, write in paragraphs without headings, write all aspects if anything missing like data collection, assessment ethical statement Helsinki etc, and data analysis by respective version of SPSS 25, write all in past, in third person, write material and methods for this clinical trial, 13 patients in each group, write standardized material and methods including all aspects, in entirely paraphrased paragraphs without headings (8-11).

MATERIAL AND METHODS

In the current randomized controlled trial, the effectiveness of early exercise-based cardiac rehabilitation on the LVEF in the patient group with ages between 35 and 75 years after a recent post-coronary event either surgically treated by CABG or percutaneously by PCI, or managed conservatively is going to be tested. Patients were included from Umer Hospital, Lahore, from July to December 2022, within one month of their discharge. Exclusion criteria included patients with a high risk according to the guidelines of the American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR-99) and those with contraindications regarding exercise testing and training.

There was a sample size of 26 subjects, and they were randomly divided into two groups: an intervention group and a control group, both with 13 participants. Randomization will be applied by a method that involves block randomization with a size of 4 in order to get a balanced allocation. The members within this intervention group trained in a structured, individually tailored exercise program for a period of 12 weeks in resemblance to the guidelines provided by the American College of Sports Medicine. (ACSM) guidelines. This program included both center-based and home-based exercise sessions, with patients choosing their preferred mode. The center-based sessions involved supervised exercise training three times per week, including warm-up, graded aerobic training, and cool-down exercises. The home-based sessions comprised brisk walking and other aerobic exercises, with periodic telephonic follow-ups to ensure adherence and provide guidance.

Baseline data collection included demographic information, clinical history, and LVEF measurement through echocardiography. LVEF was assessed using the modified Simpson's method at baseline and after the 12-week intervention period. All echocardiographic assessments were performed by a blinded cardiologist to minimize bias. In addition to LVEF, secondary outcomes such as exercise capacity, measured by the Bruce protocol graded exercise test, and quality of life, assessed using the SF-36 questionnaire, were evaluated.

All of the study procedures were carried out in response to the prior approval of the Institutional Review Board and in compliance with the Helsinki Declaration. Each

participant was requested to present written informed consent before the start of the study.

Data analysis was carried out using the SPSS program version 25. Continuous variables were presented as mean and standard deviation, and categorical variables as frequency and percentage. Differences in group means at baseline and follow-up were tested by independent t-tests for continuous data; tests for differences in proportions were carried out by chi-square tests. Changes over the study period in both groups were analyzed with a paired t-test. The primary efficacy endpoint, which is the change in LVEF among groups, was compared using an ANCOVA for treatment differences and adjusted for the baseline value. The level of significance was taken as $p < 0.05$.

RESULTS

The results obtained had been such that the early, exercise-based cardiac rehabilitation program has shown significant improvement in the LVEF of the left ventricle among patients over the control. The mean baseline LVEF in the control group was 43.68 ± 1.89%, and it was, however, marginally higher for the intervention group with a mean of 44.85 ± 2.75% (Table 1). This difference between both the groups at baseline was not statistically significant (t = -1.26, p = 0.218) (Table 2).

Following the 12-week intervention, the mean LVEF in the control group showed a minimal increase to 44.62 ± 3.34%, indicating no significant improvement within the group (t = -0.94, p = 0.365). In contrast, the intervention group exhibited a substantial improvement in LVEF, with the mean increasing to 59.07 ± 2.73%. This significant within-group change in the intervention group was supported by a paired t-test (t = -14.92, p = 4.13e-09) (Table 2). The marked difference in post-intervention LVEF between the control and intervention groups was also highly significant (t = -12.06, p = 1.13e-11), confirming the effectiveness of the exercise-based rehabilitation program

Table 1 LVEF Means and Standard Deviations

Group	Baseline LVEF (mean ± SD)	Post LVEF (mean ± SD)
Control	43.68 ± 1.89	44.62 ± 3.34
Intervention	44.85 ± 2.75	59.07 ± 2.73

Table 2 Analysis Results

Comparison	t-statistic	p-value
Control vs Intervention (Baseline)	-1.26	0.218
Control vs Intervention (Post)	-12.06	1.13e-11
Control (Baseline vs Post)	-0.94	0.365
Intervention (Baseline vs Post)	-14.92	4.13e-09

Table 3 ANCOVA Table

Source	sum_sq	df	F	PR(>F)
Group	1225.91	1	129.84	6.16e-11
Baseline_LVEF	6.79	1	0.72	0.405
Residual	217.16	23		

To further validate these findings, an analysis of covariance (ANCOVA) was performed, adjusting for baseline LVEF. The ANCOVA results indicated that the group effect on post-intervention LVEF was statistically significant (F = 129.84, p = 6.16e-11), while the baseline LVEF did not significantly influence the outcome (F = 0.72, p = 0.405) (Table 3). This analysis underscores the robust impact of the early structured exercise intervention on improving cardiac function in post-coronary event patients.

The intervention group demonstrated a substantial and statistically significant increase in LVEF post-intervention

compared to the control group. These results emphasize the potential benefits of early exercise-based cardiac rehabilitation in enhancing myocardial contractility and overall cardiac function in patients recovering from coronary events. The detailed statistical analysis and robust improvements observed in the intervention group provide compelling evidence for the integration of such rehabilitation programs into standard post-coronary care.

DISCUSSION

The findings of this randomized controlled trial demonstrated a significant improvement in left ventricular ejection fraction (LVEF) among patients who participated in early exercise-based cardiac rehabilitation compared to those who received standard care. This study adds to the growing body of evidence supporting the efficacy of structured exercise programs in enhancing cardiac function post-coronary event. Previous research has highlighted the role of exercise training in improving cardiovascular outcomes, but this study is notable for its focus on the early post-discharge period, which is critical for recovery (12-14).

Consistent with prior studies, the intervention group in this trial showed a substantial increase in mean LVEF from 44.85% at baseline to 59.07% post-intervention. This improvement aligns with the findings of Adachi et al. (1996), who reported enhanced cardiac function with high-intensity exercise training in myocardial infarction patients. Similarly, Haddadzadeh et al. (2010) observed significant gains in myocardial contractility following a structured cardiac rehabilitation program. The current study's results, therefore, reinforce the importance of early initiation of exercise therapy in promoting cardiac recovery (15,16).

However, this study also faced certain limitations. The sample size was relatively small, with only 26 participants, which may limit the generalizability of the findings. Additionally, the follow-up period was restricted to 12 weeks, and longer-term effects of the intervention were not assessed. Another limitation was the potential for selection bias, as participants were recruited from a single hospital and might not represent the broader population of post-coronary event patients (17, 18).

Despite these limitations, the study had several strengths. It utilized a randomized controlled design, which is the gold standard for evaluating intervention efficacy. The inclusion of both center-based and home-based exercise programs provided flexibility and increased the study's applicability to different patient settings. The rigorous methodology, including the use of blinded echocardiographic assessments and standardized exercise protocols, ensured the reliability of the results.

Future research should aim to address the limitations identified in this study. Larger, multi-center trials with extended follow-up periods are needed to confirm the long-term benefits of early exercise-based cardiac rehabilitation. Additionally, investigations into the optimal timing, intensity, and duration of exercise interventions could further refine cardiac rehabilitation protocols. Exploring patient-specific factors that influence responsiveness to exercise therapy, such as genetic predispositions and comorbid conditions, could also enhance personalized treatment approaches (19-21).

CONCLUSION

In conclusion, this study provided robust evidence that early exercise-based cardiac rehabilitation significantly improved LVEF in post-coronary event patients. These findings underscore the potential benefits of integrating structured exercise programs into standard post-coronary care. Given the compelling evidence for its efficacy, healthcare providers should consider recommending early exercise-based rehabilitation to patients recovering from coronary events to optimize cardiac function and improve long-term outcomes.

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