Original Article

Effect of Cycle Ergometery on Functional Capacity and Pulmonary Function in Phase – I Cardiac Rehabilitation

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Abstract

Background: Pulmonary complications are most common after the coronary artery bypass grafting. The vital role of Cardiac Rehabilitation is to prevent complication, improve functional capacity & enhance QoL of patients. The core component of rehabilitation is aerobic exercise training. Cycle ergometers have been proposed as an alternative in early cardiac rehabilitation. Therefore, the aim of study is to find out the effectiveness of cycle ergometer on functional capacity and pulmonary functions in patients with CABG surgery. **Subjects and Methods:** A prospective randomized control trial was conducted in patients who underwent for elective CABG surgery. Total 44 patients were screened and 33 patients recruited who met with an inclusion criterion. Those were allocated into two groups i.e., control group and experimental group by Balance block - computer - generated randomization. Control group received conventional therapy and experimental group received cycle ergometer start with 3 minutes and progress up to 5 minutes along with conventional therapy twice a day till the discharge. In the study, 6-minute walk test, Maximum inspiratory pressure (MIP) and Chest expansion were assessed at baseline and at time of discharge. **Results:** There is significant improvement found at time of discharge in 6 MWT distance, MIP and chest expansion as compared to baseline in both the groups. But there is no statistically significant difference seen in 6 MWT distance, MIP and chest expansion as compared to control group. **Conclusion:** Incorporation of cycle ergometer with conventional physiotherapy was not giving any additional benefits to 6-minute walk test distance, Maximum inspiratory pressure and Chest expansion between two groups.

Keywords: 6-minute walk test, cycle ergometer, functional capacity, Phase – I Cardiac rehabilitation, chest expansion, maximum inspiratory pressure.

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Introduction

CAD was discovered to be one of the leading causes of disability and death in the Indian population. CAD is an atherosclerotic disease which is inflammatory in nature, manifested by stable angina, unstable angina, myocardial infarction (MI), or sudden cardiac death.[1] Indians are more likely to be hospitalized for CAD complications 2 to 4 times related to other ethnic groups, and admission rates are superior for individuals under the age of 40 about 5 –10 times.[2] The causes of CAD are multifactorial like sedentary lifestyle, smoking, diabetes, hyperlipidemia, hypertension, homocystinuria, lack of physical activity, obesity and stress.

Developing country like, India is currently going through a transformation in its epidemiology due to its high rates of urbanization. This has improved the economy, which has increased fast food and tobacco use as well as decreased physical activity as a consequence.[3] Based on severity of symptoms and heart disease progression, which needs a plan for surgical interventions viz Percutaneous Trans-coronary Interventions (PTCA) and coronary artery bypass graft surgery (CABG). CABG is the main treatment for patients with severe refractory angina pectoris and extensive coronary artery disease, and it has rapidly become the standard of care for symptomatic patients with coronary artery disease and procedures designed to restore blood flow to the myocardium.[4,5] After CABG, postoperative problems are relatively common and may be accompanied by a prolonged hospital stay. Decreased ventilation, Atelectasis, pleural effusion, and pneumonia are the most common pulmonary problems.[6] Postoperative complications frequently occur after CABG, increasing anxiety levels and reducing quality of life (QoL). Rehabilitation is vitally important to prevent post-operative complications, reduce anxiety & hospital stay and improve QoL.[7,8,9]

According to the American Heart Association (AHA), "Cardiac rehabilitation (CR) is a medically supervised program with the ultimate goal of restoring & maintaining patient's optimal physical, psychological, social, and vocational status.[10] The

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component of CR includes nutritional counselling, weight management, blood pressure management, lipid management, diabetic management, tobacco cession, psychosocial counselling, physical activity monitoring and aerobic exercise training. The core component of cardiac rehabilitation is aerobic exercise training.[11] Phase – I rehabilitation protocol includes respiratory therapy and early mobilization. Its objectives are to improve ventilation-perfusion matching, improve lung volumes and airway clearance. It consists of different airway clearance techniques, Incentive Spirometry, lung expansion therapy, and early mobilization. In aerobic training, different modes of exercise are available. According to recent advances, cycle ergometers have been proposed as an alternative in early CR. This simple to use stationary equipment allows lower limb exercise training during voluntary active cycling with or without resistance. As there is dearth of literature available on use of cycle ergometer training in Phase -1 CR in India, which may help to recover respiratory muscle strength & pulmonary function, functional capacity and improve QoL.

Objective

The objective of the study is to find out the effectiveness of the cycle ergometer on functional capacity and pulmonary functions in patients with CABG surgery.

Materials and Methods

Study Design: It was an experimental, prospective, randomized control trial study designed. In this study a balance block - computer - generated randomization method was used for sample recruitment.

Study setting: Patients were admitted for elective coronary artery bypass grafting (CABG) and referred for physiotherapy from B M Patel cardiac Center, Karamsad.

Sample size: The estimated sample size was done by a previous published study, and detected a statistically significant difference of 60 meters between the mean maximum distances walked in the 6MWT with a power of 80%, and considering 5% level significance, a sample size of 23 in each group is required.

Patients above 45 years of age, of both genders, undergoing CABG for the first time and who were hemodynamically stable were included in the study. Patients who were on mechanical ventilation for more than 24 hours, had musculoskeletal, neurological, or peripheral vascular impairments, were known cases of respiratory diseases, or had left main coronary artery stenosis with or without an ejection fraction of less than 30% were excluded from the study.

Ethical Approval: Prior to commencing the study, approval from the Institutional Ethics Committee (IEC/ BU/ 137/ Faculty/15/2022 dated on 28/06/2022) was taken. The Helsinki Declaration 2008 ethical guidelines were also followed. This trial was registered in the clinical registry of India (CTRI/2022/07/044295 registered on 25/07/2022). After explaining the purpose & procedure of the present study, a written consent form was obtained from each participant.

The medical history reviewed and relevant investigations were recorded as per requirement. Then patients were divided into two groups, Group A and Group B.

Group A was given conventional physiotherapy of phase – I cardiac rehabilitation which included the education, breathing exercise, chest mobility exercise, incentive spirometery and forced expiratory techniques) on the second post-operative day. On the 3rd day after surgery – sitting on the edge of the bed and standing next to it. On 4th postoperative day –ambulation was initiated inside the ICU with or without oxygen support and along with close monitoring of vital parameters. The progression of ambulation was done according to the level of hemodynamic stability and patient tolerance. Starting from the 5th postoperative day, stair climbing was initiated. The entire exercise protocol was followed until the patients were discharged.

Group B received cycle ergometry training for up to 5 minutes, along with a conventional physiotherapy protocol. A tailored cycle ergometry protocol began on the 3rd postoperative day in a chair-sitting position, starting with 3 minutes and progressing up to 5 minutes based on patient tolerance and hemodynamic stability. Increment of dosage is done with monitoring of VAS (visual analogue scale of incisional pain). To ensure the safety of training, the hemodynamic parameters like pulse rate, respiratory rate, SPO_2 were monitored and kept within 20% of the baseline value during the training session. During the study, if a participant experiences any clinical symptoms or discomfort, they will be excluded from the study, and the consultant will be informed accordingly.

Physiotherapy treatment sessions were delivered to the patients by a physiotherapist. The physiotherapy treatment session started 2 hours after extubation in the ICU, conducted five times per day. The average ICU stay of the patients was around 3 days, after which they were shifted to a step-down unit. In step down unit, physiotherapy sessions continued four times a day till the time of discharge. The cycle ergometery was performed twice a day after the patients shifted to step down unit. The outcome measures functional capacity by six-minute walk test (6MWT), maximum inspiratory pressure (MIP) and chest expansion were taken before surgery (preoperative or baseline) along with demographic data, vitals parameter, laboratory and radiological investigations and at the time of discharge of the patient.

Statistical Analysis: Statistical analysis done by using STATA 14.2, where descriptive statistics of continuous variables, an independent sample t test is used to compare the difference of mean value (preoperative and at time of discharge) in 6MWT distance, maximum inspiratory pressure and chest expansion parameters between both the groups and paired t test is used to compare all continuous variables preoperative and postoperative (at time of discharge) within the both groups. The significant level for statistical analysis was considered at 5% for every comparison. ($P < 0.05$).

Results

The basic demographic details of both the groups were taken at baseline (preoperative), which were homogenous in distribution (no significant difference) for age, gender, BMI, and

postoperative hospital stay. [Table 1] The difference of 6MWT distance baseline and at discharge in both the groups showed similar improvement at the time of discharge with statistical significance. [Table 2] But table – 3 showed the mean difference of 6MWT distance baseline and at discharge between the both groups, showed both groups no statistically significant at baseline and at discharge.

In Group A, preoperative median was 330 meters and the minimum & maximum variation range was 300 meters and 390 meters respectively, and at the time of discharge median was 410 meters and minimum and maximum variation range was 360 meters and 420 meters respectively. In Group B, preoperative median was 360 meters and minimum & maximum variation range was 300 meters and 390 meters respectively and at time of discharge median was 400 meters and minimum and maximum variation range was 360 meters and 420 meters respectively. There was improvement seen in within the group but similar effect was seen between group. [Figure 1] The difference between the MIP baseline and discharge in both groups showed a similar improvement at the time of discharge, achieving statistical significance. However, the mean difference of the MIP baseline and discharge between the two groups revealed that neither group was statistically significant at baseline or discharge [Tables 4 and 5].

In Group A, preoperative median was 56 cmH_2O and the minimum & maximum variation range was 52 cmH_2O & 60 cmH_2O respectively, and at the time of discharge median was 58 cmH_2O and the minimum & maximum variation range was 54 cmH_2O & 62 cmH_2O respectively. In Group B, preoperative median was 55 cmH_2O and the minimum & maximum variation range was 50 cmH_2O & 58 cmH_2O respectively, and at time of discharge median was 58 cmH_2O and the minimum & maximum variation range was 53 cmH_2O & 60 cmH_2O respectively. There was improvement seen within the group, but a similar effect was seen between groups but Group B had greater variation in range compared to Group A [Figure 2]. The difference of chest expansion baseline and at discharge in both the groups at the level of axillary, nipple and xiphisternal showed similar improvement at the time of discharge. There was statistically significant difference in chest expansion at the level of axillary, nipple and xiphisternal in both the groups except nipple level in Group B. [Table 6] The mean difference of chest expansion at all 3 levels at baseline and at discharge between both groups had no statistically significant difference. [Table 7]

Figure 1: Performing Cycle Ergometer.

Figure 2: Performing 6MWT.

Table 1: Basic Demographic characteristics of participants in both groups

Variables		Group – A	Group – B	Sig. two tailed (P value)
Total n = 33		N = 16	N = 17	
Age (Years)		64.63 ± 8.69	61.35 ± 8.68	0.288
Gender	Male	10	14	0.259
	Female	6	3	
BMI (kg/m2)		24.98 ± 3.56	26.06 ± 4.48	0.452
Postoperative hospital stays		8.06 ± 1.12	7.47 ± 1.41	0.196

p-value:<0.05

BMI – body mass index, Group A conventional physiotherapy, and Group B conventional physiotherapy + cycle ergometer.

Table 2: 6MWT distance in 'baseline' and 'at discharge' within group comparison using Paired t test

Group	Baseline (preoperative)	At discharge	Sig. two tailed (P value)
A	343.13 ± 40.94	397.50 ± 27.20	<0.001*
B	350.00 ± 24.49	395.29 ± 25.03	<0.001*

p-value:<0.05

Table 3: 6MWT distance in 'Baseline' and 'at discharge' between group comparison using independent sample t test

Group	Mean difference of 6MWT distance	Sig. two tailed (P value)
A	54.38 ± 30.10	0.313
B	45.29 ± 20.04	

p-value:<0.05

Table 4: MIP in 'baseline' and 'at discharge' within group comparison using Paired t test

Group	Baseline (preoperative)	At discharge	Sig. two tailed (P value)
A	55.69 ± 2.39	57.88 ± 2.03	<0.001*
B	55.29 ± 2.54	57.36 ± 2.29	<0.001*

p-value:<0.05

Table 5: MIP in 'baseline' and 'at discharge' between group comparison using independent sample t test

Group	Mean difference of MIP	Sig. two tailed (P value)
A	2.19 ± 1.60	0.810
B	2.06 ± 1.29	

p-value:<0.05

Table 6: Chest expansion in 'baseline' and 'at discharge' within group comparison using Paired t test

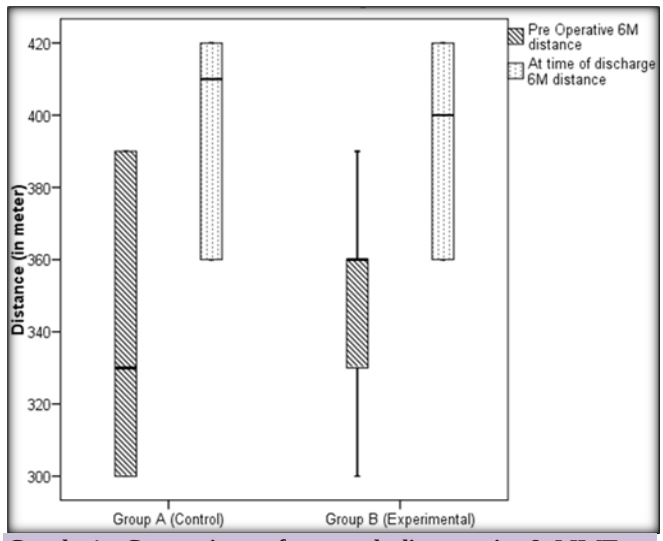
Group	Chest expansion level	Baseline (preoperative)	At discharge	Sig. two tailed (P value)
A	Axillary level	2.31 ± 0.31	2.71 ± 0.44	0.005*
	Nipple level	3.12 ± 0.22	3.40 ±0 .20	0.001*
	Xiphisternal level	3.69 ± 0.25	4.09 ± 0.20	<0.001*
B	Axillary level	2.38 ± 0.45	2.82 ± 0.30	<0.001*
	Nipple level	3.32 ± 0.35	3.41 ± 0.20	0.332
	Xiphisternal level	3.91 ± 0.19	4.12 ± 0.21	0.004*

p-value:<0.05

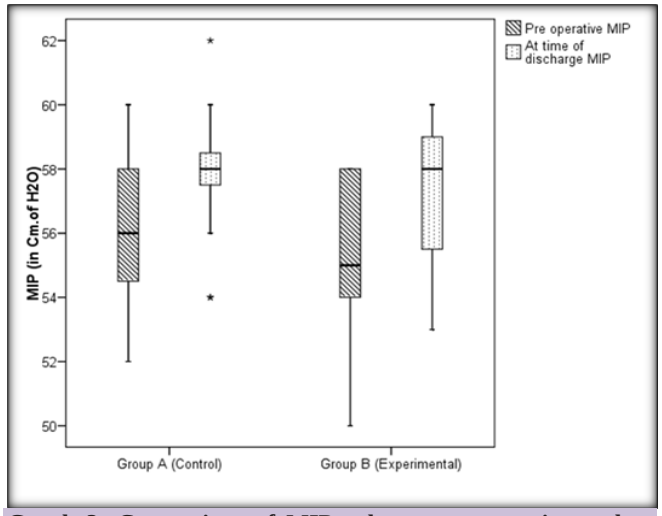
Table 7: Chest expansion 'at Axillary level, Nipple level, Xiphisternal level' in 'baseline' and 'at discharge' between group comparison using independent sample t test

Group	Chest expansion level	Mean difference of chest expansion	Sig. two tailed (P value)
A	Axillary level	0.41 ± 0.49	0.814
B		0.44 ± 0.35	
A	Nipple level	0.28 ± 0.26	0.090
B		0.09 ± 0.36	
A	Xiphisternal level	0.40 ± 0.20	0.068
B		0.20 ± 0.25	

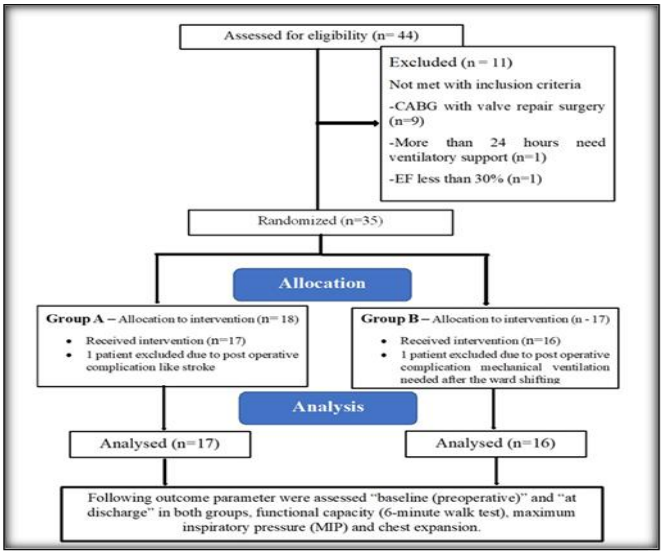
p-value:<0.05



Graph 1: Comparison of covered distance in 6 MWT at preoperative and at time of discharge.



Graph 2: Comparison of MIP value at preoperative and at time of discharge.



CONSORT DIAGRAM OF THE STUDY

Discussion

Cardiac Rehabilitation is vitally important to prevent post-operative complications, reduce psychological symptoms like anxiety and depression, reduction in hospital stay and improving quality of life. Phase – I cardiac rehabilitation during the hospital stay should be focused on restoring the pulmonary functions, improving physical & functional capacity and enhancing the quality of life of patients.[7,8,9,12]

However, there is a tendency for superiority to the alternative protocol, which used a cycle ergometery to replace walking and stair climbing training.[13] The purpose of carrying out a different rehabilitation plan that makes use of a cycle ergometery is to safely avoid the adverse effects of extended bed rest from a cardiorespiratory standpoint. Additional benefits of using this ergometer include the possible reduction in fall risk since the patient is already seated and supported with both hands, the ability to exert a continuous and longer effort, and the capability to monitor vital signs throughout the peak of exercise-induced metabolic demand.[13]

A total of 44 participants were assessed and screened for cardiac rehabilitation who underwent CABG surgery. A total of 11 patients were excluded for not meeting the inclusion criteria. Hence, Total 33 participants were randomly divided by using balance block randomization into two groups. Group A (n = 16) is the control group who received the conventional physiotherapy and Group B (n = 17) who received cycle ergometery along with the conventional physiotherapy.

In the present study, both groups showed similar improvement at the time of discharge, with statistically significant results ($P < 0.001$) as shown in [Table 2]. However, when comparing both groups, there was no statistically significant difference in the 6MWT.

AL Cordeiro et al. conducted a study to see the early mobilization in patients of coronary artery bypass grafting. The mobilized group received bed transfers and was assisted in sitting in an armchair on the 1st postoperative day, followed by ambulation on the 2nd postoperative day. The non-mobilized group underwent passive kinesiotherapy in bed. The beneficial effect of early mobilization was observed in patients, leading to improvements in functional outcomes by maintaining muscle strength and functionality.[14]

Similarly, the findings of the study conducted by J. N. Mehta,[15] on patients after open-heart surgery, following physiotherapy utilizing inspiratory muscle training, observed functional capacity in the form of the 6MWT and showed significant improvement within the groups. This could be because both groups received conventional physiotherapy, including early mobilization and early ambulation, which had a beneficial impact on functional capacity.

Daniel da Costa Torres conducted a study to know the effectiveness of early mobilization on functional capacity after coronary artery bypass grafting in which they had given a breathing exercise and aerobic exercise training as part of intervention. They have found improvement in 6MWT distance with alternative protocol which was given to the interventional group.[16] Though the study was conducted for Phase – I cardiac rehabilitation but the duration of treatment session was different including warm up and cool down period. Also, NIV support

was given to maintain tidal volume. Hence, they got improvement in 6-minute walk test distance. M D Trevisan et al. conducted a randomized control trial on cycle ergometery training during hospital rehabilitation for CABG patients where 27 individuals were included, divided into two group control and alternative group. Alternative group received cycle ergometery from 3rd postoperative day for 20 minutes two times per day and along with conventional therapy while control group received conventional therapy. It concluded that both regimens, with a tendency towards superiority in the cycle ergometery group, were equally successful in promoting increased maximum distance walked in the 6MWT in patients who completed physical therapy rehabilitation following CABG.[13]

RCT was conducted by DL. Borges et al,[17] in which 34 CABG were included and randomly divided into two groups. The intervention group received cycle ergometry without load, starting from the ICU. Patients were in a 45° Fowler position and performed cycle ergometry for 5 minutes. In the ward, they performed for 10 minutes on the first and second days and for 20 minutes from the third day until hospital discharge, along with conventional therapy. Meanwhile, the control group received only conventional therapy. It was concluded that, as compared to standard physiotherapy, early application of aerobic exercise to CABG patients may enhance maintenance of functional ability while having no effect on pulmonary function and respiratory muscle strength.[14] In comparison to our study, cycle ergometry was performed in the ward for 3 minutes and progressed up to 5 minutes based on the patient's tolerance level and hemodynamic stability. In contrast, they started cycle ergometry during the ICU stay, and its duration was 20 minutes. Therefore, compare to this studies duration for protocol was less in present study which could be reason for not significant improvement seen in intervention group.

[Table 4] shows difference of MIP at Baseline and at Discharge in Group A and B, both groups showed similar improvement at time of discharge with statistically significant. Siriluck M conducted a study on 90 CABG patients, who were divided into a control group and an interventional group. They concluded that on day 4 following CABG, participants in the combined DBE and incentive spirometry group recovered their inspiratory muscle strength considerably better than those in the DBE-only group.[18] Similarly to the present study, both groups received incentive spirometry and diaphragmatic breathing exercises. Therefore, the similar significant improvement observed in maximum inspiratory pressure after surgery in both groups could be attributed to these interventions. The mean difference in MIP between baseline and discharge for both groups was not statistically significant [Table 5]. Graziella FB conducted a study on respiratory muscle training in patients who underwent CABG, involving 46 patients divided into two groups. The control group received conventional therapy, including bronchial hygiene, tracheal stimulation, and postural drainage. And Respiratory Muscle Training (RMT) group received conventional physiotherapy along with RMT with threshold device and 3 sets of 10 repetitions, once a day and load of 40% of initial MIP value. They concluded that training respiratory muscles could help regain MIP, maximum peak expiratory flow, and expiratory pressure.[19] A similar effect was found in the present study for MIP; however, in their study, respiratory muscle training was targeted, whereas in the present study, lower limb muscles were trained. That means, peripheral muscle strengthening is also important in operated case for CAD.

The difference of chest expansion baseline and at Discharge within both the groups at the level of axillary, nipple and xiphisternal showed similar improvement at time of discharge. There was a statistically significant difference in chest expansion within both groups, whereas the difference between the groups was not statistically significant [Table 6]. Ashifa Sheikh conducted a case series study on the effect of inspiratory muscle training on chest expansion in patients undergoing CABG. A total of five postoperative CABG patients with respiratory complications performed inspiratory exercises for three consecutive days, ten times every two hours while awake They measured chest expansion using a measuring tape. An increasing trend in chest expansion was observed on the 3rd postoperative day. The study stated that the use of incentive spirometery exercise improves chest expansion in post CABG patients on 3rd POD significantly.[20] The thoracic mobility exercise was given in both groups following CABG as standard care of treatment in present study. Therefore, a significant improvement in chest expansion was observed postoperatively compared to preoperative values in both groups.

Conclusion

The incorporation of a cycle ergometery with conventional physiotherapy did not provide any additional benefits in terms of 6-minute walk test distance, maximum inspiratory pressure, and chest expansion when compared between the two groups. However, significant and comparable improvements were observed within each group for these parameters.

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Conflicts of interest

There are no conflicts of interest.

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