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Effect of Tele-Cardiac Rehabilitation Program on Functional Independence, Hand Grip Strength, and Functional Capacity in Patients with Coronary Artery Bypass Graft

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ABSTRACT

Background: Coronary artery bypass graft (CABG) is the most common treatment for relieving symptoms and reducing early mortality in patients with coronary artery disease. Cardiac rehabilitation (CR) is a standardized physical and functional enhancement program. The referral rate for cardiac rehabilitation post-operatively is very low, and further compliance is a bigger problem. Tele cardiac rehabilitation is beneficial for increasing participation in CR. Therefore, this study will assess the effect of tele CR on patients with CABG.

Methods: A randomized controlled trial was conducted in a multispecialty hospital for four years. A total of 48 consecutive CABG patients were included and divided into a telerehabilitation and home exercise group through convenient sampling. Patients of both groups were unaware of group allocation and were assessed for functional independence, hand grip strength, and 6-minute walk test distance at discharge, at 1 month, and at 3 months post-discharge.

Results: At 3 months post-discharge, patients in the tele cardiac rehabilitation group showed statistically significant improvement in functional status (p=0.041) and functional capacity (p=0.019). Hand grip strength was not different in both groups (p=0.162) after 3 months of discharge.

Conclusion: Tele-cardiac rehabilitation benefits patients with CABG who cannot attend center-based cardiac rehabilitation and want to improve their daily lives.

Keywords: Tele cardiac rehabilitation, CABG, ADLs, Exercise program, quality of life, functional status.

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INTRODUCTION

Cardiovascular diseases (CVDs) are the primary cause of morbidity and mortality in India. In contrast to the prevalence of cardiovascular diseases in individuals of Western descent, Indians are affected at least several years earlier, particularly during their most productive middle age. For example, in India, the incidence of death due to CVDs before the age of 70 years is twice that of its Western counterpart [1]. One of the most common surgeries for this fatal condition is coronary artery bypass graft (CABG). It is done to eliminate CAD symptoms and can lower high-risk patients' premature mortality [2].

Following CABG, physical function may decline as a result of activity restrictions brought on by the surgical procedure and anxiety about activity aggravating symptoms. Many qualitative and descriptive research studies on CABG patients have concluded that surgery-specific factors limit the patient's function [3]. While most CABG patients can execute basic self-care tasks, they struggle with instrumental activities of daily living (ADLs), which makes them more reliant on others and lowers their health-related quality of life. However, as patients gain confidence and the length of time after surgery grows, most ADLs get better [4,5, 6]

Cardiac rehabilitation (CR) is an evidence-based inter disciplinary program that reduces morbidity, mortality, and hospital readmissions and increases independence and quality of life. CR includes guided physical activity, health education, risk factor modification, stress management, etc., and is a Class IA recommendation in the 2021 American College of Cardiology (ACC) and American Heart Association (AHA) guidelines [7]. Despite these suggestions, India's CR participation rate is still relatively low. Worldwide, the referral rate for CR ranges from 9% to 39%. However, only 6 to 59 % of referred patients participate in such a program. According to many studies, some common factors are associated with low referral in CR, including low rate of referral by primary surgeons, associated comorbidities, insurance reimbursement, self-belief in perceived benefits of CR, transportation problems, self-motivation, family social support, and absenteeism at work [8-10].

Telecardiac rehabilitation (CR) enables the execution of cardiac rehabilitation at home through portable and remote communication and monitoring devices. It can be a substitute for center-based CR and has numerous benefits, including cost-effectiveness, less absenteeism from work, decreased re-hospitalization rate, etc. R. W. M. Brouwers (2020) states that CR can improve functional independence and capacity. It also helps to improve upper extremity function, including grip strength, which leads to improvement in ADLs [11].

Tele cardiac rehabilitation has proven beneficial, but the above factors lead to low participation. To address these issues, regular participation through telerehabilitation provides a viable option for perceived benefits similar to center-based cardiac rehabilitation. Even two systematic reviews done by Frederix I et al. (2015) and by Rawstorn JC et al. (2016) also concluded that telerehabilitation resulted in fewer adverse events and fewer re-hospitalization rates, higher physical activity levels, better adherence to physical activity guidelines, and improved quality of life. Therefore, this study aimed to assess telecardiac rehabilitation's effect on functional independence, hand grip strength, and functional capacity in patients with CABG [12-13].

METHODS

A randomized controlled study was conducted from 2019 to 2023 in the 'Matsama Heart Center' of Dhiraj Hospital in the Vadodara district of Gujarat state, India. This research followed the CONSORT (Consolidated Standards of Reporting Trials) guidelines.

After the approval of Sumandeep Vidyapeeth Institutional Ethics Committee (SVIEC) and Clinical Trial Registry India (CTRI/2018/05/013575), every consecutive patient referred for Physiotherapy, who underwent routine physiotherapy, i.e., Cardiac Rehabilitation phase I, and had an uneventful recovery (without any post-operative complications) during their post-operative stay, was approached for the study. On the day of discharge from the hospital, patients willing to participate were requested to give consent, and after their written consent, they were enrolled in the study.

Patients of both genders who understood Hindi/English/Gujarati language were included in the study. In contrast, patients having post-operative complications during their hospital stay, cognitive deficits prohibiting an understanding of the research questionnaires, and a history of neurological, musculoskeletal, or pulmonary problems before surgery that interfere with ADLs were excluded from the study.

After the eligibility screening, 66 patients were enrolled and divided into two groups based on their ability to use technology like video calls. Thirty patients who had the facility of video call through WhatsApp were recruited in Group A, i.e., the continuous monitoring group, and 36 patients who did not have the facility of video call and were not very familiar with the technology were recruited in Group B, i.e., the home program group. Both the groups were given the same 'Rehabilitation home program' (Aerobic and Strengthening exercise program of 12 weeks) as a handout (Appendix - 1). A 12-week program of Aerobic and strengthening exercises was given according to the American College of Sports Medicine's (ACSM) FITT principle. Patients of Group A were continuously monitored using video calls. The monitoring was done a minimum of twice a week, and on the other days, they were asked to continue exercising and maintain the daily exercise diary. In contrast, patients of Group B were advised to comply with the instructions on how to carry out exercises to continue their exercises and remain active. They were also asked to maintain their daily work diary. At the end of 12 weeks, data from 18 patients in Group A (nine males and nine females) and 30 patients in Group B

(13 males and 17 females) were analyzed after the drop-out. (Figure 1)

At the time of discharge, the baseline data of the patients of both groups were measured. They were assessed on their current functional status on the Functional Independence Measure scale (FIMS) [14], Hand grip strength with standard procedure (assessed with the help of JAMAR dynamometer) [15], and functional capacity with a 6-minute walk test distance (performed as per American Thoracic Society guidelines) [16]. These outcome measures were reassessed on follow-ups at the end of 1 month and 3 months post-discharge, respectively. Patients (of both groups) coming for follow-up at the end of 1st month were asked about their progress in terms of exercises, and necessary guidance was also given personally about further progression.

Instruments like a JAMAR hand-held dynamometer (JLW instruments, model number WBB2224014) [15] for hand grip strength, a stopwatch, and two cones for a 6-minute walk test to mark the turnaround points were used to measure outcome measures. The functional independence measures (FIMS) scale assessed functional independence.

RESULTS

Groups were homogeneous in terms of demographic, clinical, and surgical variables. The baseline demographic and clinical characteristics of patients of both groups are summarized in Table 1. There was no significant difference between groups regarding age, sex, body mass index, smoking history, comorbidities, left ventricular ejection fraction, or number of affected vessels. Similarly, there were no significant differences between the groups' anesthesia and surgical parameters. During the recruitment period, 94 CABG patients were screened for eligibility (figure 1). Of these, 66 fulfilled the inclusion criteria and were enrolled. Both groups received similar care per standard guidelines for their immediate post-operative hospital stay following CABG. Thirty (30) patients were enrolled in telecardiac rehabilitation (group A), and 36 were enrolled in a home program (group B). However, after the 3-month follow-ups, data from 48 patients were finally analyzed after drop-out (figure 1).

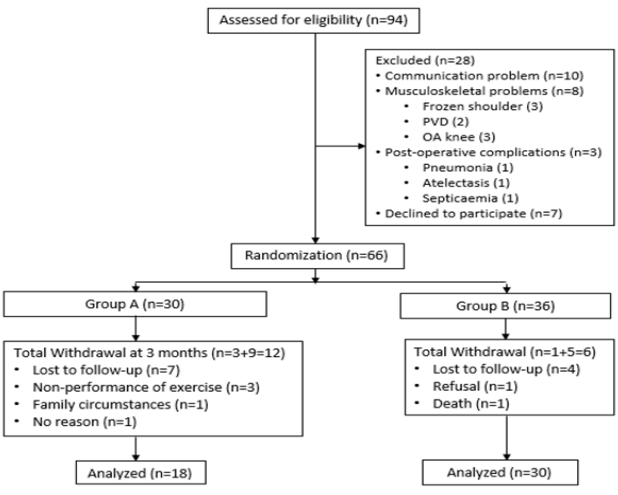

Figure 1: Study flow chart

Abbreviations: PVD - Peripheral vascular disease, OA - Osteoarthritis

Variable	Group A	Group B
Age (years)	61.22 + 6.958	60.97 + 7.810
Gender Male	9 (50%)	13 (43.3%)
Female	9 (50%)	17 (56.7%)
BMI (kg/m2)	24.317 + 2.2781	25.847 + 3.3945
History of smoking	6 (33%)	13 (43%)
Comorbidity		
Diabetes	9	16
Hypertension	10	16
Hypercholesterolemia	4	6
Diabetes	1	2
COPD	0	0
Ejection fraction (%)	45 + 15	51 + 13
Affected vessels		
Single vessel	0	3
Double vessel	5	11
Triple vessel	12	16

Table 1: Baseline demographic and clinical patient characteristics

Abbreviations: BMI - Body Mass Index, COPD - Chronic Obstructive Pulmonary Disease.

Functional independence at 3 months post-CABG in both groups is shown in Figure 2 and Table 2. There was no statistically significant difference in functional independence measured through FIMS between groups at discharge and 1st follow-up. In both groups, there was a significant improvement in functional independence from discharge to follow-ups. However, functional independence in the telecardiac rehabilitation group had significantly higher independence compared with the control group patients (p=0.0401) at a 95% confidence interval.

FIMS	Group	Mean	SD	p-value
At Discharge	Group A	107.50	5.079	.0593
	Group B	106.23	3.468	
1st Follow-up	Group A	115.67	3.430	.0773
	Group B	113.77	3.579	
2nd Follow-up	Group A	119.33	2.326	.0401
	Group B	115.13	2.408	

Table 2: Comparison of Functional independence measured with FIMS between the groups

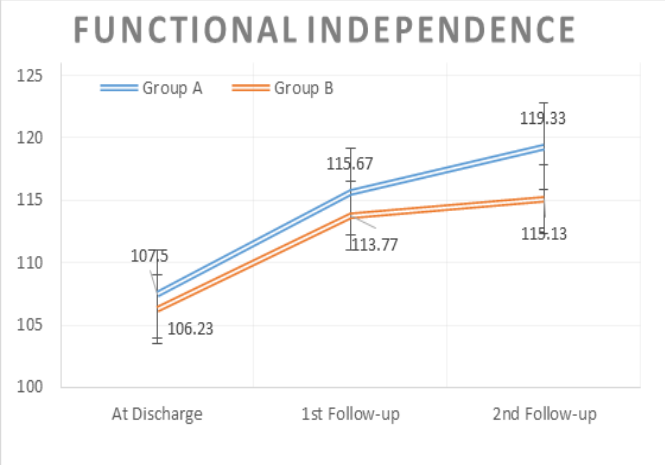

Figure 2: Functional independence (FIM) at discharge, at 1-month & 3-month follow-up after CABG compared between telecardiac rehabilitation (Group A) and home program group (Group B).

Data on hand grip strength at the 3 months post-CABG in both groups is shown in Figure 3 and Table 3. There was no statistically significant difference in hand grip strength of the dominant side between groups at discharge and 3rd follow-up. However, both groups had significant clinical improvement in hand grip strength from discharge to follow-ups. Further, hand grip strength in the telecardiac rehabilitation group at 1st follow-up had a significantly higher strength compared with the control group (p=0.0401).

Hand grip Strength (kg)	Group	Mean	SD	p-value
At Discharge	Group A	26.05	5.359	.121
	Group B	25.57	4.356	
1st Follow-up	Group A	33.89	5.040	.048
	Group B	31.00	4.616	
2nd Follow-up	Group A	38.16	5.308	.162
	Group B	37.87	4.652	

Table 3: Comparison of hand grip strength of the dominant side between the groups

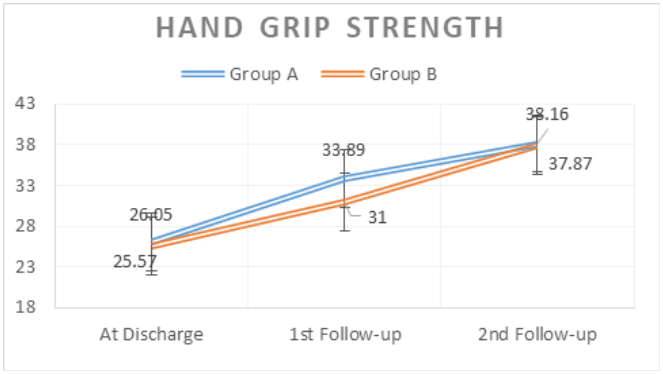

Figure 3: Hand grip strength of dominant side at discharge, at 1-month & 3-month follow-up after CABG compared between telecardiac rehabilitation (Group A) and home program group (Group B).

6MWT Distance (meters)	Group	Mean	SD	p-value
At Discharge	Group A	212.61	53.905	.058
	Group B	184.87	43.956	
1st Follow-up	Group A	278.06	76.611	.013
	Group B	227.03	58.693	
2nd Follow-up	Group A	299.22	86.857	.019
	Group B	246.70	62.021	

Table 4: Comparison of 6MWT distance between the groups

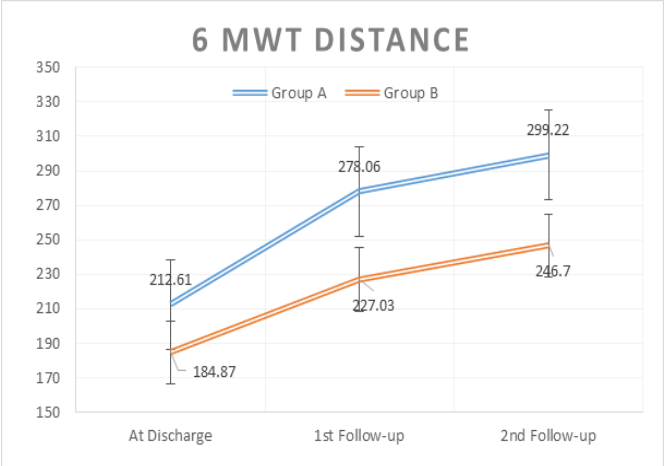

Figure 4: 6-minute walk test distance at discharge, at 1-month & 3-month follow-up after coronary artery bypass graft compared between telecardiac rehabilitation (Group A) and home program group (Group B).

Functional capacity measured with a 6-minute walk test at the 3-months post CABG in both the groups is shown in Figure 4 and Table 4. There was no statistically significant difference in functional capacity between groups at discharge. In both groups, there was a significant improvement in functional capacity from discharge to 1st and 2nd follow-ups. However, in tele cardiac rehabilitation group there was a significantly higher increase in functional capacity compared with the control group (p=0.013 at 1 month & p-0.019 at 3 months post-CABG).

DISCUSSION

This is a first-of-its-kind study conducted in India to assess the effect of telecardiac rehabilitation programs on the functional independence, hand grip strength, and functional capacity of patients undergoing CABG. The findings of this study demonstrated that continuous monitoring through a telecardiac rehabilitation program, comprising 12 weeks of aerobic and strengthening exercise training, is associated with significant improvements in functional independence and functional capacity. In contrast, both groups had clinical improvement in hand grip strength, but no statistically significant difference was noted.

In the current study, patients found significant improvement in functional independence, particularly in mobility, self-

care, and social cognition, following 12 weeks of a monitored rehabilitation program. Regular participation in physical activities under supervision improves muscle strength and power, improving confidence in performing ADLs. For instance, Muruganandam Periyasami et al. (2017) studied the effect of exercises on post-operative CABG patients' functional independence with the FIM scale. They concluded that a high-frequency exercise program improves the functional ability of patients, which decreases post-operatively due to the deleterious effect of bed rest [17]. Natasha Sutherland and Alexander Harrison's study (2018) on patients with heart disease also showed notable improvements in walking and stair-climbing abilities [18]. Niemeyer-Guimaraes et al. (2017) also concluded that FIM could detect significant functional loss in CABG patients and recommended that the FIM scale is a promising outcome for assessing functional independence over time after cardiac surgery [19].

Improvement in functional capacity noted in this study is also supported by studies like Vasiliki Raidou et al. (2024), who revealed the significance of functional capacity as a key outcome measure for patients after cardiac surgery and concluded that most patients significantly improve their physical functional capacity after participation in phase II cardiac rehabilitation program. Citing the importance of the beneficial effects of cardiac rehabilitation, they recommended having a systematic effort from all health workers to implement guidelines to have high referrals, adherence, and compliance to rehabilitation programs for all post-operative cardiac surgery patients [20]. Jomme claes et al. (2016) also studied the longer-term effects of home-based exercise interventions on functional capacity in CABG patients. They concluded that the cardiac rehabilitation program not only improves but also maintains the functional capacity of this group of patients [21].

In post-CABG patients, aerobic exercise of 5 minutes initially and strengthening at 40 to 50% of 1RM is considered physiologically safe. It leads to moderate improvement in functional capacity and upper body strength, which translates to functional independence. Regular participation in aerobic and strengthening programs reverses deterioration of skeletal muscle function due to surgery, which is common post-operatively. In the present study, patients in the telecardiac rehabilitation group showed improved functional status because, after initial sternal precautions, patients participated in basic and instrumental ADLs, making them more functionally independent and less dependent on family members [22-23].

The present study found no statistically significant difference in hand grip strength between the groups. According to Rosie Fountotos and team (2021), hand grip strength is an effective tool to categorize patients at higher risk of mortality and protracted recovery after cardiac surgery. It is a predictor of cardiovascular and non-cardiovascular mortality [24]. Marzuca et al. (2022) concluded that hybrid exercise-based cardiac rehabilitation programs could increase muscle strength in the hands and legs and improve functional exercise capacity in adults and older people with coronary artery disease [25].

Weakness in hand grip may result from limitations in activities of the upper extremity, which occurs rapidly during the postoperative period due to incisional pain & fatigue. Patients after cardiac surgery must follow sternal precautions to avoid dehiscence of the incision during the healing phase. In this study, hand grip was affected post-operatively but improved in patients of both groups, probably because of their increased participation in their ADLs post-reduction in incisional pain & fatigue. This probably explains the improvement in hand grip strength of both groups' patients. The result of this study is also similar to the study done by Kazuhiro P. Izawa et al. (2019), who also concluded that hand grip strength improved significantly from one to three months following cardiac surgery during phase II cardiac rehabilitation [26].

The current research had some limitations. It comprised a limited number of participants and divided into groups based on their ability to use video calls, which might cause selection bias. The project was conducted at a single center, and the findings might not be generalized to a broader population.

CONCLUSION

Participation in cardiac rehabilitation through telerehabilitation had significantly better recovery in CABG patients' basic and instrumental activities of daily living, i.e., function independence and functional capacity measured after 3 months post-discharge. In contrast, grip strength showed improvement in both groups. Continuous monitoring of exercise programs with telecardiac rehabilitation is beneficial for patients with CABG in improving their daily living if they cannot visit the rehabilitation center regularly for cardiac rehabilitation.

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Appendix – 1

Rehabilitation home program' (Aerobic and Strengthening exercise program)

Aerobic exercise program

Exercise program should start with warm-up exercises (5-10 minutes)

- Warm-up includes
- Stretch gymnastics (upper and lower limbs)
- Shoulder flexion and abduction exercises
- Knee extension
- Calf raises

An exercise program should end with cool-down exercises (5-10 minutes)

- Stretch gymnastics (upper and lower limbs)
- Knee extension
- Calf raises

Mode	Frequency	Intensity	Time
Walking (indoors or outdoors)	- Week 1 to week 4: 3 to 5 times a day - Week 4 to week 8: 2 or 3 times a day - Week 8 to week 12: 2 or 3 times a day	- Slow to moderate pace - Avoid becoming short of breath. - Avoid hilly terrain. (Exertion level rating: Maximum 11 to 13 on the Borg's 6-20 scale)	- Week 1: 5 to 10 minutes (aim to walk for five minutes each day. If you find that this is very easy, you can do two five-minute walks in the one day before increasing your walking time) - Week 2: 10 to 15 minutes (aim to walk for 10 minutes non-stop each day, as it becomes easier, you may increase the time by a minute or two) - Week 3: 15 to 20 minutes - Week 4: 20 minutes - Week 5: 25 minutes - Week 6: 30 minutes - Week 7: 35 minutes - Week 8: 40 minutes Continue up to 12 weeks
Cycling	- Week 1 to week 4: 3 to 5 times a day - Week 4 to week 8: 2 or 3 times a day - Week 8 to week 12: 2 or 3 times a day	- Little to moderate speed - Comfortable speed - Avoid becoming short of breath. (Exertion level rating: Maximum 11 to 13 on the Borg's 6-20 scale)	- Week 1: 5 to 10 minutes - Week 2: 10 to 15 minutes - Week 3: 15 to 20 minutes - Week 4: 20 minutes - Week 5: 25 minutes - Week 6: 30 minutes - Week 7: 35 minutes - Week 8: 40 minutes Continue up to 12 weeks.

Note: Each exercise should start with a warm-up and end with cool-down exercises. During exercise watch your breath, should maximum reach up to 13 on Borg's 6-20 scale.

The patient can alternately select walking or bicycle as per their convenience. If they want to do exercise on both, then

can be done on alternate days i.e. walking on 1st day and cycling on the next day.

It is important to exercise most days. You are advised to exercise at least 5 out of 7 days, and not to take two days off in a row. This is because you start to lose the benefits of exercise within 48 hours, so it is important to avoid this.

You should stop exercising if you experience any of the following:

- Dizziness
- Palpitations
- Chest discomfort
- Sickness
- Cramps
- Extreme fatigue

Resistance exercise program

Mode	Frequency	Intensity	Time	Progression
Strength training (40 to 60 % of 1RM) - For upper limb- Shoulder flexion extension, elbow flexion-extension. - For Lower limb- Knee flexion-extension in sitting	- RPE: 11 to 13 - No straining - No pain - 1 to 5 kg of weight	- 10 to 12 reps for each set - 1 to 2 sets for each exercise	- 2 to 3 days a week - Strengthening exercise should be done after aerobic exercise	- Increase resistance. - Reduce rest period between sets. - Add more exercises.

Note: Upper limb strength training can be done with different tools like water bottles, weight bars, and bags filled with sand. Lower limb strength training can be done with tools like plastic or cloth bags filled with sand and then tied up to the distal part of the extremity.

While doing upper limb strengthening exercises, the patient should sit in a comfortable chair with feet resting on the floor. While doing lower limb strengthening exercises, the patient should sit in a comfortable chair or table with feet hanging.

The patient should not hold their breath while doing resistance training.

Complete a smooth, controlled, and full range of motion with each activity.