Original Article

Cardiac Rehabilitation Outcomes in Indian Heart Failure Patients with Reduced and Mildly Reduced Ejection Fraction

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Abstract

Background: Heart failure (HF) is emerging as a major public health concern globally, with India facing the brunt of the issue. The efficacy of cardiac rehabilitation (CR) in improving physical, functional, psychological, and health-related quality of life (HRQoL) outcomes in HF is proven, but literature on the Indian population is scarce. This study aimed to analyze the outcomes of CR in HF patients presenting to a single center in South India. **Materials and Methods:** This retrospective study included patients with HF with reduced ejection fraction (HFrEF) and mildly reduced ejection fraction (HFmrEF) enrolled in a comprehensive outpatient CR program at our center between 2014 and 2025. Demographic details, cardiovascular risk factors, vitals, body mass index (BMI), 6-min walk distance (6MWD), and left ventricular ejection fraction (LVEF) were documented in all subjects at baseline. Physical component score and mental component score (PCS/MCS) of HRQoL using the 12-item short form health survey questionnaire, and post-program LVEF were documented, when possible. A multidisciplinary team comprising a physician, physiotherapist, dietitian, and counseling psychologist delivered the CR program, either as center-based, home-based, or hybrid. Participants attended two to three sessions per week for 6–12 weeks, combining multicomponent exercise with dietary guidance, health education, and psychosocial counseling. **Results:** Subjects (n = 60) were 55 ± 14 years, 88% male, 38% in the HFrEF group, and 62% in the HFmrEF group. Age range was 22–80 years; 30% were <50 years at enrollment. Ischemic cardiomyopathy (n = 58, 96%) was the predominant diagnosis, with 40 (69%) presenting with acute coronary syndrome. There were 6 (10%) dropouts, with more (P = 0.03) from the HFrEF (n = 5, 22%) group compared with the HFmrEF (n = 1, 3%) group. Among the program completers (n = 54) attending 16 ± 7 sessions over a period of 90 ± 58 days, there was a significant improvement in 6MWD, LVEF, PCS, and MCS in all subjects, and 6MWD and LVEF improvement was also documented in both HFrEF and HFmrEF groups. No adverse events were reported. Of the program completers, 5 (9%) are currently in the maintenance program. **Conclusions:** A CR program that is multidisciplinary and flexible in program structure and delivery mode results in improved functional capacity, cardiac function, and HRQoL in Indian HF patients with HFrEF and HFmrEF.

Keywords: Cardiac rehabilitation, cardiac function, functional capacity, HFrEF, HFmrEF, health-related quality of life

Introduction

Heart failure (HF) is emerging as a major public health concern globally, with Asia facing the brunt of the issue due to its sheer population, rise in the aging segment, improved survival rates after myocardial infarction, and an increasing prevalence of comorbidities.[1,2] While pharmacotherapy and devices for HF are evolving rapidly,[3] cardiac rehabilitation (CR), a medically supervised multidisciplinary secondary prevention program for cardiovascular disease (CVD), has gained a stronghold in the management framework of HF.[4-6] Based on left ventricular ejection fraction (LVEF), HF is currently classified as HF with reduced ejection fraction (HFrEF, LVEF ≤40%), HF with mildly reduced ejection fraction (HFmrEF, LVEF 41%–49%), and HF with preserved ejection fraction (HFpEF, LVEF ≥50%).[7] Evidence abounds on the efficacy of CR in improving

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physical, functional, psychological, and health-related quality of life (HRQoL) outcomes in HF, with sound evidence in HFrEF and growing evidence on HFpEF and HFmrEF,[8] but literature on the Indian population is scarce.

CR in general and its role in HF in particular are grossly under-researched in India, mainly due to the lack of sufficient services across the country. Nevertheless, studies from functioning units indicate that the programs are of high quality and efficacy and warrant incorporation in the mainstream care pathway of HF patients.[9-12] The pandemic-led shift in CR delivery mode from the conventional center-based to the flexible and remote home-based and hybrid formats has created a need for research into the safety profile of these newer formats in HF patients who are known to be at a higher risk for exercise-related adverse events.[13] A recent network meta-analysis evaluating 11 exercise modalities across 33 randomized controlled trials (RCTs) involving 5,900 HF patients has shown that while the efficacy of the different CR delivery modes varied, all interventions demonstrated benefits.[14]

This study aimed to analyze the outcomes of CR in HF patients presenting to a single center in South India. The primary outcomes of interest were changes in body mass index (BMI), resting heart rate (HR), blood pressure (BP), functional capacity, LVEF, and HRQoL.

Materials and Methods

Study design, setting, and participants

This retrospective cohort study included HF patients who had enrolled in the CR program provided at our center from 2014 to 2025. Patients ≥18 years of age with a diagnosis of ischemic heart disease, stable angina, angioplasty, coronary artery bypass grafting (CABG) surgery, stable HF, nonischemic cardiomyopathies, heart valve replacements, cardiac devices, and heart transplant were considered eligible and enrolled in CR after a thorough evaluation, whereas patients with nonrevascularized critical coronary artery disease, unstable angina, serious arrhythmias, and decompensated HF were not offered the program. Based on LVEF, HF patients were divided into two groups: HFrEF (defined as LVEF ≤40%) and HFmrEF (defined as LVEF 41%–49%). Patients who had dropped out of the program were excluded from the outcome analyses. The study design was in accordance with the ethical standards of the Indian Council of Medical Research and the Declaration of Helsinki.

Written informed consent was obtained from all patients at the time of enrollment in the CR program.

Variables

Intake evaluation consisted of documentation of demographic details, medical history, examination and review of medical records, health-related lifestyle assessment using an internally validated questionnaire, vitals including HR, resting systolic blood pressure (SBP) and diastolic blood pressure (DBP), nutritional assessment using 24-h diet recall and BMI, functional capacity assessment using the 6-min walk distance (6MWD) derived from the 6-min walk test (6MWT), documentation of LVEF, and HRQoL assessment using the physical component score (PCS) and mental component score (MCS) components of the 12-item short form health survey questionnaire. A combination of patient interviews, review of paper medical records (and when available electronic medical records), and questionnaires was used to assess the intake evaluation data.

For home-based CR (HBCR) patients, the entire evaluation was performed via video conference platform. The 6MWT was also conducted remotely under real-time supervision after providing relevant information about the test and giving them sufficient time to pick a suitable pre-measured test space in/around their house. The walk test distance was standardized to some extent by recommending a pre-measured test space of at least 10 m in length and agreeing on the turnaround points. They were advised to have a chair with armrests and/or a table to measure vitals before and after the walk test. Participants received clear instructions on self-pacing and were advised to stop walking immediately and sit if they experienced any chest pain, dizziness, undue breathlessness, or unusual fatigue. Caregiver presence and remote HR monitoring were encouraged where feasible, and participants were instructed to seek immediate medical attention if significant symptoms occurred. The repeat evaluation was conducted in the same location as much as possible.

CVD risk factors assessed at the time of intake evaluation using history and medical record review were diabetes mellitus, hypertension, dyslipidemia, presence of overweight/obesity (BMI ≥25 kg/m^2), and history of tobacco use in the past (ever tobacco user) and/or tobacco use at the time of CVD diagnosis (current tobacco user). LVEF was documented from the last echocardiogram before CR enrollment, and when feasible, a repeat echocardiogram was conducted after the program.

Intervention

The intensive phase of the CR program usually consisted of two to three sessions per week for 6–12 weeks. The recommended program dose was 24 sessions, but the minimum number of sessions for which a patient had to enroll was 12, upon completion of which a repeat evaluation was performed. However, <12 sessions were considered as completion when the patient had a valid reason for program termination and completed the end-of-program evaluation. The evaluation was repeated after completion of every 12-session block.

Patients who attended ≥80% sessions in-person at the center were classified as center-based CR (CBCR), those who attended ≥80% sessions remotely were classified as HBCR, and those who attended a combination of in-person and remote sessions with neither comprising ≥80% of total sessions were classified as Hybrid CR (HyCR). A multidisciplinary team of healthcare professionals, including a preventive cardiologist, cardiorespiratory physiotherapist, nutritionist, and psychologist, provided the CR programs. The core components of the program included exercise training, nutritional counseling, psychosocial counseling, return-to-work, sexual counseling, health education, and personalized behavior modification, including smoking cessation.

The CR program was normally initiated with a target exercise intensity of 11–13 on the Borg scale and a target HR of 40%–60% of HR reserve, with gradual progression based on patient performance and hemodynamic response to exercise, for all program formats. While there were no major changes to the exercise program during the study period, the pandemic-led complete lockdown and the abrupt shift to remote home-based sessions resulted in a change to non-equipment-based, bodyweight, and calisthenic exercises during that time, and the subsequent incorporation of similar exercises for the home-based/hybrid exercise group.

A typical in-person session consisted of an exercise component (40–60 min), which included a warm-up period (7–10 min), an active exercise period (30–40 min), and a cool-down period (7-10 min) plus an education/counseling component (30 min) every week. The CBCR participants performed a combination of treadmill walking, recumbent cycling, resistance exercises with free weights and theraband/dumbbells, floor exercises, and balance exercises. Special attention was paid to the symptom monitoring, posture, and breathing pattern during exercise. Rating of perceived exertion (RPE) on the Borg scale, HR, and BP were used to assess the intensity of and response to exercise, respectively.

A typical remote session lasted about 30–45 min, and it was usually either an exercise or an education/counseling session. All remote exercise sessions were supervised in real-time by the physiotherapist who virtually demonstrated, and the participant performed the exercises. The exercise prescription included non-equipment-based exercises such as brisk walking, stair climbing, spot marching, squats, and wall pushups. Resistance training with dumbbells/resistance bands (if available) or water-filled bottles, and abdominal and core muscle strengthening exercises were also included.

All participants were trained to monitor their RPE using the Borg scale and for any exercise-related symptoms. Participants were instructed to document their HR and BP, before and after exercise, regularly using their home BP monitor. The presence of a home BP monitor was mandatory for HBCR participants. The exercise safety precautions recommended for the remote 6MWT were recommended for all home exercise sessions.

The HF-specific education topics were red flag signs of worsening HF, salt intake, and individualized fluid management, adult immunization, medication side effects, and strategies to manage medication-related symptoms such as low BP and giddiness, self-management of HF, stress management techniques, and practical tips for patients with cardiac devices. The education/counseling sessions were group sessions with an audiovisual presentation followed by interaction. Family members of participants were encouraged to attend all sessions, particularly the education/counseling sessions.

All patients who completed the intensive phase of the CR program were termed "program completers" and were advised to enroll in the maintenance phase of the program. The frequency of sessions in this phase was weekly or fortnightly in the immediate post-completion period for about 1–2 months, followed by monthly sessions thereafter. Exercise review and progression, nutritional support, and ensuring adherence to medications were the main components of this phase.

All remote sessions were provided using video conference platforms such as Google Meet/WhatsApp/Zoom (since the start of the pandemic). Communication about the sessions and educational materials, including demonstration videos, was shared through email and WhatsApp.

Statistical analysis

Categorical data were expressed as numbers (n) and percentages (%), and continuous data were expressed as mean and standard deviation. Chi-square test and unpaired t test were used to compare categorical and continuous variables, respectively. Pre- and post-program parameters were compared using a paired t test. A P value of <0.05 was considered statistically significant.

Results

The study included 60 subjects [Figure 1] aged 55±14 years, 88% male, 38% in the HFrEF group, and 62% in the HFmrEF group. The age range of the cohort was 22–80 years, and 30% were <50 years old at CR enrollment. The baseline characteristics were comparable between the two groups [Table 1]. Diabetes mellitus was the commonest risk factor, followed closely by overweight/obesity and hypertension. Seventy-two percent of subjects had two or more risk factors. All subjects were on guideline-directed medical therapy and were adherent to their treatment.

Among the subjects with ischemic cardiomyopathy (n = 58, 96%), acute coronary syndrome (ACS) was

Table 1: Baseline characteristics of the study subjects

Baseline characteristics	All subjects *n* = 60	HFrEF *n* = 23	HFmrEF *n* = 37	*P* value
Age, years (mean ± SD)	55 ± 14	53 ± 16	58 ± 13	0.1904
Male, *n* (%)	53 (88)	19 (83)	34 (92)	0.4116
During/post-pandemic enrolled, *n* (%)	37 (61)	15 (65)	22 (61)	0.7866
CBCR, *n* (%)	26 (43)	11 (48)	15 (41)	0.6032
HBCR, *n* (%)	17 (28)	3 (13)	14 (38)	0.0447
HyCR, *n* (%)	17 (28)	9 (39)	8 (22)	0.2381
Risk factor profile				
Overweight/Obesity, *n* (%)	30 (50)	11 (48)	19 (52)	1.0000
Hypertension, *n* (%)	29 (48)	11 (48)	18 (50)	1.0000
Diabetes mellitus, *n* (%)	31 (51)	13 (57)	18 (50)	0.6033
Dyslipidemia, *n* (%)	22 (36)	8 (35)	14 (38)	1.0000
Ever tobacco user, *n* (%)	21 (35)	10 (43)	11 (29)	0.4041
Current tobacco user, *n* (%)	10 (16)	5 (22)	5 (14)	0.4851
Disease profile				
Ischemic cardiomyopathy, *n* (%)	58 (96)	21 (93)	37 (100)	0.1429
ACS, *n* (%)	40 (69)	17 (73)	23 (62)	0.4083
Nonischemic cardiomyopathy, *n* (%)	2 (3)	2 (11)	NA	NA
Procedural profile*				
Angioplasty, *n* (%)	38 (63)	16 (70)	22 (59)	0.5828
CABG, *n* (%)	23 (38)	6 (26)	17 (46)	0.1739
Hybrid revascularization, *n* (%)	6 (10)	1 (5)	5 (13)	0.3914
Rehab program details				
No. of sessions attended (mean ± SD)	16 ± 7	14 ± 7	17 ± 8	0.1444
Duration of program, days (mean ± SD)	90 ± 58	72 ± 47	102 ± 62	0.1928

ACS, acute coronary syndrome; CABG, coronary artery bypass grafting; CBCR, center-based CR; HBCR, home-based CR; HFrEF, HF with reduced ejection fraction; HFmrEF, HF with mildly reduced ejection fraction; HyCR, Hybrid CR; SD: standard deviation.

*Some patients had undergone more than one revascularization procedure

documented in 40 (69%) subjects. Dilated cardiomyopathy and human metapneumovirus cardiomyopathy were diagnosed in one subject each. Percutaneous coronary intervention (PCI)/angioplasty was the most common (63%) revascularization procedure, followed by CABG (38%). Hybrid revascularization, a combination of minimally invasive CABG and PCI, was performed in a few ACS patients during the pandemic-led lockdown.

CBCR was the predominant CR format before the pandemic, HBCR during the pandemic, and HyCR postpandemic [Figure 2]. Subjects enrolled in the flexible CR formats, that is, HBCR and HyCR combined (n = 36), attended more (18 ± 8) sessions than those in the conventional CBCR group (n = 24,14 ± 6, P = 0.04).

There were 6 (10%) dropouts [Figure 1], with more (P = 0.03) from the HFrEF (n = 5, 22%) group compared with the HFmrEF (n = 1, 3%) group. The reasons for dropout were long commute with inability to follow remote sessions (n = 2), noncardiac complications (n = 1), ill health of child (n = 1), and unknown cause (n = 2). The dropouts were lost to follow-up when attempts were later made to check on their health.

Outcome analysis was performed for subjects (n = 54) who had completed the intensive phase of the CR program. BMI, HR, SBP, and DBP showed some improvement that did not reach the significance level [Table 2]. Post-program LVEF and HRQoL scores were available for analysis in 39 (72%) and 22 (41%) program completers, respectively. There was a significant improvement in 6MWD, LVEF, PCS, and MCS in all subjects [Figures 2–4], and the improvement in 6MWD and LVEF was also documented in both groups [Figures 5 and 6]. Of the current tobacco users (n = 8), 7 (87.5%) were smokers and had quit completely; one smokeless tobacco user failed to quit. No adverse events were reported in any of the subjects.

Five (9%) of the program completers continued with the maintenance phase of the CR program after the intensive phase, attending weekly, fortnightly, or monthly sessions at the current time. One of the subjects in the maintenance phase, attending sessions remotely, is a 49-year-old male with a cardiac resynchronization therapy defibrillator for HFrEF with LVEF 30% post PCI for ACS. Of the program completers not enrolled in the maintenance phase (n = 49), 6 (12%) had died in the time period after the program. They were older at CR enrollment than those alive (72 ± 8 and 55 ± 13, P = 0.003). Three subjects had improved from HFmrEF to normal LVEF, one had improved from HFrEF to

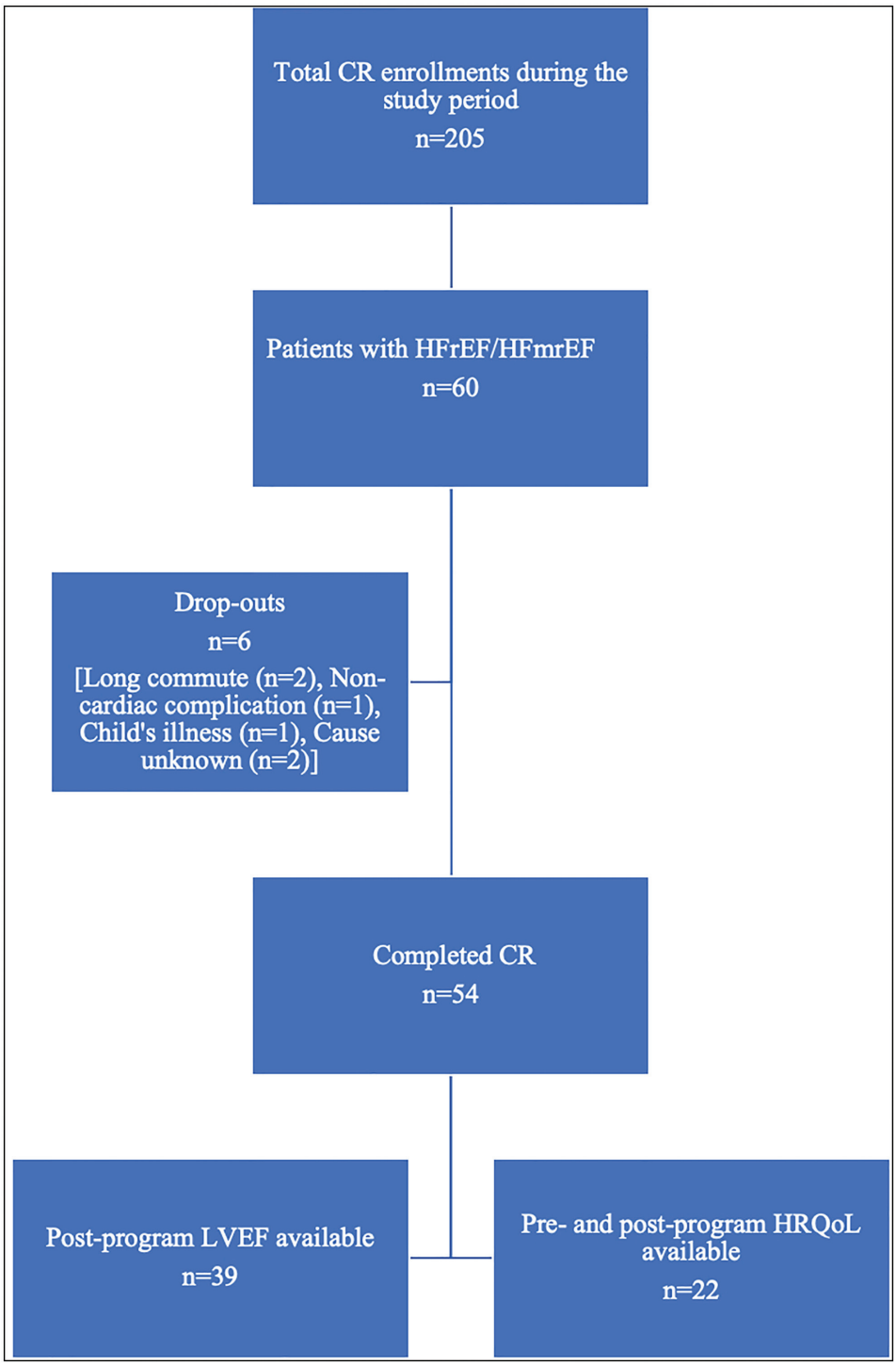


Figure 1: Flowchart of the number of subjects in the screening, program, and analyses stages

HFmrEF, and one each in the HFrEF and HFmrEF groups lacked post-program LVEF.

Discussion

The key findings of this study are that Indian patients with HFrEF and HFmrEF documented an improvement in functional capacity, systolic function, and health-related QoL upon completion of CR. The study also showed that when compared with global data, Indian HF patients enrolling in CR were younger, had lower dropout rates, and the program's safety profile, including for the home-based format, was satisfactory.[6,15]

Ischemic cardiomyopathy was the predominant cause of HF in our study, with the mean age at CR enrollment being

Table 2: Outcomes of the cardiac rehabilitation program

Parameter (mean ± SD)	All subjects *n* = 54			HFrEF *n* = 18			HFmrEF *n* = 36		
	Pre	Post	*P*	Pre	Post	*P*	Pre	Post	*P*
BMI, kg/m^2	25.28±3.98	25.10±3.83	0.1572	24.81±3.37	24.63±2.96	0.4950	25.51±4.29	25.33±4.22	0.2034
Heart rate, bpm	74±13	72±8	0.2792	77±11	74±6	0.3437	72±14	71±9	0.5325
SBP, mm Hg	117±22	114±17	0.1627	108±18	109±20	0.7272	122±22	116±15	0.0791
DBP, mm Hg	73±11	70±9	0.0549	71±12	69±11	0.3381	76±9	73±9	0.0985
6MWD, m	389±98	454±109	0.0001#	369±107	424±114	0.0001#	400±94	470±99	0.0001#
LVEF, %	40±5	47±10	0.0001#(*n* = 39)	34±3	41±8	0.0097# (*n* = 15)	43±2	51±9	0.0006# (*n* = 24)
PCS	38.7±9.2	45.6±7.09	0.0086#(*n* = 22)	38.7±8.7	45.6±7.2	0.0551(*n* = 10)	38.6±10.1	45.5±7.2	0.0836 (*n* = 12)
MCS	46.5±7.8	52.0±7.95	0.0108#(*n* = 22)	46.8±7.3	53.6±6.7	0.0889(*n* = 10)	46.3±8.5	50.6±8.8	0.0636 (*n* = 12)

6MWD, 6-min walk distance; BMI, body mass index; bpm, beats per minute; DBP, diastolic blood pressure; HFmrEF, HF with mildly reduced ejection fraction; HFrEF, HF with reduced ejection fraction; LVEF, left ventricular ejection fraction; MCS, mental component score; PCS, physical component score; SBP, systolic blood pressure; SD: standard deviation

#*P* < 0.05

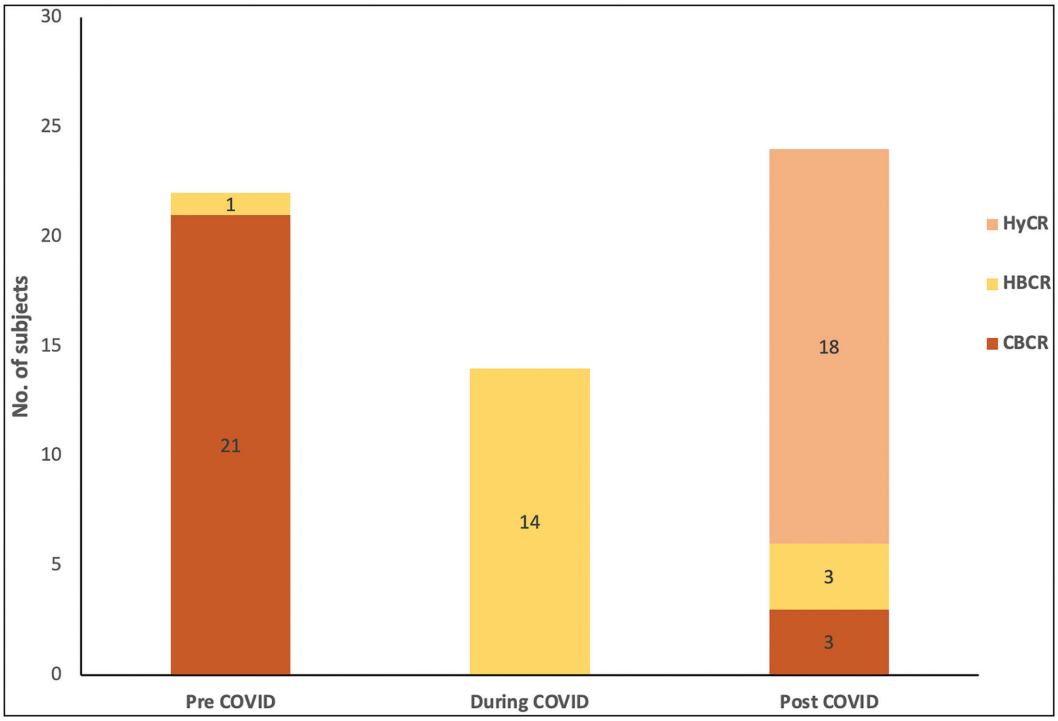


Figure 2: Format of cardiac rehabilitation program in relation to the Corona virus disease 2019 pandemic

56 years, and 30% being <50 years. This reaffirms the huge population health impact of premature CVD and a call to action for age- and work status-sensitive prevention and rehabilitation strategies in our population.[16,17]

The heart failure - a controlled trial investigating outcomes of exercise training study, the landmark RCT analyzing the safety and efficacy of exercise training in HFrEF patients in the United States, enrolled 1159 patients in the exercise arm, provided 36 sessions over 3 months, and concluded that exercise training was safe and documented a 13% risk reduction for cardiovascular mortality or HF hospitalization and significant improvements in 6MWD and peak oxygen consumption in the program completers (64%).[18] The recent Cochrane review included 60 RCTs on exercise-based CR with a total of 8,728 HF patients and concluded that there was a likely reduction in both all-cause and HF-related hospitalization risk in both the short and long term, and a likely clinically meaningful improvement in HRQoL. Trials of home- and hybrid-based CR delivery were associated with similar improvements in outcome compared with traditional, center-based programs.[19]

An RCT study by Babu *et al.*[10] compared an in-patient rehabilitation followed by a structured 8-week home-based

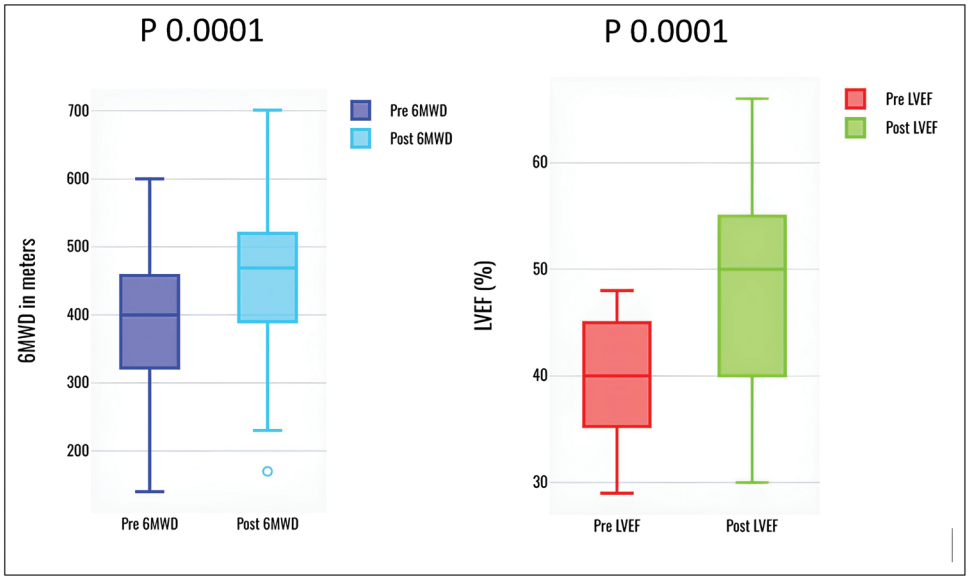


Figure 3: Changes in 6-min walk distance and left ventricular ejection fraction in all subjects

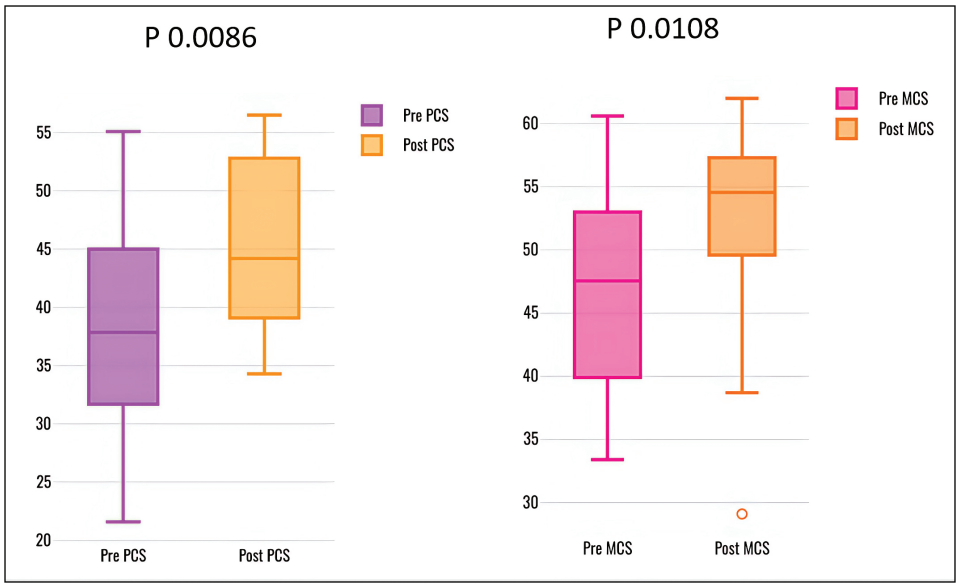


Figure 4: Changes in physical component score and mental component score in all subjects

program to a no rehabilitation group, showed that 6MWD and QoL improved significantly in the intervention arm, consisting of 14 congestive HF patients. The home-based sessions were provided by a therapist who guided exercise progression via weekly telephone calls. This study did not report on the non-exercise components of CR or the changes in LVEF.

Recently, a rural tertiary care hospital in South India conducted a 6-week hybrid CR program on 100 HF patients using a combination of three to five exercise sessions per week and fortnightly telephone calls focused on dietary changes, smoking, and alcohol cessation. They too have documented significant improvements in various parameters, including 6MWD and QoL, but have not reported on LVEF.[11]

A nurse-led RCT conducted at a tertiary care hospital in South India has reported significant improvements in QoL of HFrEF patients, reinforcing the fact that nurse practitioners could play a key role in CR in our country.[20] A recent non-CR observational study on 157 HFmrEF patients from South India reported no change in LVEF in 79% of patients and a mortality of 2% at the 6-month follow-up.[21]

While being comparable in outcomes to studies from more developed countries, the current study is unique in that it is the first study from India reporting the outcomes of CR, including LVEF, in HFrEF and HFmrEF patients, and also the first to document the efficacy and safety of medically supervised remote CR sessions in HF patients. The dropout rate (10%) of the current study was lower

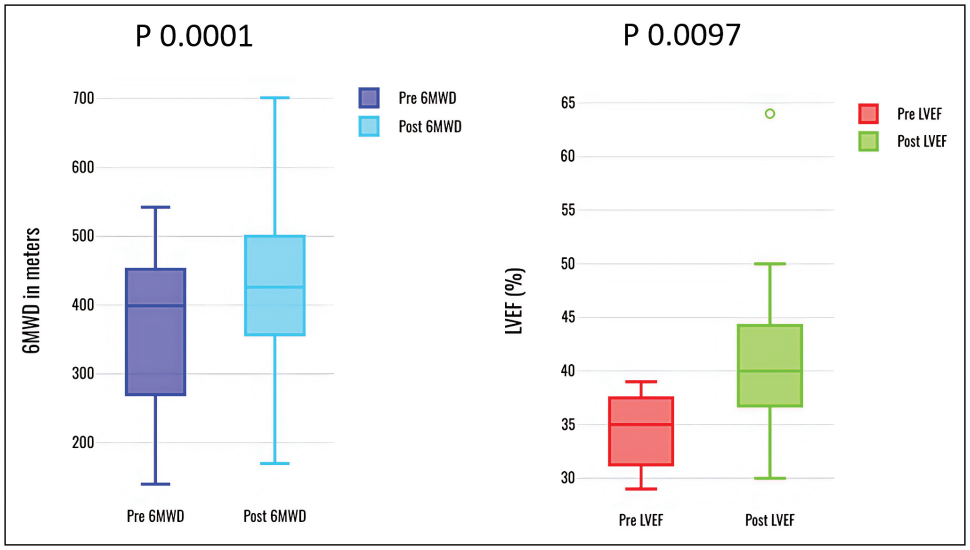


Figure 5: Changes in 6-min walk distance and left ventricular ejection fraction in the HF with reduced ejection fraction group

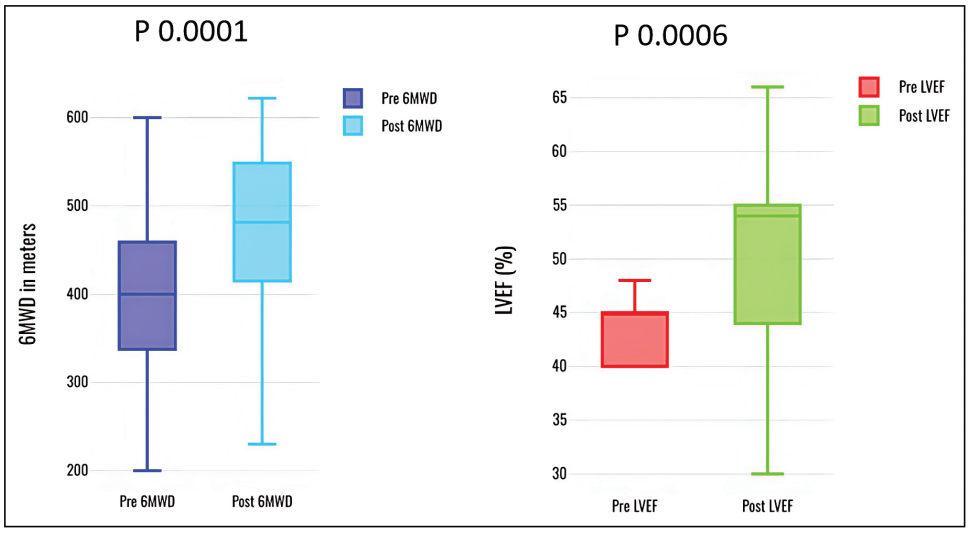


Figure 6: Changes in 6-min walk distance and left ventricular ejection fraction in the HF with mildly reduced ejection fraction group

than that (17%–39%) reported by programs in developed countries.[22] The personalization and flexibility of the CR program were key factors in improving adherence in the current study. High safety standards were maintained during the center-based and remote sessions, resulting in an event-free study period.

An abysmally low awareness about CR among cardiologists, combined with a disinterest of the patients, is at present the biggest barrier for incorporating CR in HF management in India.[23,24] Given that a lack of understanding among patients on the benefits and rationale of CR is the prime reason for declining to enroll in a home-based CR program, it would be useful for referring physicians to train their nurses to provide counseling about CR before discharge from the hospital.[25]

Additional challenges, such as delayed diagnosis and reluctance to refer women for CR, lack of resource allocation for CVD prevention, noninsurance coverage for CR programs, and failure to include CVD prevention and rehabilitation in the medical curriculum, are all adding up to hinder the expansion of the field in our country. It also needs to be emphasized that CR is still an evolving field, and HFpEF is grossly under-recognized and yet to come under the purview of CR in our country.[26-28]

The limitations of this study are that it is retrospective in nature, has a small cohort size, lacks post-program LVEF and HRQoL for all program completers, and does not represent the group of HFpEF. Larger, prospective studies looking into the safety and efficacy of the various CR formats across the LVEF phenotypes of HF are warranted.

Conclusions

A CR program that is multidisciplinary, flexible in delivery mode, and includes HFrEF and HFmrEF results in favorable outcomes in terms of functional capacity, cardiac function, and HRQoL in Indian patients. The satisfactory safety profile of a supervised remote program in the setting of adequate patient education and counseling, as evidenced in this study, is a prerequisite to scaling up CR for HF management in India.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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