Scientific Research Publishing

World Journal of Cardiovascular Diseases, 2025, 15(11), 519-536
https://www.scirp.org/journal/wjcd
ISSN Online: 2164-5337
ISSN Print: 2164-5329

Cardiac Rehabilitation Program Effects on Functional Capacity and Quality of Life in Stable Chronic Heart Failure Patients: A Randomized Controlled Trial

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How to cite this paper: Ndobo, V., Bwemba, D.E., Djibrilla, S., Wafeu, G.S., Mbouh, S., Lele, C.E.B., Tsague, H., Ndongo, S., Kamdem, F., Mandengue, S., Menanga, A.P., Boombhi, J. and Mfeukeu-Kuate, L. (2025) Cardiac Rehabilitation Program Effects on Functional Capacity and Quality of Life in Stable Chronic Heart Failure Patients: A Randomized Controlled Trial. *World Journal of Cardiovascular Diseases*, **15**, 519-536.
https://doi.org/10.4236/wjcd.2025.1511046

Received: July 24, 2025
Accepted: October 31, 2025
Published: November 3, 2025

Abstract

Background: Heart failure (HF) poses a significant global health burden, necessitating effective management strategies. This randomized controlled trial evaluated the effects of a seven-week cardiac rehabilitation program on functional capacity and quality of life in patients with stable chronic HF. **Methods:** Participants were randomly assigned to either a rehabilitation group (n = 10) or a control group (n = 10). The mean age of participants was 62.9 ± 9.45 years in the intervention group and 60.3 ± 8.23 years with extremes ranging from 45 years to 79 years. The male gender was the most represented in both groups, with a rate of 70% in the intervention group and 60% in the control group, *i.e.*, a sex ratio of 1.87. The rehabilitation program consisted of structured exercise,

education, and psychological support. Functional capacity was assessed using the six-minute walk test (6MWT), exercise testing, and estimated VO_{2max}. Quality of life, anxiety, and depression were measured using validated questionnaires. Hemodynamic parameters and physical activity levels were also evaluated. **Results:** Results demonstrated significant improvements in the rehabilitation group compared to the control group; specifically a significant increase in 6MWT distance ($p < 0.001$) exercise duration ($p = 0.008$) and functional capacity ($p = 0.029$). Furthermore, participants in the rehabilitation group exhibited significant reductions in anxiety and depression scores ($p = 0.008$ and $p < 0.001$, respectively), and reported a significant improvement in quality of life ($p = 0.002$) and PA level ($p = 0.011$). Systolic blood pressure also significantly decreased in the rehabilitation group. Physical activity levels increased significantly in the rehabilitation group. **Conclusions:** A seven-week cardiac rehabilitation program significantly improved functional capacity, quality of life, and psychological well-being in patients with stable chronic HF. These findings emphasize the importance of integrating cardiac rehabilitation into the comprehensive management of HF patients.

Keywords

Cardiac Rehabilitation, Functional Capacity, Quality of Life, Heart Failure

1. Backgrounds

Heart failure (HF) represents a significant global public health challenge, affecting an estimated 26 million individuals worldwide. The prevalence of HF is on the rise, with an estimated 2% of the global population affected. This prevalence increases with age, ranging from approximately 1% in individuals under 55 years to over 10% in those over 70 years in Western countries [1] [2]. HF is often the final clinical manifestation of various underlying cardiac pathologies. In Sub-Saharan Africa, HF accounts for a substantial proportion of hospital admissions within cardiology departments, with reported rates ranging from 9.4% to 42.5% [3]. A study conducted in Cameroon by Kuate *et al.* in 2017 revealed a hospital prevalence of 40.8%, accompanied by a mortality rate of approximately 16.4% [4]. The management of chronic heart failure (CHF) has undergone significant advancements in recent years, particularly in the realms of pharmacological and non-pharmacological therapies (e.g., surgery, circulatory support, cardiac stimulation, myocardial cell transplantation). However, despite these advancements, a considerable number of patients continue to experience persistent symptoms, recurrent hospitalizations, diminished quality of life, and elevated mortality [5].

Comprehensive CHF management encompasses both primary and secondary prevention strategies. Secondary prevention, which includes both in-hospital and post-hospital care, is defined as a multidisciplinary approach aimed at optimizing patients' physical, mental, and social well-being to improve their cardiac condi-

tion. This approach facilitates patients' reintegration into society, enabling them to lead active and productive lives.

Given the established link between reduced exercise tolerance and increased mortality and morbidity, enhancing exercise performance in patients with CHF is a critical component of their management. Cardiac rehabilitation (CR) plays a pivotal role in achieving this goal. Unfortunately, CR programs are not universally accessible, with availability limited to approximately half of the countries worldwide [6]. Furthermore, there is a paucity of evidence from randomized controlled trials (RCTs) evaluating the effectiveness of CR in low- and middle-income countries (LMICs) [7]. In Cameroon, there is a limited body of research specifically examining the efficacy of CR. To address this gap, we conducted a randomized controlled trial involving patients with stable chronic heart failure at two hospitals in Yaoundé, Cameroon. This study aimed to evaluate the effects of a structured cardiac rehabilitation program on functional capacity and quality of life in these patients.

2. Methods

Study Design and Setting

We conducted a randomized controlled clinical trial from January to August 2024 on inpatients and outpatients in the cardiology units of Yaoundé General Hospital (HGY) and Yaoundé Central Hospital (HCY). Exercise rehabilitation, therapeutic education, and psychological support sessions were carried out at the National Institute of Youth and Sports (INJS) in Yaoundé.

Study Population and Sampling

We included patients with stable chronic heart failure, followed as outpatients at the HCY and the HGY. The inclusion criteria comprised an age range of 21 to 79 years, a diagnosis of chronic heart failure confirmed by cardiac echocardiography, stability under treatment, and the provision of signed informed consent. Patients lost to follow-up or those with poor adherence to cardiac rehabilitation sessions (fewer than 15 sessions within six weeks) were excluded.

The sample size was calculated using the formula by Whitley *et al.*, considering an expected difference in maximal oxygen consumption (VO_{2max}) variation of 2.9 mL/kg/min as found by Belardinelli *et al.*, a standard deviation of 2, a significance level of 0.05, and a statistical power of 80% [8] [9]. Based on these parameters, the minimum required sample size was 8 patients per arm.

Randomization and Blinding

Following the fulfilment of inclusion criteria, participants were randomly assigned to one of two study arms, using a 1:1 allocation ratio. To ensure balanced group sizes, block randomization was employed with a block size of three. Due to the nature of the intervention, which involved physical activity, blinding was not feasible.The random allocation sequence was generated using a computer-based random number generator (R software, version 4.2.3) with a block size of three. Allocation concealment was ensured by using sequentially numbered, opaque,

sealed envelopes prepared by an independent statistician not involved in patient recruitment or assessment. Neither participants nor investigators could be masked to the treatment allocation. After the assignment to interventional or control group, parameters were measured at baseline and after a seven-week follow-up of the interventional group.

Intervention Components

The intervention consisted of three distinct components: 1) Exercise Rehabilitation, 2) Therapeutic and Nutritional Education, and 3) Psychological Support.

Exercise Rehabilitation was tailored to each participant's functional capacity and conducted at the NIYS under the supervision of a cardiologist and a physical activity coach. Sessions, lasting approximately 60 minutes, included warm-up 5 min, endurance (walking) 30 min, resistance (muscle strengthening) 15 min, and cool-down phases 10 min. Exercise intensity was determined using the Karvonen formula to calculate target heart rate (Targeted HR = Resting HR + (50% to 75%) [Max HR – Resting HR]) [10]. Continuous monitoring of heart rate, perceived exertion (using the modified Borg scale), and pre- and post-exercise medical assessments ensured participant safety [11]. A six-minute walk test was performed every six sessions to monitor the progression of participants. Therapeutic and nutritional education was delivered twice a week, focusing on improving disease understanding and promoting healthy lifestyle behaviours. Regular knowledge assessments were conducted to evaluate learning. Psychological support involved weekly sessions with a psychologist to address the emotional aspects of the disease. Anxiety and depression were assessed using the Hospital Anxiety and Depression Scale (HADS) questionnaire [12]. Topics covered were depression, anxiety, sexuality, and addictions, with stress management techniques provided. The comprehensive intervention was delivered over seven weeks, with combined exercise and education sessions on Mondays and Wednesdays, and combined exercise and psychological support sessions on Fridays. The control group did not receive any components of this intervention and received standard medical care and follow-up from a cardiologist.

Outcomes

The primary outcome of this study was VO_{2max} (VO_2 peak), which represents the maximum amount of oxygen consumed per minute by the body, expressed in mL/min per kilogram of body weight. VO_{2max} was estimated using the 6-minute walk test, conducted according to the American Thoracic Society (ATS) protocol [13]. VO_{2max} values were calculated using the predictive equation from the American College of Sports Medicine: VO_{2max} (mL/kg/min) = walking distance (m/min) × 0.1 + 3.5 mL/kg/min, the ACSM predictive equation was used to estimate VO_{2max} from the 6-minute walk distance, as it has been previously validated for estimating functional capacity in patients with chronic heart failure, although it may slightly over- or underestimate directly measured values in this population; functional capacity, expressed as a score ranging from 40 to 99, was calculated from the distance covered during the six-minute walk test according to stand-

ardized conversion tables; this score reflects the patient's overall ability to perform daily physical activities, with higher values indicating better exercise tolerance [14].

Secondary outcomes included exercise tolerance, assessed during the exercise stress test; quality of life, measured using the Minnesota Living with Heart Failure Questionnaire (MLHFQ) [12]; anxiety and depression scores, evaluated by the Hospital Anxiety and Depression Scale (HADS) [15] and physical activity level, categorized as low, moderate, or high, using the International Physical Activity Questionnaire (IPAQ) [16].

Statistical Analysis

A per-protocol analysis was conducted, focusing exclusively on participants who adhered to the prescribed cardiac rehabilitation intervention. Categorical variables are presented as counts and percentages, while continuous variables are summarized using medians and interquartile ranges (IQR), along with minimum and maximum values, to account for potential non-normal distributions. Comparison of categorical variables between groups was performed using the chi-square test, with Fisher's exact test performed when necessary. Changes in continuous variables within each group (pre- and post-intervention) were assessed using the Wilcoxon signed-rank test. Inter-group comparisons of continuous variables were performed using the Wilcoxon rank-sum test. A two-tailed p-value of less than 0.05 was considered statistically significant for all analyses.In addition to p-values, effect sizes were reported as median differences between groups with corresponding 95% confidence intervals (95% CI) to convey clinical relevance All statistical analyses were performed using R version 4.2.3 (2023-03-15 ucrt) and RStudio version 2023.6.1.524 (Integrated Development Environment for R. Posit Software, PBC, Boston, MA. URL http://www.posit.co/).

Ethical Considerations

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki [17]. Prior to commencement, ethical clearance was obtained from the Centre Regional Ethical Committee for Human Health Research (N˚: 0456/CRERSHC/2024). Furthermore, administrative authorizations were secured from all participating hospitals and institutions. All participants provided written informed consent before enrolment, ensuring their voluntary participation and understanding of the study procedures and potential risks.

3. Results

A total of 42 patients were screened for eligibility, with 2 excluded, resulting in 40 participants being randomized into either the intervention group or the control group (20 in each). During the study period, 8 participants in the intervention group were lost to follow-up, including 2 deaths. In the control group, 6 participants were lost to follow-up, including 4 deaths. The final analysis included 10 participants in each group (**Figure 1**).

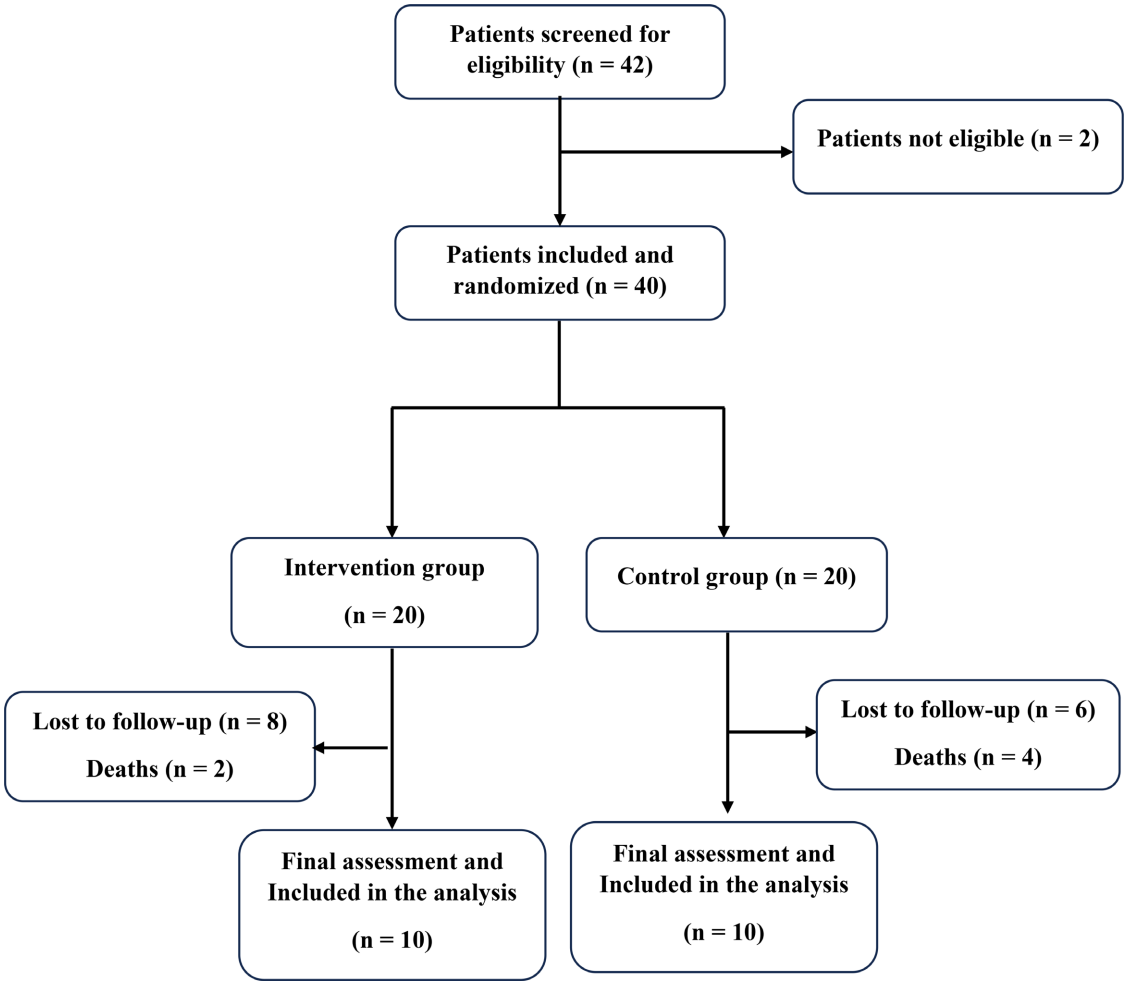

Figure 1. Flow chart of study participants.

Baseline Sociodemographic and Clinical Data

Table 1 presents the baseline characteristics of the participants. Sociodemographic, anthropometric and clinical data were not significant between the two groups. The median age was 62.0 years overall, with a similar distribution in both groups (62.0 in cardiac rehabilitation, 60.5 in control). Sex, marital status, profession, and education level showed no significant differences. The frequency of left versus global heart failure and underlying heart diseases was similar. Risk factors such as hypertension (80% overall), diabetes (5% overall), and dyslipidemia (15% overall) were evenly distributed. Median waist circumference was 86.5 cm overall, and median BMI was 23.9 kg/m^2, with no significant intergroup differences. Medication use, including diuretics (70% overall), ACE inhibitors (75% overall), and mineralocorticoid receptor antagonists (30% overall), was comparable (Table 1).

Outcome Data before Intervention

Heart rate (HR) at 0, 2, 4, and 6 minutes showed no significant differences (median HR at the start: 73.5 bpm in both groups). Oxygen saturation (SpO_2) levels were also similar (median SpO_2 0 min: 98% in cardiac rehabilitation, 97% in control). Respiratory rate (RR), Borg effort perception, and NYHA class

Table 1. Baseline characteristics of study participants.

Variables	Overall N = 20[1]	Cardiac rehabilitation N = 10[1]	Control N = 10[1]	p-value[2]
Age in years				0.762
Median [Q1 - Q3]	62.0 [54.5 - 68.5]	62.0 [58.0 - 67.0]	60.5 [52.0 - 69.0]	
Min - Max	47.0 - 79.0	47.0 - 79.0	49.0 - 69.0	
Sex				>0.999
Male	13 (65.0)	7 (70.0)	6 (60.0)	
Female	7 (35.0)	3 (30.0)	4 (40.0)	
Marital status				>0.999
Married	10 (50.0)	5 (50.0)	5 (50.0)	
Single	3 (15.0)	1 (10.0)	2 (20.0)	
Widowed	5 (25.0)	3 (30.0)	2 (20.0)	
Divorced	2 (10.0)	1 (10.0)	1 (10.0)	
Profession				0.922
Public sector employee	1 (5.00)	1 (10.0)	0 (0)	
Private sector	6 (30.0)	2 (20.0)	4 (40.0)	
Self-employed	3 (15.0)	2 (20.0)	1 (10.0)	
Retired	6 (30.0)	3 (30.0)	3 (30.0)	
Unemployed	4 (20.0)	2 (20.0)	2 (20.0)	
Education level				0.069
Uneducated	8 (40.0)	2 (20.0)	6 (60.0)	
Primary	8 (40.0)	5 (50.0)	3 (30.0)	
Secondary	3 (15.0)	3 (30.0)	0 (0)	
University	1 (5.00)	0 (0)	1 (10.0)	
Duration of HF in months				0.147
Median [Q1 - Q3]	24.0 [7.5 - 48.0]	24.0 [16.0 - 60.0]	12.0 [3.0 - 24.0]	
Min - Max	1.0 - 120.0	1.0 - 120.0	1.0 - 84.0	
Type of heart failure				>0.999
Left HF	5 (25.0)	3 (30.0)	2 (20.0)	
Global HF	15 (75.0)	7 (70.0)	8 (80.0)	
Current NYHA class of HF				0.148
1	3 (15.0)	3 (30.0)	0 (0)	
2	12 (60.0)	4 (40.0)	8 (80.0)	
3	5 (25.0)	3 (30.0)	2 (20.0)	

Continued

Underlying heart disease				0.103
Hypertensive heart disease	9 (45.0)	6 (60.0)	3 (30.0)	
Dilated cardiomyopathy	8 (40.0)	2 (20.0)	6 (60.0)	
Ischemic heart disease	2 (10.0)	2 (20.0)	0 (0)	
Valvular heart disease	1 (5.00)	0 (0)	1 (10.0)	
Hypertension				0.582
Yes	16 (80.0)	7 (70.0)	9 (90.0)	
No	4 (20.0)	3 (30.0)	1 (10.0)	
Diabetes				>0.999
Yes	1 (5.00)	0 (0)	1 (10.0)	
No	19 (95.0)	10 (100.0)	9 (90.0)	
Dyslipidemia				>0.999
Yes	3 (15.0)	2 (20.0)	1 (10.0)	
No	17 (85.0)	8 (80.0)	9 (90.0)	
Waist circumference in cm				0.761
Median [Q1 - Q3]	86.5 [82.0 - 98.5]	86.0 [82.0 - 102.0]	90.0 [82.0 - 95.0]	
Min - Max	71.0 - 126.0	71.0 - 126.0	72.0 - 115.0	
BMI in kg per m²				0.796
Median [Q1 - Q3]	23.9 [21.6 - 31.0]	23.9 [21.1 - 25.4]	24.2 [22.1 - 32.4]	
Min - Max	19.5 - 44.1	19.5 - 44.1	19.6 - 41.5	
BMI cat in kg per m²				>0.999
Normal	10 (50.0)	5 (50.0)	5 (50.0)	
Overweight	3 (15.0)	2 (20.0)	1 (10.0)	
Obese	7 (35.0)	3 (30.0)	4 (40.0)	
Treatment				
Diuretics	14 (70.0)	6 (60.0)	8 (80.0)	0.628
ACE inhibitors	15 (75.0)	7 (70.0)	8 (80.0)	>0.999
Mineralocorticoid receptor antagonists	6 (30.0)	4 (40.0)	2 (20.0)	0.628
Hygienic dietary measures	9 (45.0)	4 (40.0)	5 (50.0)	>0.999
LVEF				>0.999
Median [Q1 - Q3]	49.0 [38.0 - 57.5]	48.5 [38.0 - 53.0]	49.0 [38.0 - 58.0]	
Min - Max	26.0 - 70.0	35.0 - 62.0	26.0 - 70.0	

[1]n (%); [2]Wilcoxon rank sum test; Fisher's exact test; Wilcoxon rank sum exact test; ACE: Angiotensin Converting Enzyme, BMI: Body Mass Index, HF: Heart Failure, LVEF: Left Ventricular Ejection Fraction, NYHA: New York Heart Association, Q1: First quartile, Q3: Third quartile.

distribution showed no significant differences. Distance walked (median: 317.5 m in cardiac rehabilitation, 355.5 m in control), maximum systolic blood pressure (SBP), maximum HR, and target HR were also similar. Exercise duration and recovery time showed no significant intergroup differences. Functional capacity was similar (median 60) in both groups. Quality of life scores were higher in the control group (median 47) than in the cardiac rehabilitation group (median 19), p = 0.051. Anxiety and depression scores were similar. Physical activity level distribution was also comparable (Table 2).

Table 2. Description of outcome variables before intervention in both groups.

Variables	Overall N = 20[1]	Cardiac rehabilitation N = 10[1]	Control N = 10[1]	p-value[2]
HR 0 min				0.384
Median [Q1 - Q3]	73.5 [62.0 - 79.5]	73.5 [64.0 - 89.0]	73.5 [58.0 - 79.0]	
Min - Max	50.0 - 110.0	57.0 - 110.0	50.0 - 80.0	
HR 2 min				0.650
Median [Q1 - Q3]	83.0 [69.0 - 99.0]	83.5 [70.0 - 102.0]	83.0 [67.0 - 98.0]	
Min - Max	48.0 - 112.0	63.0 - 112.0	48.0 - 103.0	
HR 4 min				0.623
Median [Q1 - Q3]	96.5 [69.5 - 101.5]	94.0 [70.0 - 102.0]	96.5 [67.0 - 101.0]	
Min - Max	49.0 - 110.0	63.0 - 110.0	49.0 - 106.0	
HR 6 min				0.910
Median [Q1 - Q3]	93.0 [71.0 - 102.5]	82.5 [72.0 - 104.0]	95.0 [70.0 - 101.0]	
Min - Max	51.0 - 111.0	64.0 - 111.0	51.0 - 107.0	
SpO_2 0 min				0.242
Median [Q1 - Q3]	98.0 [97.0 - 98.5]	98.0 [97.0 - 99.0]	97.0 [97.0 - 98.0]	
Min - Max	90.0 - 99.0	90.0 - 99.0	95.0 - 99.0	
SpO_2 2 min				0.938
Median [Q1 - Q3]	98.0 [95.5 - 98.0]	98.0 [94.0 - 98.0]	97.5 [96.0 - 98.0]	
Min - Max	92.0 - 99.0	92.0 - 99.0	95.0 - 99.0	
SpO_2 4 min				0.100
Median [Q1 - Q3]	95.0 [92.5 - 97.0]	97.0 [95.0 - 98.0]	94.5 [92.0 - 96.0]	
Min - Max	89.0 - 99.0	90.0 - 99.0	89.0 - 97.0	
SpO_2 6 min				0.067
Median [Q1 - Q3]	94.5 [93.0 - 97.0]	96.0 [95.0 - 98.0]	93.0 [93.0 - 94.0]	
Min - Max	89.0 - 99.0	89.0 - 99.0	90.0 - 97.0	
SBP				0.449
Median [Q1 - Q3]	132.5 [116.5 - 147.5]	141.5 [128.0 - 150.0]	131.5 [111.0 - 139.0]	

Continued

Min - Max	97.0 - 160.0	97.0 - 156.0	97.0 - 160.0	
DBP				0.850
Median [Q1 - Q3]	86.0 [80.0 - 89.5]	87.0 [82.0 - 88.0]	84.5 [78.0 - 90.0]	
Min - Max	67.0 - 110.0	67.0 - 98.0	67.0 - 110.0	
RR				0.699
Median [Q1 - Q3]	17.0 [16.0 - 19.5]	17.5 [16.0 - 20.0]	17.0 [16.0 - 19.0]	
Min - Max	16.0 - 22.0	16.0 - 22.0	16.0 - 21.0	
Borg effort perception				0.500
Median [Q1 - Q3]	4.0 [3.0 - 4.5]	4.0 [3.0 - 5.0]	4.0 [3.0 - 4.0]	
Min - Max	2.0 - 7.0	3.0 - 7.0	2.0 - 5.0	
NYHA class of HF				0.395
1	7 (35.0)	2 (20.0)	5 (50.0)	
2	9 (45.0)	5 (50.0)	4 (40.0)	
3	4 (20.0)	3 (30.0)	1 (10.0)	
Distance walked in m				0.623
Median [Q1 - Q3]	354.5 [301.0 - 364.0]	317.5 [302.0 - 364.0]	355.5 [300.0 - 372.0]	
Min - Max	252.0 - 525.0	252.0 - 525.0	270.0 - 384.0	
VO_{2max} in mL/Kg/min				0.623
Median [Q1 - Q3]	9.4 [8.5 - 9.6]	8.8 [8.5 - 9.6]	9.4 [8.5 - 9.7]	
Min - Max	7.7 - 12.3	7.7 - 12.3	8.0 - 9.9	
Max SBP				0.971
Median [Q1 - Q3]	154.5 [137.5 - 174.5]	146.0 [137.0 - 194.0]	155.5 [143.0 - 164.0]	
Min - Max	113.0 - 205.0	113.0 - 205.0	126.0 - 190.0	
Max HR				0.241
Median [Q1 - Q3]	113.0 [102.0 - 123.5]	107.0 [98.0 - 122.0]	119.5 [108.0 - 125.0]	
Min - Max	78.0 - 139.0	78.0 - 139.0	101.0 - 136.0	
Target HR				0.129
Median [Q1 - Q3]	100.5 [93.0 - 105.0]	94.0 [90.0 - 102.0]	102.0 [100.0 - 105.0]	
Min - Max	73.0 - 117.0	73.0 - 117.0	81.0 - 117.0	
Exercise duration min				0.510
Median [Q1 - Q3]	6.0 [5.0 - 7.0]	6.0 [5.0 - 7.0]	6.0 [5.0 - 6.0]	
Min - Max	3.0 - 8.0	4.0 - 8.0	3.0 - 8.0	
Recovery time min				0.357
Median [Q1 - Q3]	2.0 [2.0 - 2.0]	2.0 [2.0 - 2.0]	2.0 [2.0 - 2.0]	
Min - Max	1.0 - 4.0	2.0 - 4.0	1.0 - 4.0	

Continued

Functional capacity				0.785
Median [Q1 - Q3]	60.0 [50.0 - 80.0]	60.0 [50.0 - 80.0]	60.0 [50.0 - 80.0]	
Min - Max	40.0 - 90.0	40.0 - 80.0	40.0 - 90.0	
Stopping criteria				0.211
On demand	2 (10.0)	0 (0)	2 (20.0)	
Exhaustion	17 (85.0)	10 (100.0)	7 (70.0)	
Others	1 (5.00)	0 (0)	1 (10.0)	
Quality of life score				0.051
Median [Q1 - Q3]	34.5 [16.0 - 54.5]	19.0 [12.0 - 38.0]	47.0 [33.0 - 59.0]	
Min - Max	2.0 - 71.0	2.0 - 66.0	15.0 - 71.0	
Anxiety score				0.789
Median [Q1 - Q3]	10.0 [8.0 - 11.5]	10.0 [8.0 - 11.0]	10.0 [8.0 - 12.0]	
Min - Max	4.0 - 16.0	4.0 - 14.0	6.0 - 16.0	
Depression score				0.080
Median [Q1 - Q3]	9.0 [5.0 - 11.0]	6.0 [4.0 - 10.0]	9.5 [8.0 - 11.0]	
Min - Max	3.0 - 15.0	3.0 - 11.0	5.0 - 15.0	
Physical activity level				>0.999
Low	12 (60.0)	6 (60.0)	6 (60.0)	
Moderate	8 (40.0)	4 (40.0)	4 (40.0)	

[1]n (%); [2]Wilcoxon rank sum test; Fisher's exact test; Wilcoxon rank sum exact test.

Variable	Rahab Group (n = 101)	Control Group (n = 101)	Median Difference [95% CI]*	p-value
Distance walked (m)	317.5 [302.0 - 364.0]	355.5 [300.0 - 372.0]	−38 m [−70; +45]	0.623
VO_{2max} (mL/kg/min)	8.8 [8.5 - 9.6]	9.4 [8.5 - 9.7]	−0.6 mL/kg/min [−1.3; +0.3]	0.623
Quality of life (MLHFQ)	19.0 [12.0 - 38.0]	47.0 [33.0 - 59.0]	−28 points [−40; −12]	0.051
Functional capacity (score 40 - 99)	60.0 [50.0 - 80.0]	60.0 [50.0 - 80.0]	0 [−10; +10]	0.785

DBP: Diastolic Blood Pressure, HR: Heart Rate, NYHA: New York Heart Association, Q1: First quartile, Q3: Third quartile, RR: Respiratory Rate, SBP: Systolic Blood Pressure, SpO_2: peripheral oxygen saturation.

Effect of Cardiac Rehabilitation on Functional Capacity

The cardiac rehabilitation group demonstrated a significantly higher median walked distance (464.5 m) compared to the control (342.0 m, $p < 0.001$), reflecting a significantly higher estimated VO_{2max} in the rehabilitation group (11.2 mL/kg/min) compared to the control group (9.2 mL/kg/min) post-intervention ($p < 0.001$). Maximum HR was lower in the cardiac rehabilitation group (median 96.5 bpm) than in the control group (median 120.0 bpm, $p < 0.001$). Similarly, target HR was lower

in the cardiac rehabilitation group (median 89.5 bpm) compared to the control group (median 104.0 bpm, p = 0.005). Exercise duration was longer in the cardiac rehabilitation group (median 7.0 min) than in the control group (median 5.5 min, p = 0.008). Functional capacity was higher in the cardiac rehabilitation group (median 80) compared to the control group (median 60, p = 0.029)

Effect of Cardiac Rehabilitation on Anxiety, Depression and Quality of Life

After the intervention, the cardiac rehabilitation group exhibited a better quality of life score (16.0) compared to the control group (46.0, p = 0.002). Anxiety scores were also significantly lower in the cardiac rehabilitation group (median 7.5) compared to the control group (median 10.5, p = 0.008). Depression scores showed a notable difference, with the cardiac rehabilitation group having a lower median score of 4.0, while the control group had a median score of 10.0 (p < 0.001).

Table 3. Description of outcome variables after intervention in both groups.

Variables	Overall N = 20[1]	Cardiac rehabilitation N = 10[1]	Control N = 10[1]	p-value[2]
HR 0 min				0.325
Median [Q1 - Q3]	75.5 [65.0 - 81.0]	80.0 [62.0 - 87.0]	74.0 [68.0 - 79.0]	
Min - Max	50.0 - 92.0	50.0 - 92.0	50.0 - 82.0	
HR 2 min				0.545
Median [Q1 - Q3]	84.5 [66.5 - 90.5]	84.5 [63.0 - 89.0]	86.5 [70.0 - 95.0]	
Min - Max	47.0 - 105.0	53.0 - 96.0	47.0 - 105.0	
HR 4 min				0.226
Median [Q1 - Q3]	87.0 [68.0 - 95.0]	85.5 [64.0 - 88.0]	93.0 [72.0 - 97.0]	
Min - Max	48.0 - 106.0	53.0 - 96.0	48.0 - 106.0	
HR 6 min				0.161
Median [Q1 - Q3]	87.5 [71.5 - 94.5]	86.0 [68.0 - 88.0]	92.5 [75.0 - 98.0]	
Min - Max	50.0 - 105.0	53.0 - 96.0	50.0 - 105.0	
SpO_2 0 min				0.030
Median [Q1 - Q3]	98.0 [95.5 - 98.5]	98.0 [98.0 - 99.0]	96.5 [95.0 - 98.0]	
Min - Max	92.0 - 99.0	95.0 - 99.0	92.0 - 99.0	
SpO_2 2 min				< 0.001
Median [Q1 - Q3]	96.5 [95.0 - 98.0]	98.0 [97.0 - 98.0]	95.0 [94.0 - 95.0]	
Min - Max	90.0 - 99.0	97.0 - 99.0	90.0 - 96.0	
SpO_2 4 min				0.003
Median [Q1 - Q3]	87.0 [68.0 - 95.0]	85.5 [64.0 - 88.0]	93.0 [72.0 - 97.0]	
Min - Max	48.0 - 99.0	53.0 - 96.0	48.0 - 99.0	

Continued

SpO_2 6 min				< 0.001
Median [Q1 - Q3]	96.0 [94.0 - 98.0]	98.0 [97.0 - 99.0]	94.0 [92.0 - 95.0]	
Min - Max	90.0 - 99.0	95.0 - 99.0	90.0 - 97.0	
SBP				0.307
Median [Q1 - Q3]	130.0 [105.5 - 145.0]	115.5 [101.0 - 143.0]	135.0 [121.0 - 147.0]	
Min - Max	97.0 - 160.0	97.0 - 154.0	98.0 - 160.0	
DBP				0.307
Median [Q1 - Q3]	80.5 [74.0 - 85.5]	78.0 [70.0 - 85.0]	83.5 [75.0 - 90.0]	
Min - Max	67.0 - 112.0	67.0 - 89.0	68.0 - 112.0	
RR				0.123
Mean ± SD	18.1 ± 0.7	17.8 ± 0.4	18.3 ± 0.8	
Median [Q1 - Q3]	18.0 [18.0 - 18.0]	18.0 [18.0 - 18.0]	18.0 [18.0 - 19.0]	
Min - Max	17.0 - 20.0	17.0 - 18.0	17.0 - 20.0	
Borg effort perception				< 0.001
Median [Q1 - Q3]	3.0 [2.5 - 5.0]	2.5 [2.0 - 3.0]	5.0 [4.0 - 5.0]	
Min - Max	2.0 - 5.0	2.0 - 4.0	3.0 - 5.0	
NYHA class of HF				0.001
1	10 (50.0)	9 (90.0)	1 (10.0)	
2	9 (45.0)	1 (10.0)	8 (80.0)	
3	1 (5.00)	0 (0)	1 (10.0)	
Distance walked in m				< 0.001
Median [Q1 - Q3]	362.5 [342.0 - 464.5]	464.5 [375.0 - 510.0]	342.0 [288.0 - 350.0]	
Min - Max	275.0 - 650.0	350.0 - 650.0	275.0 - 390.0	
VO_{2max} in mL/Kg/min				< 0.001
Median [Q1 - Q3]	9.5 [9.2 - 11.2]	11.2 [9.8 - 12.0]	9.2 [8.3 - 9.3]	
Min - Max	8.1 - 14.3	9.3 - 14.3	8.1 - 10.0	
Max SBP				0.791
Median [Q1 - Q3]	159.0 [139.5 - 165.0]	147.5 [135.0 - 180.0]	159.0 [142.0 - 160.0]	
Min - Max	120.0 - 190.0	120.0 - 190.0	130.0 - 180.0	
Max HR				< 0.001
Median [Q1 - Q3]	106.0 [96.5 - 120.0]	96.5 [88.0 - 105.0]	120.0 [110.0 - 125.0]	
Min - Max	80.0 - 130.0	80.0 - 107.0	102.0 - 130.0	
Target HR				0.005
Median [Q1 - Q3]	98.5 [87.0 - 104.0]	89.5 [85.0 - 98.0]	104.0 [100.0 - 107.0]	
Min - Max	73.0 - 118.0	73.0 - 100.0	82.0 - 118.0	

Continued

Exercise duration in min				0.008
Median [Q1 - Q3]	6.0 [5.5 - 7.5]	7.0 [6.0 - 8.0]	5.5 [5.0 - 6.0]	
Min - Max	4.0 - 9.0	6.0 - 9.0	4.0 - 8.0	
Recovery time in min				0.368
Median [Q1 - Q3]	2.0 [2.0 - 2.0]	2.0 [2.0 - 2.0]	2.0 [2.0 - 2.0]	
Min - Max	1.0 - 2.0	1.0 - 2.0	2.0 - 2.0	
Functional capacity				0.029
Median [Q1 - Q3]	80.0 [60.0 - 82.5]	80.0 [80.0 - 95.0]	60.0 [60.0 - 80.0]	
Min - Max	40.0 - 99.0	60.0 - 99.0	40.0 - 95.0	
Stopping criteria				0.582
On demand	4 (20.0)	1 (10.0)	3 (30.0)	
Exhaustion	16 (80.0)	9 (90.0)	7 (70.0)	
Quality of life score				0.002
Median [Q1 - Q3]	34.5 [15.5 - 46.0]	16.0 [5.0 - 25.0]	46.0 [37.0 - 56.0]	
Min - Max	2.0 - 74.0	2.0 - 40.0	16.0 - 74.0	
Anxiety score				0.008
Median [Q1 - Q3]	9.0 [7.0 - 11.0]	7.5 [5.0 - 9.0]	10.5 [9.0 - 12.0]	
Min - Max	3.0 - 15.0	3.0 - 11.0	7.0 - 15.0	
Depression score				< 0.001
Mean ± SD	7.3 ± 3.9	4.2 ± 2.1	10.4 ± 2.6	
Median [Q1 - Q3]	7.0 [4.0 - 10.0]	4.0 [3.0 - 6.0]	10.0 [9.0 - 13.0]	
Min - Max	1.0 - 14.0	1.0 - 7.0	5.0 - 14.0	
Physical activity level				0.011
Low	6 (30.0)	0 (0)	6 (60.0)	
Moderate	14 (70.0)	10 (100.0)	4 (40.0)	

[1]n (%); [2]Wilcoxon rank sum test; Fisher's exact test.

Variable	Rehabilitation (n = 101)	Control (n = 101)	Median Difference (Rehab - Control) [95% CI]	p-value
Distance walked (m)	464.5 [375 - 510]	342.0 [288 - 350]	+122 m [85; 160]	<0.001
VO_{2max} (mL/kg/min)	11.2 [9.8 - 12.0]	9.2 [8.3 - 9.3]	+2.0 mL/kg/min [1.5; 2.5]	<0.001
Functional capacity (score 40 - 99)	80.0 [80 - 95]	60.0 [60 - 80]	+20 points [10; 25]	0.029
Quality of life (MLHFQ)	16.0 [5 - 25]	46.0 [37 - 56]	−30 points [−38; −22]	0.002
Anxiety score (HADS)	7.5 [5 - 9]	10.5 [9 - 12]	−3 points [−4; −2]	0.008
Depression score (HADS)	4.0 [3 - 6]	10.0 [9 - 13]	−6 points [−7; −5]	<0.001
Physical activity level	Moderate - Low 100%	Moderate - Low 100%	+notable shift toward moderate activity	0.011

DBP: Diastolic Blood Pressure, HR: Heart Rate, NYHA: New York Heart Association, Q1: First quartile, Q3: Third quartile, RR: Respiratory Rate, SBP: Systolic Blood Pressure, SpO_2: Peripheral oxygen saturation.

4. Discussion

This randomized controlled trial aimed to evaluate the effects of a cardiac rehabilitation program in patients with stable chronic heart failure in our setting.

We observed reductions in systolic and diastolic blood pressure in the intervention group (median 141.5 to 115.5 mmHg) and median 87.0 to 78.0, respectively). But the differences were not significant. These results are different from numerous studies [18] [19] demonstrating the beneficial effects of exercise on blood pressure like O'Connor *et al.* [18]. Regular exercise helps to reduce peripheral vascular resistance, which in turn lowers blood pressure.

The six-minute walk test (6MWT) distance significantly increased comparable to those results reported by Chaves *et al.* [19], while Ajiboye *et al.* [20] reported a smaller increase. The 6MWT is a valuable tool for assessing functional capacity, and the observed increase suggests improved functional status. We also observed significant improvements in Borg scale scores ($p < 0.001$), exercise duration ($p = 0.008$) which are consistent with findings by Simms *et al.* [21]. These improvements can be attributed to the benefits of physical activity, patient education, and psychological support. We observed a significant improvement in estimated VO_{2max} but lower than those reported by Chen *et al.* [22], which may be attributed to the different methods used for VO_{2max} assessment. We used an indirect estimation based on the American College of Sports Medicine prediction equation [14], while CPET, the gold standard for aerobic capacity assessment, was not accessible. The observed improvement likely reflects the benefits of patient education and exercise.

Using the IPAQ questionnaire, we observed a significant increase in physical activity levels ($p = 0.011$), with 100% of participants achieving moderate activity levels post-intervention. This is consistent with findings by Ajiboye *et al.* [20].

We observed significant reductions in anxiety and depression scores ($p = 0.008$ and $p < 0.001$ respectively), which were greater than those reported by Amarathi *et al.* [23]. The psychological support provided during cardiac rehabilitation, including self-acceptance and disease management, likely contributed to these improvements. Regular physical activity also has mood-stabilizing effects [24] [25]. This observed effect therefore suggests an advantage to combining physical interventions with psychological interventions in these patients. This calls on practitioners and cardiologists to consider these combined aspects in their management.

Our study demonstrated a significant improvement in quality of life ($p = 0.002$), as measured by the Minnesota Living with Heart Failure Questionnaire. These findings are consistent with those reported by Chen *et al.* [22]. Improved disease understanding, self-management, and regular physical activity likely contributed to the observed improvement in quality of life.

Limitations

Several limitations must be acknowledged, including the small sample size, the absence of accelerometers for objective physical activity assessment, and the lack

of cardiopulmonary exercise testing (CPET) for direct measurement of VO_{2max}. Also, its single-city setting and the use of a per-protocol analysis, which may restrict the generalizability of the findings to broader heart-failure populations.

5. Conclusion

This study aimed to evaluate the impact of a cardiac rehabilitation program on stable chronic heart failure patients. Our findings revealed significant improvements in functional exercise capacity and a marked decrease in anxiety and depression levels following seven weeks of rehabilitation. Furthermore, patients experienced an enhanced quality of life and increased physical activity levels. These results underscore the beneficial impact of cardiac rehabilitation in this patient population, highlighting its potential as a valuable component of comprehensive heart failure management.

Clinical Trial Number

PACTR202506534820803.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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