World Journal of Cardiovascular Diseases, 2024, 14, 447-458
https://www.scirp.org/journal/wjcd
ISSN Online: 2164-5337
ISSN Print: 2164-5329

Effect of Cardiac Rehabilitation on Physical Capacity of Heart Failure Patients in Senegal

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How to cite this paper: Gaye, N.D., Ngaidé, A.A., Mingou, J., Aw, F., Ka, M.M., Sy, A.M., Lamrani, Z.N. and Kane, A. (2024) Effect of Cardiac Rehabilitation on Physical Capacity of Heart Failure Patients in Senegal. *World Journal of Cardiovascular Diseases*, **14**, 447-458.
https://doi.org/10.4236/wjcd.2024.148038

Received: May 27, 2024
Accepted: August 9, 2024
Published: August 12, 2024

Abstract

Background: Heart failure is a chronic and severe condition that often results from various heart diseases. Cardiac rehabilitation (CR) is currently a crucial component in managing this condition. The aim was to assess the effects of cardiac rehabilitation on physical capacity of heart failure patients. **Methods:** This was a cross-sectional study conducted from February 1, 2021, to June 30, 2023. We included all patients with heart failure who underwent cardiac rehabilitation. Data analysis was performed using SPSS software version 24.0, with a significance level set at $p < 0.05$. **Results:** The study included 87 heart failure patients, with a male-to-female ratio of 1.8. Mean age was 57.10 years (±11.75). Coronary artery disease was the primary cause of heart failure, accounting for 75.9% of cases. Atrial fibrillation was present in 4.7% of cases. Following cardiac rehabilitation, Left Ventricular Ejection Fraction increased from 40.15% to 49.48% ($p = 0.001$). Resting heart rate decreased significantly from 81.4 bpm to 68.3 bpm ($p = 0.000$), and the number of METS increased from 4.3 to 6.57 (+56.8%; $p = 0.000$). The mean distance covered in the 6-minute walk test significantly increased from 337.8 meters to 522.7 meters ($p = 0.000$), reflecting a gain of 183.5 meters. Moreover, the increase in the number of METS was more pronounced in females ($p = 0.001$), non-obese individuals ($p = 0.000$), non-diabetics ($p = 0.001$), non-sedentary individuals ($p = 0.000$), and non-smokers ($p = 0.000$). The study reported a low readmissions rate of 2.2% and a mortality rate of 1.1%. **Conclusion:** Our study demonstrates that cardiac rehabilitation is beneficial for black African heart failure patients, resulting in significant improvements in symptoms, physical and capacity.

Keywords

Cardiac Rehabilitation, Chronic Heart Failure, Physical Capacity, Senegal

1. Introduction

Heart failure (HF) poses a significant health burden globally, characterized by its chronic and debilitating nature, often stemming from diverse underlying heart pathologies. Approximately 64 million people are estimated to have heart failure (HF) globally, and its prevalence is increasing in many middle- and low-income countries. Much of the current understanding of HF epidemiology is based on studies conducted in high-income countries [1]. In Africa, there is a notable absence of population-based studies focusing on heart failure (HF), resulting in a lack of comprehensive data regarding its incidence and prevalence across different regions. Data from several registries suggests that HF afflicts mostly young and economically active adults in Sub-Saharan Africa, leading to severe impairment in quality of life, and loss of productivity amongst patients, their families and society in general [2]. This gap in research poses significant challenges in accurately understanding the epidemiology of HF and implementing effective public health interventions. Moreover, patients with heart failure in low-income countries (LICs) face a fivefold increase in the risk of mortality during the 30-day period following hospitalization, highlighting the critical necessity of promptly implementing effective strategies [1].

In the management of HF, cardiac rehabilitation (CR) has emerged as an integral therapeutic approach. Cardiac rehabilitation is defined as a multidisciplinary program that includes exercise training, cardiac risk factor modification, psychosocial assessment, and outcomes assessment [3]. Exercise training and other components of cardiac rehabilitation (CR) are safe and beneficial and result in significant improvements in quality of life, functional capacity, exercise performance, and heart failure (HF)-related hospitalizations in patients with HF [3]. Several studies have illustrated the safety and advantages of engaging in exercise and physical activity among patients with HF, while also highlighting the detrimental consequences of prolonged bed rest and immobilization in these patients [4]-[7]. As proposed by a recent state of the art review, evidence for exercised CR, supports its place as a "fifth pillar" of HF management and alongside the four classes of drugs, that is, angiotensin receptor neprilysin inhibitors, beta-blockers, mineralocorticoid receptor antagonists, and sodium-glucose cotransporter 2 inhibitors [8]. Despite the documented benefits of cardiac rehabilitation (CR), including improved clinical outcomes, cost-effectiveness, and strong recommendations in clinical practice guidelines, its utilization remains notably low, particularly in low- and middle-income countries (LMICs). The underutilization of CR in LMICs is a multifaceted issue influenced by various factors. These may include limited resources and infra-structure for rehabilitation services, insufficient healthcare provider training and awareness about the importance of CR, financial constraints among patients, and structural barriers such as lack of transportation or long distances to rehabilitation facilities. In addition, it's crucial to note the glaring gap in research regarding cardiac re-habilitation within the sub-Saharan African context.

Cardiac rehabilitation (CR) improves the physical capacity and quality of life of heart failure patients, with anticipated enhancements in exercise tolerance, cardiovascular function, and overall functional capacity. We expect these improvements to be particularly notable in underserved populations, underscoring CR's effectiveness in addressing health disparities in heart failure management. Therefore, we aim to elucidate the impact of CR interventions on physical capacity of Senegalese heart failure patients.

2. Patients and Methods

2.1. Study Design and Period

This study utilized a descriptive and analytical cross-sectional design, incorporating both retrospective and prospective data collection methodologies. Data collection occurred between February 1, 2021, and June 30, 2023, within the cardiovascular rehabilitation department of Idrissa POUYE General Hospital.

2.2. Study Population

The sampling method employed in our study entailed a retrospective analysis of data collected from both prospective and retrospective sources within an open cohort of individuals enrolled in a cardiac rehabilitation program. Participation in this program is strictly voluntary. The study cohort consisted of males and females aged 18 years and older, who received a diagnosis of heart failure upon hospital admission or referral from outpatient clinics, and subsequently admitted to Idrissa POUYE General Hospital's cardiovascular rehabilitation unit.

2.2.1. Inclusion Criteria

We included all stable heart failure patients with reduced or preserved left ventricular ejection fraction (LVEF), regardless of etiology, who had undergone at least 15 sessions of exercise training.

2.2.2. Exclusion Criteria

Patients who refused to participate and those with decompensated heart failure were excluded from the present study. Additionally, patients who discontinued their physical retraining sessions or missed more than two consecutive sessions were also excluded.

2.3. Data Collection

All heart failure patients referred for cardiac rehabilitation underwent a comprehensive initial evaluation, including medical history, clinical examination, assessment of cardiovascular risk factors, laboratory tests, electrocardiogram, transthoracic echocardiography, exercise testing, and a 6-minute walk test. This initial evaluation allowed risk stratification of the patients and adaptation of the modalities and monitoring of cardiac rehabilitation.

Exercise testing was performed on a treadmill using the modified Bruce protocol or the elderly protocol for those with significant physical deconditioning, and on a bicycle using ramp protocol. Exercise tests determined the level of exercise training, initial workload, resting heart rate (HR rest), maximum heart rate (HR max), and calculated target heart rate training zone using the Karvonen formula [9].

The rehabilitation protocol involved three sessions per week, each consisting of an endurance phase of 30 to 45 minutes on a treadmill and/or bicycle preceded by a warm-up phase of 3 to 5 minutes and followed by a 3 to 5-minute cool-down phase. Patients then engaged in 20 minutes of gymnastics. The Borg scale or perceived exertion measurement was used during the sessions.

During the program, all patients were offered participation in an educational program (group sessions, sometimes individual) on their disease and treatment, dietary counseling to promote lifestyle modifications targeting cardiovascular risk factors, physical activity promotion, smoking cessation support, and assistance with vocational reintegration.

At the end of the program, post-rehabilitation exercise testing, 6-minute walk test, and echocardiography were performed. A telephone call at 1 month and 3 months was made by the nurse to ensure continuous physical activity and lifestyle modifications, and consultation appointments were scheduled for the patients.

2.4. Study Parameters

Data were collected using a survey form containing the studied parameters by exploiting the hospitalization and rehabilitation records of the patients.

The evaluated parameters included:

- Socio-demographic parameters: age, sex, place of residence, existence of healthcare insurance, profession.
- Cardiovascular risk factors.
- Physical examination: general condition, dyspnea according to NYHA, blood pres-sure, heart rate, body mass index (BMI) and waist circumference.
- Patient's medication and compliance according to Girerd questionnaire [10].
- LDLc levels before and after CR.
- Echocardiography: left ventricular ejection fraction using Simpson's biplane method and left ventricular filling pressures.
- 6 minutes walk test distance covered before and after CR.
- Exercise testing [11]: percentage of theoretical maximum heart rate achieved, number of METs, blood pressure response to exercise, heart rate adaptation during exercise (considered good if peak heart rate minus resting heart rate exceeded 50 bpm), adequacy of heart rate recovery adaptation (considered good if the difference between maximum heart rate during exercise and heart

rate after one minute of recovery was greater than 12 bpm) [12], and the presence or absence of arrhythmias during exercise.

2.5. Statistical Analysis

The analysis plan in our study was predefined to explore potential differences in treatment response across various demographic and clinical subgroups, including gender, BMI, smoking status, diabetes status, and sedentary lifestyle, based on clinically relevant factors identified during the initial evaluation of patients referred for cardiac rehabilitation. Data analysis was performed using SPSS (Statistical Package for Social Sciences) version 24.0. In the case of quantitative observations, baseline characteristics were presented as mean standard deviation (SD) for parameters with normal distribution. Median interquartile range was used for parameters showing no normal distribution. Pearson's Chi-square test or Fisher's bilateral exact test were employed to compare frequencies up-on applicability. Mean comparisons were executed using a one-way repeated measures ANOVA test, with a significance threshold set at $p < 0.05$ and odds ratios calculated for significant associations. The 95% confidence intervals of the odds ratios were determined using the Woolf method.

3. Results

A total of 87 heart failure patients were included with 64.4% of males. The mean age was 57.10 yrs. ± 11.75. Heart failure with reduced ejection fraction (HFrEF) was the main type of heart failure in 53.5% of cases. 83.5% of the patients presented with dyspnea stage 2 to 3 of NYHA classification against 16.3% after CR. 64.4% of patients exhibited good therapeutic adherence, while 32.2% demonstrated poor adherence to treatment; only 3.4% of patients were non-adherent. Coronary artery disease was the leading cause of heart failure, accounting for 75.9% of cases. Cardiovascular risk factors included sedentary lifestyle (87.4%), dyslipidemia (77%), age (65.5%), hypertension (49.4%), diabetes (42.5%), smoking (29.9%), and obesity (9.2%). Atrial fibrillation was found in 4.7% of cases. Demographics characteristics of our population are summarized in **Table 1**. Left Ventricular Ejection Fraction (LVEF) increased from 40.15% ± 9% to 49.48% ± 10% ($p = 0.001$), representing an increase of 6.5%. Resting heart rate decreased from 81.38 bpm to 68.27 bpm after cardiac rehabilitation ($p = 0.000$). The number of METS increased from 4.3 ± 2.11 to 6.57 ± 2.78 [+56.8%; $p = 0.000$]. **Figure 1** gives an overview of physical capacity in our population. The mean distance covered in the 6-minute walk test increased significantly from an initial value of 337.8 meters to 522.7 meters at the end of cardiac rehabilitation, representing a gain of 183.5 meters ($p = 0.000$). Evolution of clinical parameters post Cr are summarized in **Table 2**. Increase in number of METS was more pronounced in females ($p = 0.001$), non-obese individuals ($p = 0.000$), non-diabetics ($p = 0.001$), non-sedentary ($p = 0.000$) and non-smokers ($p = 0.000$). Severe limitation in daily life activities dropped by 32% (**Figure 2**). Additionally, the readmissions rate in our study was 2.2% and mortality rate 1.1%.

Table 1. Characteristics of studied population.

Parameters	Value
Age (Mean value ± SD)	57.10 ± 11.75
Male (%)	64.4
Low literacy (%)	36.8
Employment (%)	20.7
Lack of health insurance (%)	73.6
Sedentarity (%)	87.4
Dyslipidemia (%)	77
Hypertension (%)	49.4
Diabetes mellitus (%)	42.5
Tobacco use (%)	29.9
Obesity (%)	9.2
HFrEF	43.5
HFmEF	33.7
HFpEF	12.8
Coronary artery disease (%)	75.9
Dilated cardiomyopathy (%)	18.4
Valvular heart disease (%)	2.3
Hypertension (%)	1.1
Restrictive cardiomyopathy (%)	1.1
Peripartum cardiomyopthy (%)	1.1

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Table 2. Evolution of clinical parameters in post CR.

Parameters	Pre CR	Post CR	p value
Systolic BP (mm Hg)	129.1	127.5	0.35
Diastolic BP (mm Hg)	78.3	72.2	0.000
Weight (kg)	78.51 ± 12	77.17 ± 12	0.007
BMI	24.61 ± 3.73	23.49 ± 2.73	0.000
AC (cm)	90.89 ± 19.12	86.74 ± 12.46	0.001
Resting HR (bpm)	81.38 ± 11.18	68.27 ± 7.92	0.000
LDLc (g/l)	1.72	0.96	0.000
LVEF (%)	40.15 ± 9	49.48 ± 10	0.000
METS	4.3 ± 2.11	6.57 ± 2.78	0.000
6 TMW	337.82 ± 113	522.7 ± 118.99	0.000

BMl = body mass index; AC = abdominal circumference; HR = heart rate; LVEF = left ventricular ejection fraction; 6 MWT = 6 minutes walk test.

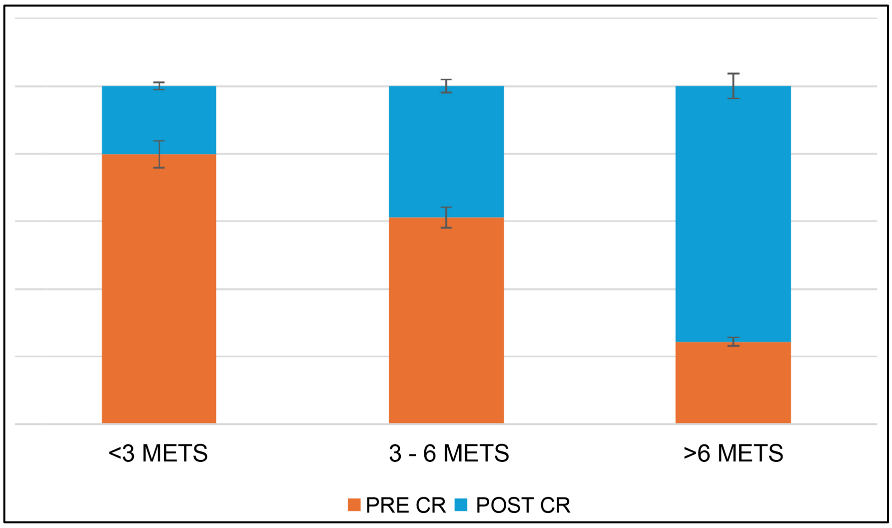

Figure 1. Distribution according to number of METS in pre and post CR.

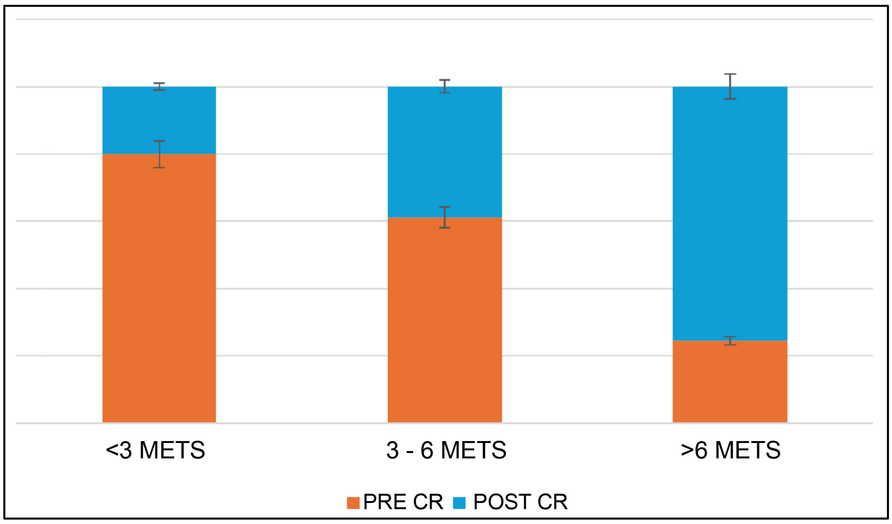

Figure 2. Overview of daily life activities limitations before and after cardiac rehabilitation.

4. Discussion

The findings of our study demonstrate significant improvements in physical capacity among HF patients following cardiac rehabilitation (CR). Specifically, we observed notable increases in parameters such as Left Ventricular Ejection Fraction (LVEF), distance covered in the 6-minute walk test and number of METS. These improvements indicate enhanced cardiac function and exercise tolerance among HF patients post-CR, which are crucial factors in improving overall quality of life. The evidence that CR is able to improve functional capacity and QoL is largely accepted [12]. In 2009, results of HF-Action, which is to date, the largest controlled clinical trial aimed to test the efficacy and safety of exercise training among patients with HF, showed a median 20-m increase at the 6 MWT compared with a 5-m increase in the control group [13]. Uddin *et al.* concluded that exercise-based CR improved significantly exercise capacity; the magnitude of improvement was similar in CHF and coronary heart disease patients [14]. EXTRAMATCH II, the largest meta-analysis to date, found that exercise-based CR significantly improve both exercise capacity and health-related quality of life [15].

The notable disparities in the improvements observed in the 6-minute walk test (6 MWT) distance covered between our study and existing literature may indeed be attributed to racial ethnicity. A post hoc analysis by HF-ACTION investigators [13] demonstrated a significant interaction between exercise-based cardiac rehabilitation (ExCR) and ethnicity, particularly regarding changes in 6 MWT distance. This analysis indicated that black patients exhibited a mean increase of 26 meters in the 6 MWT distance following ExCR, whereas white patients showed a mean increase of only 11 meters. Awotidebe and al. demonstrate 87 meters increase in 6 MWT distance in Nigerians heart failure patients after CR compared to control group ($p = 0.001$) [16]. Thus, ethnicity emerges as a potential influencing factor contributing to the observed discrepancies in the response to cardiac rehabilitation interventions, suggesting that black patients might demonstrate greater enhancements in functional capacity compared to their white counterparts. Further research is warranted to delve deeper into the underlying mechanisms driving these ethnic disparities and to explore tailored rehabilitation strategies that can optimize outcomes across diverse patient populations.

Furthermore, our study highlighted the demographic factors influencing these improvements. We found that increases in METS were more pronounced in females, non-obese individuals, non-diabetics, non-sedentary individuals, and non-smokers. Through an observational retrospective cohort study, De Souza *et al*. showed that women participating in the long-term medically supervised exercise program (MSEP) showed better long-term survival compared to men [17]. This emphasizes the importance of considering individual characteristics when designing rehabilitation programs tailored to maximize benefits.

Our observation of female underrepresentation in our cohort aligns with documented trends in the existing literature. Numerous studies have highlighted the disproportionate underrepresentation of women in cardiovascular research and clinical trials, reflecting a pervasive issue within the field. Indeed, women are less likely to be referred to CR than men and are adherent [18] [19]. This consistency underscores the urgent need for targeted interventions to address barriers to female participation and ensure gender equity in re-search endeavors. Lack of referral may be caused by some unconscious clinician bias [20]. Referral should be accompanied by bedside education and discussion to encourage women's attendance at CR programs [21]. Common barriers women face should be discussed such as transportation, care-giving responsibilities, and perceptions toward exercise [22] [23]. By acknowledging and addressing these discrepancies, we can foster more inclusive and representative studies that better reflect the diverse demographics affected by heart failure, ultimately advancing our understanding and management of this complex condition.

Importantly, our findings also revealed a low readmission rate of 2.2% and a mortality rate of 1.1%, underscoring the positive impact of cardiac rehabilitation on overall health outcomes in our population. Cardiac rehabilitation (CR) has been widely acknowledged for its positive impact on improving functional capacity and quality of life (QoL) among patients with heart failure. Numerous studies [12] [15] [24] have provided substantial evidence supporting these benefits. However, it is crucial to recognize that the translation of improved functional capacity and QoL into hard clinical endpoints, such as mortality rates and hospitalizations, remains a subject of debate and uncertainty within the medical community. While CR has shown promising results in enhancing patients' overall well-being and symptom management, its direct influence on reducing mortality or hospitalization rates requires further investigation and validation through rigorous clinical trials and long-term follow-up studies. Therefore, while acknowledging the positive out-comes associated with CR, it is imperative to approach its effectiveness in improving hard clinical endpoints with caution and continue research efforts to better understand its comprehensive impact on patient outcomes [24].

Overall, our findings align with previous research demonstrating the beneficial effects of CR on physical capacity and clinical outcomes in HF patients. Consistent with existing literature, our study highlights the importance of CR as an integral component of HF management, emphasizing its role in optimizing patient outcomes and reducing the burden of HF-related complications. However, our study also offers unique insights into the Sub-Saharan African context, providing valuable data on CR outcomes in a population that has been historically underrepresented in HF research.

4.1. Implications for Clinical Practice and Future Research

The improvements observed in physical capacity and clinical parameters post-CR have significant implications for clinical practice. Healthcare providers should consider incorporating CR into the comprehensive management of HF patients, as it offers a promising approach to improving functional status, symptom control, and overall prognosis. By optimizing CR referral pathways and ensuring access to rehabilitation services, healthcare systems can enhance the quality of care for HF patients and mitigate the progression of the disease.

Moving forward, further research is needed to explore additional factors influencing CR utilization and outcomes in Sub-Saharan African settings, including cultural, socioeconomic, and healthcare system-related barriers.

Additionally, efforts should be made to explore novel interventions and strategies to enhance CR utilization and effectiveness in African settings.

4.2. Strength and Limitations

Our study addresses a critical gap in HF research by providing valuable hospital-based data on CR outcomes in Africa. By elucidating the effectiveness of CR in this context, our findings contribute to a more comprehensive understanding of HF management, particularly in underserved populations, thereby enhancing knowledge in the African setting.

However, our study presents several limitations. This is cross-sectional study with data from patients undergoing CR. While the study design lacked a specific control group, the comprehensive nature of the cohort data allowed for the evaluation of outcomes over an extended period, providing valuable insights into the effectiveness of the program in a real-world setting.

While our study provides important insights into the benefits of CR for HF patients in Sub-Saharan Africa, several limitations should be considered. These include the relatively small sample size, limited follow-up duration, and potential confounding factors that may have influenced the observed outcomes. Optimal drug therapy, which is a key component of cardiac rehabilitation, may serve as a confounding factor in our study. These medications can exert direct effects on cardiovascular function, symptom severity, and exercise tolerance, potentially confounding the interpretation of rehabilitation outcomes. For example, beta-blockers are known to reduce heart rate and myocardial oxygen demand, thereby influencing exercise capacity and functional performance during rehabilitation sessions. Additionally, variations in medication adherence and dosages among participants can introduce further variability in outcomes, necessitating careful consideration and adjustment for these factors in the analysis. Therefore, while our study aimed to evaluate the efficacy of cardiac rehabilitation, it is crucial to acknowledge the potential influence of concurrent medication usage as a confounding factor that may have contributed to the observed outcomes.

Future research should aim to address these limitations through larger, longitudinal studies with more diverse patient populations.

Conflicts of Interest

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

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