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Impact of Cardiovascular Rehabilitation on the Functional Capacity of Patients with Heart Failure: A Cohort Study at Yaoundé General Hospital, Cameroon

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Abstract

Background: Cardiovascular rehabilitation (CR) enhances the functional capacity of patients with heart failure (HF), but its effectiveness remains understudied in low-resource settings such as Cameroon. This study aimed to evaluate the impact of CR on the functional capacity of HF patients at Yaoundé General Hospital (YGH). **Methods:** A mixed retrospective and prospective cohort study was conducted at the Cardiovascular and Metabolic Rehabilitation Unit (CMRU) of YGH from February 2024 to May 2025. It included adults (≥21 years) diagnosed with HF according to the 2021 ESC criteria, who completed at least 10 CR sessions. The primary outcome was 6-minute walk test (6 MWT) distance. Secondary outcomes included VO_2max estimated from 6 MWT (VO_2max_6 MWT = distance × 0.1 + 3.5; the most objective VO_2max estimate), VO_2max estimated from the Duke Activity Status Index (DASI) questionnaire (VO_2max_DASI = 0.43 × DASI + 9.6), Metabolic Equivalents (METs), and DASI score. These functional parameters were assessed before and after CR, and factors associated with changes (delta) in outcomes post CR were identified via linear regression. **Results:** Thirty-three patients (mean age

59 ± 12 years; 60.6% male) were included. CR significantly improved 6 MWT distance (456 to 571 m), VO_2max_6 MWT (11.02 to 13.02 mL/kg/min), VO_2max_DASI (15.7 to 22.3 mL/kg/min), METs (5.08 to 8.6), and DASI score (13.3 to 29.5) (all $p < 0.001$). Reductions in resting heart rate and systolic blood pressure, as well as improvements in dyspnoea (100% NYHA stage I post-CR), were also observed. Older age was associated with less improvement in VO_2max_DASI, while higher baseline heart rate and a greater number of sessions were linked to better 6 MWT performance. **Conclusion:** CR significantly improves functional capacity and haemodynamic parameters in HF patients in a low-resource setting. Integrating CR into universal health coverage and tailoring programmes for older patients could optimise outcomes.

Keywords

Cardiovascular Rehabilitation, Heart Failure, Functional Capacity, Cameroon

1. Introduction

Cardiovascular diseases (CVDs), the leading global cause of death with 19.8 million annual fatalities (32% of total mortality), include heart failure (HF) as a major burden in sub-Saharan Africa, where hospital prevalence reaches 12.0% in Sudan, 17.6% in Burkina Faso, 28.6% in Togo, and 30% in Cameroon, affecting 1% - 3% of the global adult population with a stable incidence of 1 - 20 cases per 1000 person-years, an annual cost of €25,500 per patient, and disproportionately impacting younger, often uninsured and less-educated individuals who commonly present in advanced New York Heart Association (NYHA) functional class IV [1]-[3]. The burden of HF in SSA is rising, with in-hospital mortality ranging from 3.7% - 19.0% [4].

HF leads to progressive physical deconditioning, impairing functional capacity and quality of life [5]. In a Cameroonian cohort, 54% of patients had moderate daily physical activity, 45% had low activity, and approximately 39.2% exhibited impaired physical fitness associated with obesity, low physical activity, and non-adherence to treatment, negatively affecting their quality of life [6]. Despite reduced mortality from medical treatments, morbidity due to deconditioning persists, increasing rehospitalisations and socioeconomic costs [7].

Cardiovascular rehabilitation (CR), defined by the WHO as a set of activities aimed at optimising physical, mental, and social conditions [8], improves functional capacity, reduces hospitalisations, and promotes healthy lifestyle adoption [9]. However, in SSA, CR remains underutilised due to a lack of infrastructure, trained personnel, and awareness [10] [11]. Yaoundé General Hospital (YGH), a leading teaching hospital, established its Cardiovascular and Metabolic Rehabilitation Unit (CMRU) in February 2024, a pioneering initiative for managing HF patients in a resource-constrained setting. This study aims to: 1) describe the sociodemographic, clinical, and therapeutic profiles of HF patients;

2) compare their functional capacity before and after CR; and 3) identify determinants of changes in functional capacity. These findings could inform public health policies to integrate CR into universal health coverage, reducing access inequalities and contributing to the Sustainable Development Goals by 2030 [12].

2. Methodology

2.1. Study Design

An analytical cohort study with retrospective and prospective components was conducted to assess the impact of CR on the functional capacity of HF patients at YGH.

2.2. Setting and Study Period

The study was conducted at the CMRU of YGH, located in Yaoundé, Cameroon, in a 25 m^2 room equipped with treadmills, cycle ergometers, a muscle-strengthening device, an electrocardiograph, and an echocardiograph. The unit, managed by two cardiologists, one general practitioner, and one nurse, serves approximately 10 patients monthly. The study spanned February 2024 to May 2025, with retrospective recruitment (February 2024-January 2025) and prospective recruitment (February-May 2025). Patients were followed for up to 4 weeks post-CR to assess outcomes and complications.

2.3. Participants

- **Inclusion Criteria:** Adults (≥21 years) diagnosed with HF per the 2021 European Society of Cardiology criteria (ESC), who completed ≥ 10 CR sessions at the CMRU and provided consent [13].
- **Exclusion Criteria**: Insufficient sessions (<10), contraindications to exercise (e.g., severe arrhythmias, exercise intolerance).

A consecutive non-probability sampling included all eligible patients.

2.4. Variables

- *Sociodemographic*: Age, sex, residence, occupation, education level, marital status, and financial coverage.
- *Clinical*: Cardiovascular risk factors (CVRF) (hypertension, diabetes, obesity, etc.), HF aetiology, left ventricular ejection fraction (LVEF), treatments, complications.
- *Functional parameters*: 6 MWT distance (m) was the primary outcome; secondary outcomes: VO_2max_6 MWT (mL/kg/min; a more objective VO_2max estimate, calculated as 6 MWT distance × 0.1 + 3.5), VO_2max_DASI (mL/kg/min; calculated as 0.43 × DASI + 9.6), DASI score, METs, exercise stage/duration (modified Bruce protocol), resting/maximal heart rate (HR, bpm), systolic/diastolic blood pressure (SBP/DBP, mmHg), body mass index (BMI), dyspnoea (NYHA stage), fatigue.

- *Predictors/Modifiers*: Age, sex, CVRF, number/frequency of sessions, baseline HR.
- *Confounders*: HF type, aetiology, disease duration.

HF types were operationally defined as: "Left-sided HF" (predominant left ventricular dysfunction without clinical signs of systemic congestion) and "Congestive HF" (biventricular dysfunction with clinical signs of systemic congestion, e.g., peripheral oedema, jugular venous distension). These categories were not mutually exclusive, as some patients with left-sided HF may progress to congestive features.

2.5. Data Sources and Measurements

- *Retrospective Phase*: Data extracted from CMRU registers and medical records.
- *Prospective Phase*: Data collected at the start and end of CR via clinical examinations, ECG, echocardiography, 6 MWT (20 m track), exercise tests (modified Bruce protocol), Systolic Blood Pressure/Diastolic Blood Pressure/Heart Rate measurements (OMRON HEM-432C sphygmomanometer), oxygen saturation (SpO_2) measured via pulse oximetry, weight/height. Methods were standardised for comparability.

2.6. CR Procedure

The CR programme (10 - 25 sessions, 3 - 10 weeks, 2 - 3 sessions/week, 60 min) included:

- **Warm-up (10 - 15 min):** Stretching, slow walking.
- **Main Exercise (40 min):** Aerobic exercises (treadmill/cycle ergometer, max Heart Rate per Karvonen formula, Borg scale 12 - 14) and light muscle strengthening.
- **Recovery (5 - 10 min):** Slow walking, relaxation.

Sessions, supervised by a cardiologist or nurse, included therapeutic education. Contraindications were monitored via Electrocardiography.

2.7. Bias

Consecutive sampling minimised selection bias. Standardised protocols reduced information bias, despite occasional incomplete retrospective records. Linear regression controlled for confounders (age, sex, CVRF). Patients lost to follow-up were excluded, with reasons documented.

2.8. Sample Size

The sample size was calculated a priori to detect a clinically meaningful improvement in the primary outcome (6-minute walk test [6 MWT] distance) of 36 m—the minimal important difference (MID) for stable chronic heart failure patients over 6 - 12 months, derived from a standard error of measurement (SEM) approach in two large cohorts [14], assuming a standard deviation of 115 m (typical

baseline SD in heart failure rehabilitation cohorts [14] [15]), using a paired t-test, $\alpha = 0.05$, and 80% power. This yielded a minimum of n = 29 patients. Allowing for up to 15% attrition due to incomplete sessions or missing data, a recruitment target of n = 34 was set. The final sample of n = 33 met this requirement. Post-hoc power analysis confirmed > 99.9% power to detect the observed improvement of 115 m (SD = 112 m). Analysis of factors associated with 6 MWT and VO_2max_DASI (11 predictors) was suboptimal (ideal: 60 - 120 patients) [16].

2.9. Statistical Analysis

Continuous variables (6 MWT distance, VO_2max_6 MWT, VO_2max_DASI, etc.) were expressed as means ± standard deviation. Data normality was tested using the Shapiro-Wilk test. Pre- and post-CR parameters were compared using the paired Student's t-test for quantitative variables and McNemar's test for qualitative variables. Multivariate linear regression identified determinants of aerobic capacity (VO_2max_DASI, 6 MWT), with regression coefficients adjusted for age and sex. Missing data were not imputed; patients with incomplete data were excluded from specific analyses.

2.10. Ethical Considerations

The study was approved by the Ethics Committee of the University of Douala (Ref: 4796/CEI-UDo/03/2025) and YGH (Ref: 0301-25/HGY/DG/DPM/APM-AS). Informed consent was obtained in the prospective phase; a waiver was granted for the retrospective phase (anonymised data). Data were coded, securely stored, and used solely for research purposes.

3. Results

3.1. Participant Characteristics

Of 35 patients enrolled in CR at the CMRU from February 2024 to May 2025, 33 were included (23 retrospective, 10 prospective) after excluding 2 for < 10 sessions, as shown in **Figure 1**. The mean age was 59 ± 12 years, with 60.6% male (M/F ratio: 1.54). **Table 1** and **Figure 2** present the sociodemographic, clinical, and therapeutic characteristics. Hypertension was the most common CVRF (54.5%). Hypertensive heart disease was the primary aetiology (36.4%). LVEF was < 40% in 62.5% of patients (mean 37.6 ± 16.3%). Congestive HF predominated (63.6%), with a mean disease duration of 3.6 years. Loop diuretics (90.9%) and beta-blockers (87.9%) were the most used treatments; ARNi (9.1%) and SGLT2 inhibitors (18.2%) were less prescribed (**Figure 2**).

3.2. CR Programme

The mean time from HF diagnosis to CR initiation was 3.6 years. Patients completed 14.09 ± 4.3 sessions (10 - 25), with 60.6% attending three sessions per week, as reported in **Table 2**.

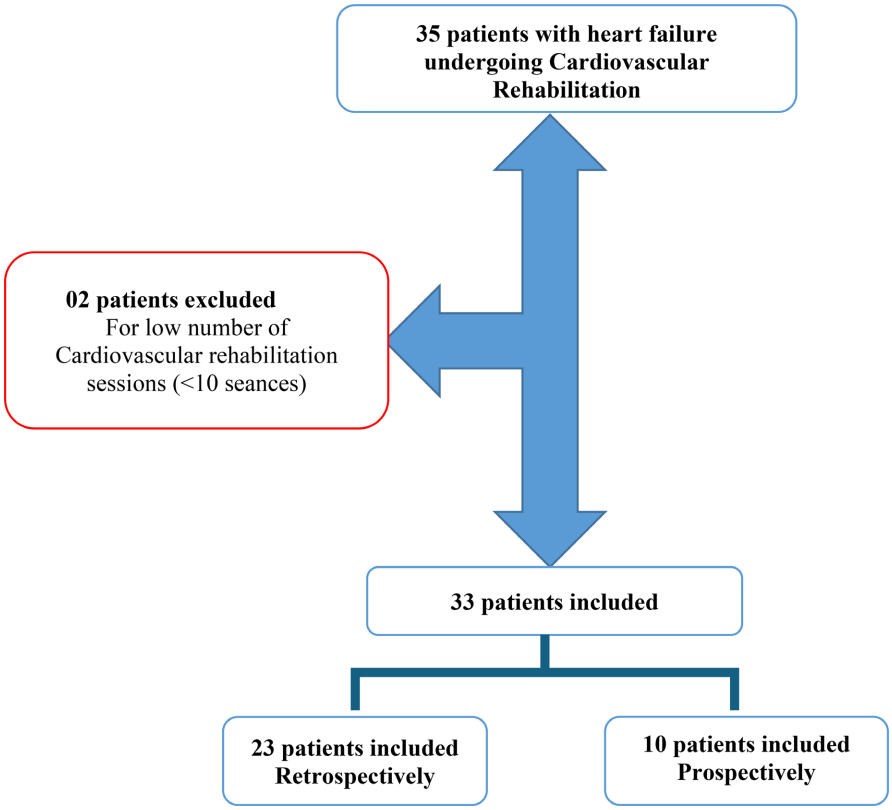


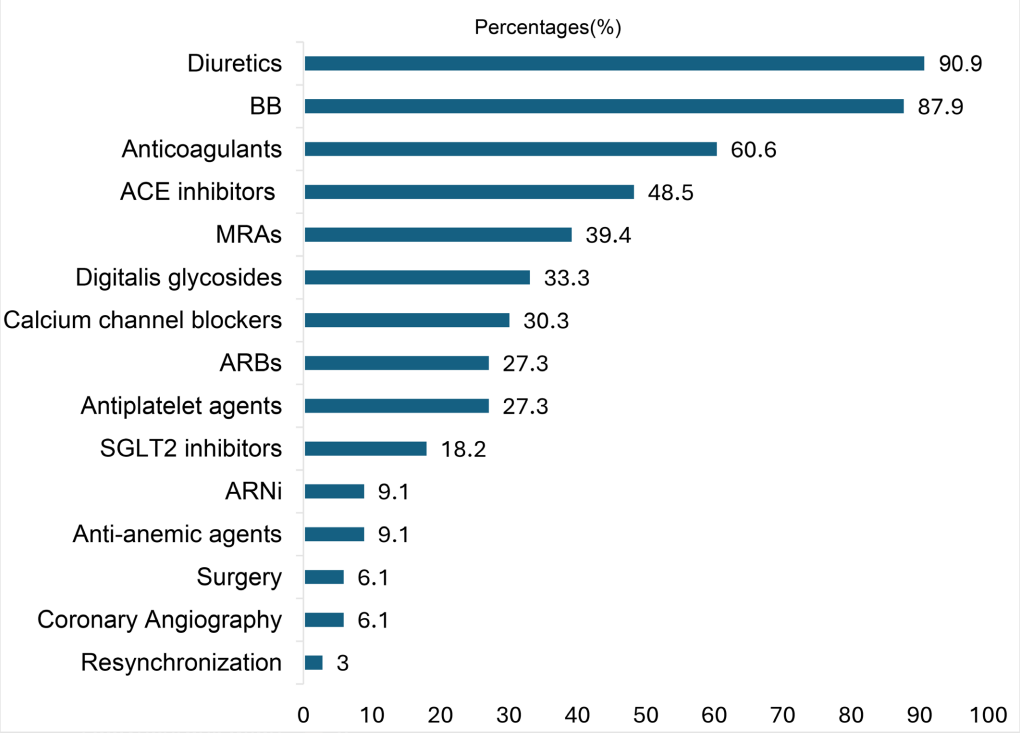
Figure 1. Participant flow chart.

Table 1. Sociodemographic and clinical characteristics.

Characteristics	Frequency (N = 33)	%
Age (years)		
<50	10	30.4
≥50	23	69.6
Sex		
Male	20	60.6
Female	13	39.4
Residence		
Yaoundé	19	57.6
Other Cameroonian cities	11	33.3
Abroad (Chad-N'Djamena)	3	9.1
Comorbidities		
Hypertension	18	54.5
Alcoholism	16	48.5
Dyslipidaemia	14	42.4
Obesity	11	33.3
Sedentary lifestyle	11	33.3

Continued

Smoking	10	30.3
Diabetes	6	18.2
Gout	4	12.1
Heart Failure (HF) Aetiology		
Hypertensive heart disease	12	36.4
Ischaemic heart disease	9	27.3
Dilated cardiomyopathy	7	21.2
Valvular heart disease	4	12.1
Peripartum cardiomyopathy	1	3.0
Left Ventricular Ejection Fraction		
<40%	20	62.5
40% - 49%	3	9.4
≥50%	9	28.1
HF Type		
Left-sided HF	12	36.4
Congestive HF	21	63.6



ARNi: Angiotensin receptor-neprilysin inhibitors; BB: Beta-blockers; ARB: Angiotensin II receptor blockers; MRA: Mineralocorticoid receptor antagonists; SGLT2i: Sodium-glucose cotransporter 2 inhibitors; ACEi: Angiotensin-converting enzyme inhibitors.

Figure 2. Distribution of patients by treatment received.

Table 2. Number and frequency of CR sessions.

Variables	Frequency (N = 33)	%
Number of Sessions		
10	8	24.2
11 - 19	17	51.5
≥20	8	24.2
Frequency (days/week)		
2	13	39.4
3	20	60.6

3.3. Changes in Physiological and Clinical Parameters

Table 3 shows significant reductions in haemodynamic parameters and BMI, alongside a substantial increase in LVEF (+22.9%, $p < 0.001$). Significant improvements ($p < 0.001$) were observed in all cardiorespiratory fitness and rehabilitation parameters. The greatest improvement in cardiorespiratory fitness was for VO_2max_DASI (+42.0%), while 6 MWT distance increased by +25.2% and VO_2max_6 MWT (the most objective VO_2max measure) by +18.1%. Maximal workload showed the largest

Table 3. Haemodynamic and clinical changes.

Variable	Pre-CR	Post-CR	Δ (%)	p
Resting HR (bpm)	76 ± 13	70 ± 10	−7.9%	0.001
Resting SBP (mmHg)	124 ± 17	117 ± 11	−5.6%	0.004
Resting DBP (mmHg)	76 ± 11	71 ± 8	−6.6%	0.008
BMI (kg/m^2)	28.7 ± 10.2	28.0 ± 9.9	−2.4%	0.025
LVEF (%)	37.6 ± 16.3	46.2 ± 13.4	+22.9%	<0.001
6 MWT (m)	456 ± 124	571 ± 101	+25.2%	<0.001
VO_2max 6 MWT (mL/kg/min)	11.02 ± 4.3	13.02 ± 4.5	+18.1%	<0.001
VO_2max DASI (mL/kg/min)	15.7 ± 4.3	22.3 ± 4.5	+42.0%	<0.001
METs	5.08 ± 1.86	8.6 ± 2.2	+69.3%	<0.001
Peak Exercise Level	2.79 ± 1.11	4.42 ± 0.83	+58.4%	<0.001
Exercise Duration (min)	8.5 ± 3.3	13.27 ± 2.49	+56.1%	<0.001
Maximal Workload (Watts)	25.0 ± 12.1	42.9 ± 12.8	+71.6%	<0.001
Fatigue	32 (97%)	2 (6.1%)	−90.9%	<0.001
Dyspnoea NYHA II-III	33 (100%)	0	−100%	<0.001

Δ = Change from pre CR to post CR; BMI = Body Mass Index; DASI = Duke Activity Status Index; DBP = Diastolic Blood Pressure; HR = Heart rate; LVEF = Left Ventricular Ejection Fraction; METs = Metabolic Equivalents, NYHA = New York Heart Association; SBP = Systolic Blood Pressure; VO_2max = highest oxygen uptake during physical work at sea level; 6 MWT = 6 Minute Walking Test.

increase among rehabilitation parameters (+71.6%). Clinically, of 32 patients, only two reported fatigue post-CR. All patients had NYHA stage II or III dyspnoea at baseline, but all were staged NYHA I post-CR.

3.4. Determinants of Functional Capacity Changes

Older age was associated with less improvement in VO_2max_DASI ($\beta = -0.23$, $p < 0.001$). Longer HF duration ($\beta = 7.02$, $p = 0.003$), higher baseline resting HR ($\beta = 3.33$, $p = 0.007$), and more sessions ($\beta = 5.44$, $p = 0.033$) were linked to greater 6 MWT distance improvement. Male sex predicted less 6 MWT improvement ($\beta = -58.58$, $p = 0.013$), as shown in Table 4.

Table 4. Determinants of changes in VO_2max_DASI and 6 MWT distance.

Parameters	VO_2max_DASI		6 MWT Distance	
	$\beta \pm$ SE	p	$\beta \pm$ SE	p
Age (years)	−0.23 ± 0.06	<0.001	0.24 ± 1.09	0.828
HF Duration (years)	0.02 ± 0.18	0.924	7.02 ± 2.39	0.003
Sex (Female)	−1.01 ± 1.62	0.534	−58.58 ± 23.65	0.013
HF Type (Global)	0.46 ± 1.65	0.781	32.22 ± 26.91	0.231
Hypertension (Yes)	−0.99 ± 1.58	0.531	−29.15 ± 25.45	0.252
Dyslipidaemia (Yes)	−1.19 ± 1.6	0.457	−40.56 ± 25.81	0.116
Resting SBP (mmHg)	0.02 ± 0.05	0.68	−0.13 ± 0.79	0.87
Resting DBP (mmHg)	0.04 ± 0.08	0.6	0.77 ± 1.19	0.517
Resting HR (bpm)	−0.04 ± 0.07	0.523	3.33 ± 1.24	0.007
LVEF	0.03 ± 0.05	0.526	1.36 ± 1.18	0.250
BMI (kg/m^2)	0.00 ± 0.08	0.97	1.74 ± 2.26	0.44
Number of Sessions	−0.19 ± 0.17	0.284	5.44 ± 2.56	0.033
Frequency (/week)	0.44 ± 1.43	0.759	−13.21 ± 22.84	0.563

β = regression coefficient; DBP = Diastolic Blood Pressure; HF = Heart Failure; HR = Heart rate; LVEF = Left Ventricular Ejection Fraction; SE = Standard Error; SBP = Systolic Blood Pressure; VO_2max = highest oxygen uptake during physical work at sea level; 6 MWT = 6 Minute Walking Test.

3.5. Complications and Follow-Up

No deaths occurred during CR. One readmission for dyspnoea was noted within 4 weeks post-CR, with no deaths reported.

4. Discussion

This cohort study, conducted at YGH's CMRU from February 2024 to May 2025, assessed the impact of CR on 33 HF patients. Results demonstrate that CR significantly enhances cardiorespiratory fitness, improves haemodynamic profiles, and reduces dyspnoea in all patients. Post-CR VO_2max_DASI was significantly associated with age, while 6 MWT distance was linked to disease duration, sex, baseline resting HR, and number of sessions.

This study aligns with international literature confirming CR benefits for HF patients. A systematic review by Sadek *et al.* (2021) showed that structured aerobic exercise in CR significantly improves VO_2max and LVEF in chronic HF patients [17]. For instance, Wissløff *et al.* (2007) in Norway reported VO_2max increases from 13 ± 1.6 to 19 ± 2.1 mL/kg/min ($p < 0.01$) and LVEF from 28% ± 7.3% to 38% ± 9.8% ($p < 0.01$) with intensive CR, while less intensive protocols showed smaller improvements (VO_2max: 13 ± 1.1 to 14.9 ± 0.9 mL/kg/min, $p < 0.01$; LVEF: 32.8% ± 4.8% to 33.5% ± 5.7%, $p > 0.05$) [18]. Our study reports comparable or superior improvements in a low-resource setting (6 MWT: +115 m; VO_2max_6 MWT: +2.0 mL/kg/min; VO_2max_DASI: +6.6 mL/kg/min; LVEF: +22.9%), highlighting CR's efficacy despite modest infrastructure at YGH. The notable LVEF improvement (22.9%), rarely reported in SSA, may reflect the combined effect of session intensity (Borg scale 12 - 14) and therapeutic education, which potentially encouraged medication adherence (though not formally assessed in this study). However, the lack of a control group limits comparisons with randomised trials like those of Wissløff (2007) or Ellingsen (2017) [18] [19].

The significant improvements in functional capacity and haemodynamic parameters can be attributed to the YGH CMRU's CR programme, combining aerobic exercises (treadmill, cycle ergometer), light muscle strengthening, and therapeutic education over 10–25 sessions (mean 14.09 ± 4.3), which optimised physical reconditioning and treatment adherence, as supported by the WHO [8]. LVEF improvement may stem from better adherence to pharmacological treatments (loop diuretics: 90.9%; beta-blockers: 87.9%), reinforced by therapeutic education at the CMRU, a mechanism noted by Tüner *et al.* (2025) in Türkiye [20].

Older age, limiting VO_2max improvement ($\beta = -0.23$, $p < 0.001$), reflects reduced functional reserve, as reported by other authors [18]-[20]. Greater 6 MWT improvement with more sessions ($\beta = 5.44$, $p = 0.033$) and higher baseline resting HR ($\beta = 3.33$, $p = 0.007$) re-emphasises the importance of session intensity and regularity, aligning with Sadek *et al.* (2021) [17]. The resolution of dyspnoea (97% NYHA stage I, $p < 0.001$) may relate to improved physical fitness and reduced oxidative stress, though the lack of a control group limits causal attribution [21]-[23].

This study, among the first in Central Africa, reinforces CR's feasibility in low-resource settings. Standardised tests ensure methodological robustness. However, the small sample size ($n = 33$) limits generalisability, and the absence of a control group complicates causal attribution. High CR costs and lack of health insurance (84.8% without coverage) may have affected adherence.

5. Conclusions

CR significantly improves functional capacity and haemodynamic parameters in HF patients in Cameroon, despite a resource-constrained setting. These findings underscore the urgency of integrating CR into universal health coverage and developing tailored infrastructure. Personalising programmes for older patients and enhancing therapeutic education could optimise outcomes, contributing to reduced cardiovascular morbidity.

What Is Known About This Topic?

- HF is a major cause of morbidity and mortality in SSA, with high hospital prevalence (up to 30% in Cameroon) and in-hospital mortality of 3.7% - 19%.
- CR improves functional capacity, reduces hospitalisations, and enhances quality of life in high-resource settings, but its use in SSA is limited by inadequate infrastructure and awareness.
- HF patients in Cameroon, often young and uninsured, exhibit significant physical deconditioning, exacerbated by low physical activity and treatment non-adherence.

What This Study Adds

- CR at YGH significantly improved 6 MWT distance (+25.2%; primary outcome), VO_2max_6 MWT (+18.1%; most objective VO_2max), VO_2max_DASI (+42%), METs (+69.3%), DASI score (+121.8%), and LVEF (+22.9%), demonstrating its feasibility in SSA.
- Older age limits VO_2max_DASI improvement, while more sessions and higher baseline resting HR enhance 6 MWT progress, highlighting the need for tailored programmes.
- These findings advocate for integrating CR into universal health coverage in Cameroon, with an urgent need for adapted infrastructure and improved financial access to reduce inequalities.

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Data Availability

Data supporting the study's findings are available from the corresponding author (SD) upon reasonable request.

Ethical Approval

The study was approved by the Ethics Committee of the University of Douala (Ref: 4796/CEI-UDo/03/2025) and YGH (Ref: 0301-25/HGY/DG/DPM/APM-AS). The requirement for informed consent was waived for the retrospective phase due to

the use of anonymised secondary data. All procedures complied with applicable guidelines and regulations.

Author Contributions

Study conception and design: TH, SD, NNE. Data collection: NNE. Data analysis and interpretation: NNE. Manuscript drafting: All authors. Final manuscript approval: All authors. KF supervised the study. SD and NNE had full access to all study data and took responsibility for data integrity and analysis accuracy. All authors agreed to submit the manuscript in its current form.

Conflicts of Interest

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

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