

# Outcome of a Supervised Cardiovascular Rehabilitation Program on Muscle Strength, Symptoms, and Functional Capacity in Patients with Stable Chronic Heart Failure: A Multicentre Longitudinal Study in Yaoundé, Cameroon

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## Abstract

**Background:** Peripheral muscle weakness contributes significantly to exercise intolerance in chronic heart failure (CHF). This multicenter longitudinal study evaluated the impact of a supervised cardiovascular rehabilitation (CVR) program on segmental muscle strength, symptoms, and functional capacity in stable CHF patients in Yaoundé, Cameroon. **Methods:** In this multicentre longitudinal study, adults aged  $\geq 18$  years with stable CHF (NYHA class I-III) underwent a standardized outpatient CVR program targeting 18 sessions (3 sessions/week over 6 - 7 weeks on average; minimum 15 sessions; median 18, range 15 - 20). The program comprised aerobic exercise (treadmill/cycling at 50% - 75% heart rate reserve) interspersed with segmental resistance training (body weight/light loads, 10 - 15 repetitions in 2 - 3 sets for major muscle groups), warm-up, cool-down, and therapeutic education. Baseline data were retrospectively extracted from program intake records; post-intervention assessments were prospectively conducted within one week of completion. The primary outcome was lower-limb segmental muscle strength (handheld dynamometry: quadriceps). Secondary outcomes included symptoms (dyspnoea,



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palpitations), body weight, Duke Activity Status Index (DASI), six-minute walk test (6 MWT) distance, and peak metabolic equivalents/estimated  $VO_{2max}$  (cycle ergometer). Pre-post changes were analysed with Wilcoxon signed-rank tests ( $p < 0.05$ ). **Results:** The cohort (median age 56 years; 54% female; 70% preserved ejection fraction) showed significant improvements post-CVR. Lower limb strength increased dramatically (median 0.0 to 10.0 kgf;  $p < 0.001$ ). Symptoms reduced markedly (dyspnoea: 22% to 2%,  $p = 0.037$ ; palpitations: 16% to 2%,  $p < 0.001$ ). Functional capacity improved robustly: 6 MWT +100 m (400 to 500 m;  $p < 0.001$ ), DASI score + 26.25 (24.45 to 50.70;  $p < 0.001$ ), peak METs + 3.37 ( $p < 0.001$ ), estimated  $VO_{2max}$  + 11.72 ml/kg/min ( $p < 0.001$ ). Modest weight loss occurred (-1.5 kg;  $p = 0.001$ ). No adverse events were reported. **Conclusion:** A supervised CVR program with combined aerobic and resistance training significantly enhanced lower limb strength, reduced symptoms, and improved functional capacity in stable CHF patients in a resource-limited setting. These findings support CVR implementation to optimize outcomes in sub-Saharan Africa.

## Keywords

Cardiovascular Rehabilitation, Chronic Heart Failure, Segmental Muscle Strength, Functional Capacity, Cameroon

## 1. Introduction

Chronic heart failure (CHF) is a complex clinical syndrome characterized by typical symptoms such as dyspnoea and fatigue, often accompanied by signs of fluid retention [1]. It results from structural or functional cardiac abnormalities that impair ventricular filling or ejection [1]. Despite therapeutic advances, CHF carries a grim prognosis, with approximately 14% of patients dying within 5 years of symptom onset [2] [3]. Cardiovascular rehabilitation (CVR), an evidence-based intervention that combines structured exercise, risk factor modification, patient education, and psychosocial support, has emerged as an essential component to optimise outcomes and curb this mortality [4].

International guidelines strongly recommend CVR for patients with cardiovascular disease such as CHF or post-cardiac surgery, citing improvements in exercise tolerance, symptom burden, quality of life, and hospitalization rates [5]-[8]. Exercise training, particularly in patients with heart failure with reduced ejection fraction (HFrEF), counteracts peripheral abnormalities, such as skeletal muscle atrophy and endothelial dysfunction, that significantly contribute to exercise intolerance and additionally, it enhances cardiac output, autonomic regulation, and biochemical parameters, supporting its role as a safe and effective therapeutic intervention [9].

While the benefits of cardiac rehabilitation (CVR) on peak oxygen uptake ( $VO_{2max}$ ) and overall endurance are well-documented [10], its impact on segmental muscle strength, particularly in the lower limbs, has received comparatively

limited attention. Muscle weakness is a hallmark of CHF, driven by catabolic states, systemic inflammation, and prolonged physical inactivity, and it independently predicts morbidity and mortality [11]. Emerging evidence suggests that even short-duration interventions can yield significant improvements in peripheral muscle strength and functional balance. For instance, Nazari *et al.* (2014) demonstrated that one month of structured cardiac rehabilitation significantly improved lower limb strength and both static and dynamic balance in post-CABG patients, highlighting the potential of targeted training to restore functional capacity [12]. Yet, in resource-limited settings such as Cameroon, where CHF management remains largely pharmacological and CVR programs are only recently being introduced, there is a paucity of data assessing whether current protocols adequately address segmental strength deficits or balance impairments.

This study was conducted to evaluate the real-world effects of a supervised CVR program on segmental muscle strength, clinical symptoms, and both subjective and objective measures of functional capacity in a cohort of stable CHF patients in Yaoundé. By focusing on these under-explored outcomes, we aimed to provide local evidence to support wider CVR implementation and inform program optimization. Our general objective was to assess the impact of CVR on segmental muscle strength. Specific objectives included characterizing the study population, quantifying changes in muscle strength, and evaluating effects on functional capacity.

## 2. Methods

### 2.1. Study Design and Setting

This was a multicenter longitudinal study integrating a retrospective review of initial assessments and prospective follow-up post-intervention, conducted from February 2024 to June 2025. Participants were recruited from the Cardiovascular and Metabolic Rehabilitation Unit at Yaoundé General Hospital (a tertiary public facility) and the Saint Charbel Cardiac Center (a private specialized center). Both sites offered dedicated CVR facilities, including treadmills, cycle ergometers, and resistance equipment, supervised by cardiologists and trained physiotherapists.

### 2.2. Participants, Eligibility and Operational Definition

Participants were recruited upon referral to the CVR units after clinical stabilisation; time since diagnosis or surgical intervention varied but all patients were stable at enrolment.

- Inclusion criteria: Adults aged over 18 years with stable CHF (NYHA class I–III, optimized medical therapy) were enrolled consecutively. Inclusion required informed consent, the ability to perform exercise testing, and evidence of muscle strength alteration on baseline assessment.
- Exclusion criteria: Patients who interrupted the program, had adherence below 15 sessions, had major cardiovascular events during follow-up, or had cognitive impairment precluding consent. Exclusion criteria did not target prior

physiotherapy exposure.

Stable chronic heart failure was defined as patients on optimised medical therapy with no recent ( $\leq 6$  weeks) acute decompensation, major cardiovascular events, hospitalisations, or planned major interventions, consistent with cardiac rehabilitation eligibility guidelines.

### 2.3. Intervention: Cardiovascular Rehabilitation Program

The same programme structure was applied to all participants regardless of NYHA class (I-III) or ejection-fraction category, with only intensity and progression adjusted individually for safety and tolerance.

The standardised outpatient programme targeted 18 sessions (3 sessions per week over 6 - 7 weeks on average), with a minimum of 15 sessions required for inclusion (median achieved: 18, range 15 - 20), to accommodate individual scheduling while maintaining protocol uniformity.

Each 60-minute session included:

- 5 - 10 minutes warm-up (light cycling or walking).
- 40 minutes main aerobic phase (treadmill walking or cycling at 50% - 75% of heart rate reserve, calculated via Karvonen formula from baseline exercise test).
- Interspersed segmental resistance exercises (10 - 15 repetitions in 2 - 3 sets for major muscle groups of lower limbs using body weight or light loads, plus core exercises).
- 5 minutes cool-down with stretching

Sessions incorporated therapeutic education on diet, medication adherence, and symptom recognition.

### 2.4. Outcome Measures

Assessments were conducted at baseline (prior to program initiation) and post-rehabilitation (within one week following program completion).

#### 2.4.1. Primary Outcome

Segmental muscle strength, expressed in kilograms of force (kgf), was assessed using handheld dynamometry for the lower limb (quadriceps).

#### 2.4.2. Secondary Outcomes

- Anthropometrics: body weight and body mass index (BMI).
- Symptoms: prevalence of dyspnoea and palpitations, evaluated via structured interview.
- Subjective functional capacity: Duke Activity Status Index (DASI) questionnaire.
- Objective functional capacity:
  - ✓ Six-minute walk test (6 MWT) distance (meters).
  - ✓ Symptom-limited cycle ergometer test using an incremental 10-W protocol, from which peak metabolic equivalents (METs) and estimated  $VO_{2max}$  (derived from the DASI formula and direct ergometer data) were obtained.

## 2.5. Statistical Analysis

Statistical analyses were performed using R software version 2025.09.2 + 418 (2025.09.2 + 418). Continuous variables are expressed as mean  $\pm$  standard deviation (SD) and median (interquartile range) where appropriate. Given the moderate sample size (and evidence of non-normal distribution in most post-rehabilitation outcome measures (Shapiro-Wilk and Anderson-Darling tests, supplemented by visual Q-Q plot inspection), pre-post changes were assessed using Wilcoxon signed-rank tests. Statistical significance was set at  $p < 0.05$  (two-tailed).

## 2.6. Ethical Consideration

Ethical clearance was granted by the Centre Regional Ethics Committee for Human Research N: 003014/CRERSHC/2025 which waved informed consent for the retrospective phase. For the prospective phase, all patients provided written informed consent prior to inclusion. All study was conducted according to the Declaration of Helsinki.

## 2.7. Sample Size

A convenience sample of 50 consecutive participants was enrolled. This reflected the real-world, pilot nature of the emerging CVR programme in a resource-limited multicentre setting. No formal a priori power calculation was performed; however, the sample yielded highly significant pre-post differences ( $p < 0.001$  for primary outcomes).

## 3. Results

All 50 participants completed the program with good adherence (mean 18 sessions) and no adverse events.

### 3.1. Participant Characteristics

The cohort had a median age 56.0 years (42.5 - 66) with a range from 22 - 78 years. Female participants predominated (54%) as shown in **Table 1**. Hypertension was the predominant risk factor (24%), followed by diabetes (14%). Most common indication for CVR was post-cardiac surgery (38%) and most patients had preserved ejection fraction (70%).

### 3.2. Changes in Anthropometrics and Symptoms

Participants experienced modest but significant weight loss from a median 78.5 kg (IQR: 68.0 - 87.7) to 77.0 kg (IQR: 68.6 - 86.1) as shown in **Table 2**. Clinically meaningful symptom reductions occurred: dyspnoea prevalence fell from 22% to 2% ( $p = 0.037$ ), and palpitations from 16% to 2% ( $p < 0.001$ ).

### 3.3. Segmental Muscle Strength

Lower limb strength improved dramatically, from a median of 0.0 kg to 10.0 (W = 0.00,  $r = 0.88$ ,  $p < 0.001$ ), reflecting the program's emphasis on weight-bearing

and leg-focused resistance exercises as shown in **Figure 1**.

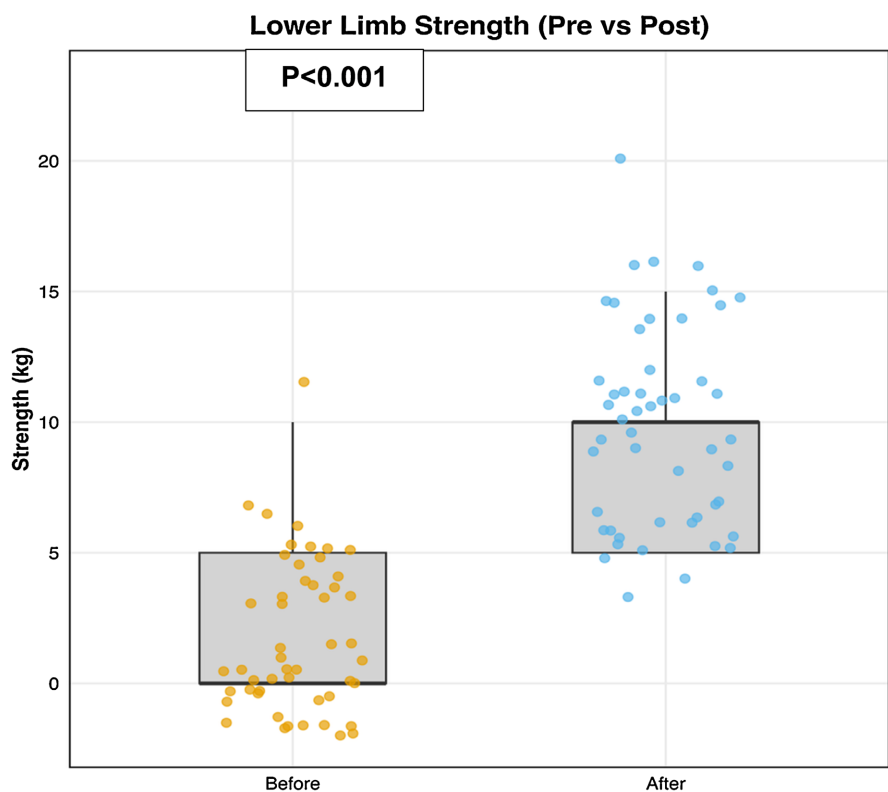
**Table 1.** Sociodemographic and clinical characteristics (N = 50).

Characteristic	Value
Age (years, median and IQR)	56.0 (42.5 - 66)
Female sex, n (%)	27 (54)
Hypertension, n (%)	12 (24)
Diabetes, n (%)	7 (14)
Post-cardiac surgery, n (%)	19 (38)
Ejection fraction	
Reduced EF, n (%)	11 (22)
Mildly reduced EF, n (%)	4 (8)
Preserved EF, n (%)	35 (70)

EF = Ejection Fraction, IQR = Interquartile Range.

**Table 2.** Pre-post changes in anthropometrics and symptoms.

Parameter	Baseline	Post-CVR	p-value
Weight (kg), median (IQR)	78.5 (68.0 - 87.7)	77.0 (68.6 - 86.1)	0.001
Dyspnea, n (%)	11 (22)	1 (2)	0.037
Palpitations, n (%)	8 (16)	1 (2)	<0.001



**Figure 1.** Pre-post lower limb muscle strength (paired box plots).

### 3.4. Functional Capacity

Objective measures demonstrated robust improvements, including 6 MWT distance [+100 m, median 400 to 500 m;  $p < 0.001$ ), the DASI score (+26.25,  $p < 0.001$ ). Exercise testing revealed higher peak workload with increments of 3.32 METs ( $p < 0.001$ ) and estimated increments in  $VO_{2max}$  of 11.72 ( $p < 0.001$ ), as shown in **Table 3**.

**Table 3.** Functional capacity outcomes.

Parameter	Baseline median (IQR)	Post-Rehabilitation median (IQR)	p-value
DASI score	24.45 (15.45 - 34.70)	50.70 (50.70 - 58.20)	<0.001
6MWT distance (m)	400.00 (232.50 - 515.00)	500.00 (400.00 - 583.75)	<0.001
Peak METs	5.60 (4.60 - 7.01)	8.97 (8.97 - 9.89)	<0.001
$VO_{2max}$ (ml/kg/min, est. from DASI)	19.68 (16.16 - 24.52)	31.40 (31.40 - 34.63)	<0.001

### 4. Discussion

This multicenter longitudinal study in Yaoundé, Cameroon, demonstrated that a supervised CVR program combining aerobic and resistance exercises yielded significant benefits in patients with stable chronic heart failure. Key improvements included dramatic gains in lower-limb strength, substantial reductions in dyspnoea and palpitations, modest weight loss, and marked enhancements in both subjective and objective functional capacity. High adherence (18 sessions) and absence of adverse events further confirmed the programme's safety and feasibility.

The observed improvements align with global evidence on exercise-based CVR in CHF. A 2023 Cochrane review of 60 randomized trials involving 8728 HF patients reported reduced hospitalization risk and clinically meaningful improvements in health-related quality of life, with typical gains in exercise capacity including 50 - 80 m in 6 MWT and 3 - 5 ml/kg/min in  $VO_{2max}$  [13]. In sub-Saharan Africa, a systematic review found CR improves  $VO_{2max}$  by 1 - 5 ml/kg/min and 6 MWT by 40 - 87 m [14], underscoring CVR's adaptability in low-resource settings. Our findings (+100 m in 6 MWT, +11.72 ml/kg/min estimated  $VO_{2max}$ ) exceed these averages, though  $VO_{2max}$  was estimated. Symptom reductions mirror meta-analyses showing decreased hospitalization and improved well-being [14]. Resistance training benefits peripheral muscle strength, countering CHF-related myopathy; a meta-analysis demonstrated significant increases in extremity strength [15] [16].

The aerobic component likely drove cardiorespiratory enhancements (e.g.,  $VO_{2max}$ , 6 MWT) by improving endothelial function, autonomic regulation, and oxygen utilization [17]. Resistance exercises, focused on lower limbs, countered catabolic states and inactivity-induced atrophy, explaining dramatic quadriceps gains (from near-zero baseline, possibly reflecting severe initial weakness) [18].

Symptom relief and weight loss reflect multifaceted benefits, including education on diet and adherence. The cohort's predominance of preserved ejection fraction (70%) suggests applicability beyond HF<sub>r</sub>EF, where peripheral factors dominate exercise intolerance [16].

Limitations include the non-randomized design (precluding causality attribution), moderate sample size, short-term follow-up (no long-term sustainability data), and potential baseline measurement inconsistencies (e.g., low initial lower limb values). Reliance on handheld dynamometry, while practical, may introduce variability versus isokinetic standards. Strengths include the real-world multicenter sites in a low-resource setting with scarce CVR data, the high adherence, comprehensive outcomes (segmental strength, symptoms, functional measures), in addition to ethical and statistical rigour.

Policymakers should prioritise affordable, hybrid models (supervised/outpatient) to address access barriers. Future research should include randomized trials, longer follow-up, cost-effectiveness analyses, and analyses of the impact of muscle strength gains on functional capacity.

## 5. Conclusion

In this multicentre longitudinal study in Cameroon, a supervised cardiovascular rehabilitation programme combining aerobic and resistance training was safe, well-adhered to, and associated with reduced symptoms (dyspnoea and palpitations), modest weight loss, and substantial gains in functional capacity (six-minute walk distance, Duke Activity Status Index, peak METs, and estimated  $VO_{2max}$ ) in patients with CHF. Marked lower limb strength gains aligned with the programme's weight-bearing focus and the role of peripheral myopathy in exercise intolerance. Overall functional improvements likely stemmed from aerobic adaptations, endothelial benefits, and education. These real-world findings from a resource-limited sub-Saharan African setting support integrating cardiovascular rehabilitation into routine care, with optimised protocols emphasising equitable limb training, and underscore the need for randomised trials to assess long-term outcomes.

## Declarations

## Acknowledgements

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## Ethics Approval and Consent to Participate

Ethical clearance was granted by the Centre Regional Ethics Committee for Human Research N: 003014/CRERSHC/2025 which waved informed consent for the retrospective phase. For the prospective phase, all patients provided written informed consent prior to inclusion. All study was conducted according to the Declaration of Helsinki. Patient data were anonymized, coded, and stored on a pass-

word-protected computer accessible only to the principal investigator. The study adheres to the STROBE guidelines to ensure transparent, standardized reporting of observational research.

### Availability of Data and Materials

The data supporting this study's findings are available from the corresponding author upon reasonable request.

### Author Contribution

Study concept and design: SD, TKHN, NYLC and WWE. Data collection: WWE. Analysis and interpretation of data: WWE and MMLE. Manuscript writing: SD, TKHN, NYLC, WWE, NN, MC, MMLE and NG. Final approval of manuscript: All authors. NG supervised the study. SD, and MMLE had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. 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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