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Outcome of a supervised cardiovascular rehabilitation programme 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).

Objective: This 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 ≥18 years with stable CHF (NYHA class I-III) underwent a standardised 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 × 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 muscle strength (handheld dynamometry: quadriceps). Secondary outcomes included symptoms (dyspnoea, palpitations), body weight, Duke Activity Status Index (DASI), six-minute walk test (6MWT) 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: 6MWT +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 ($p < 0.001$). A modest weight loss of -1.5 kg occurred ($p = 0.001$). 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 optimise outcomes in sub-Saharan Africa.

Keywords: Cardiovascular rehabilitation, chronic heart failure, segmental muscle strength, functional capacity, Cameroon

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INTRODUCTION

Chronic heart failure (CHF) is a complex clinical syndrome characterised 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

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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 hospitalisation 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, 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. 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 clinical 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 optimisation.

MATERIALS AND METHODS

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 Centre (a private specialised centre). Both sites offered dedicated CVR facilities, including treadmills, cycle ergometers, and resistance equipment, supervised by cardiologists and trained physiotherapists.

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 18 years and above with stable CHF (NYHA class I–III, optimised medical therapy) were enrolled consecutively. Inclusion required informed consent, the ability to perform exercise testing, and evidence of muscle strength alteration on baseline assessment. Stable chronic heart failure was defined as patients on optimised medical therapy with no recent (≤6 weeks) acute decompensation, major cardiovascular events, hospitalisations, or planned major interventions, consistent with cardiac rehabilitation eligibility guidelines.
- 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.

Intervention: cardiovascular rehabilitation program

The same CVR 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. The duration per session was 60 minutes.

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 × 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.

Outcome measures

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

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

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 (6MWT) 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.

Statistical analysis
Statistical analyses were performed using R software version 2025.09.2 + 418 (2025.09.2 + 418). Continuous variables are expressed as mean ± 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).

Sample size
A convenience sample of 50 consecutive participants was enrolled. This reflected the 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).

RESULTS

All 50 participants completed the program with good adherence (mean 18 sessions) and no adverse events. The cohort had a median age of 56.0 years (42.5 - 66), with a range of 22–78 years. Female participants predominated (54%), as shown in Table 1. Hypertension was the most common risk factor (24%), followed by diabetes (14%). The most common indication for CVR was post-cardiac surgery (38%), and most patients had preserved ejection fraction (70%).

Participants experienced modest but significant weight loss, from a median of 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 decreased from 22% to 2% ($p = 0.037$), and palpitations decreased from 16% to 2% ($p < 0.001$). 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 CVR programme emphasis on weight-bearing and leg-focused resistance exercises as shown in Figure 1. Objective measures demonstrated robust improvements, including 6MWT distance [+100 m, median 400 to 500 m; $p < 0.001$),

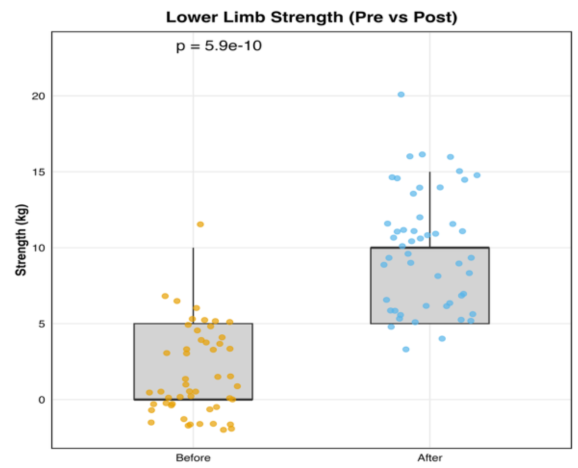

Figure 1. Pre–post lower limb muscle strength (paired box plots)

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

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

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.

DISCUSSION

This multicenter longitudinal study in Yaoundé, Cameroon, demonstrated that a supervised CVR program combining aerobic and resistance exercises yields 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 randomised trials involving 8728 HF patients reported reduced hospitalisation risk and clinically meaningful improvements in health-related quality of life, with typical gains in exercise capacity, including 50 – 80 m in 6MWT and 3–5 ml/kg/min in VO_2max [13]. In sub-Saharan Africa, a systematic review found that CR improves VO_2max by 1–5 ml/kg/min and 6MWT by 40 – 87 m [16], underscoring CVR's adaptability in low-resource settings. Our findings (+100 m in 6MWT, +11.72 ml/kg/min estimated VO_2max) exceed these averages, though VO_2max was estimated. Symptom reductions mirror meta-analyses showing decreased hospitalisation and improved well-being [13]. Resistance training benefits peripheral muscle strength, countering CHF-related myopathy; a meta-analysis demonstrated significant increases in extremity strength [14,15].

The aerobic component likely influenced cardiorespiratory enhancements (e.g., VO_2max, 6MWT) by improving endothelial function, autonomic regulation, and oxygen utilisation [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 HFrEF, where peripheral factors dominate exercise intolerance [15].

Limitations of this present study include the non-randomised 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. The strengths of our study 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 randomised trials, longer follow-up, cost-effectiveness analyses, and analyses of the impact of muscle strength gains on functional capacity.

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

Ethical consideration

Ethical clearance was granted by the Centre Regional Ethics Committee for Human Research (N: 003014/CRERSHC/2025), which waived informed consent for the retrospective phase. For the prospective phase, all patients provided written informed consent prior to inclusion. All studies were conducted according to the Declaration of Helsinki. Patient data were anonymised, coded, and stored on a password-protected computer accessible only to the principal investigator. The study adheres to the STROBE guidelines to ensure transparent, standardised reporting of observational research.

Consent to publish

All authors agreed on the content of the final paper.

Funding

None

Competing Interest

The authors declare no conflict of interest

Author contribution

SD, TKHN, NYLC, and WWE conceptualised and designed the study. WWE conducted the data collection. WWE and MMLE analysed and interpreted the data. SD, TKHN, NYLC, WWE, NN, MC, MMLE, and NG drafted the manuscript. NG supervised the study. SD and MMLE had full access to all the data and were responsible for the integrity and accuracy of the data analysis. All authors reviewed, approved, and agreed to submit the final version of the manuscript.

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Availability of data

Data is available upon request to the corresponding author

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