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Resistance versus Aerobic Training and the Muscle–Quality-of-Life Axis in Chronic Heart Failure.

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Abstract

Background: Skeletal-muscle dysfunction and loss of strength are major determinants of symptoms, functional limitation, and impaired quality of life in chronic heart failure (HF), yet rehabilitation has traditionally emphasized aerobic training. The relative impact of resistance versus aerobic training on muscle strength and quality of life is not well established. ***Methods:*** In this single-centre, parallel-group randomized controlled trial, 140 patients with chronic stable HF (NYHA II–III) on optimized therapy were randomized 1:1 to supervised resistance (Group B) or aerobic (Group A) training for 12 weeks. The pre-specified primary outcome was change in 6-minute walk test (6MWT) distance; secondary outcomes were muscle strength, Kansas City Cardiomyopathy Questionnaire (KCCQ) score, peak oxygen uptake (peak VO_2), and safety. 126 patients (63 per group) completed the trial. ***Results:*** Resistance training produced substantially greater gains in handgrip strength (+34.4% vs +11.3%; $p<0.001$) and limb 1-RM, and a larger improvement in KCCQ score (+22.1 vs +17.3 points; $p=0.03$). Aerobic training produced greater gains in 6MWT distance (+60 vs +40 m; $p=0.01$) and peak VO_2 (+3.6 vs +1.7 mL/kg/min; $p<0.001$). Modality effects on strength and KCCQ remained significant after multivariable adjustment. Both modalities were safe, with no deaths. ***Conclusions:*** Resistance training preferentially improves muscle strength and quality of life, while aerobic training preferentially improves walking capacity and cardiopulmonary fitness. For patients in whom weakness, frailty, or poor quality of life predominate, resistance training should be prioritized within individualized — and ideally combined — exercise prescription.

Keywords: heart failure; resistance training; muscle strength; sarcopenia; quality of life; exercise prescription.

INTRODUCTION

Chronic heart failure (HF) is increasingly recognized as a systemic syndrome in which skeletal-muscle dysfunction, rather than central haemodynamic impairment alone, is a principal determinant of symptoms and functional limitation.1 Progressive loss of muscle mass and strength — ranging from subclinical myopathy to overt sarcopenia and cardiac cachexia — affects a substantial proportion of patients and is an independent predictor of mortality.1,2 This "muscle hypothesis" of HF reframes weakness, fatigue, and exercise intolerance as consequences not only of reduced cardiac output but of intrinsic abnormalities in muscle structure, metabolism, and mass.3

Against this background, exercise training has become a class I recommendation in HF, supported by trials and meta-analyses showing improved functional capacity, fewer hospitalizations, and good safety.4,5,6 Historically, however, rehabilitation programmes have emphasized aerobic conditioning, which improves central haemodynamics and peripheral oxygen extraction and reliably raises peak oxygen uptake (peak VO_2) — a key prognostic marker.7,8 While effective for cardiopulmonary fitness, aerobic training only partially addresses the loss of strength and muscle mass that underpins functional decline and impaired quality of life in many patients.9

Resistance (strength) training targets these deficits directly. Progressive loading stimulates muscle hypertrophy and neuromuscular adaptation, improving strength, physical function, and independence.9,10 Earlier reluctance to prescribe resistance exercise in HF — driven by concerns about ventricular loading — has given way to evidence that supervised, progressive resistance training is safe and well tolerated, and contemporary guidelines and scientific statements now endorse its inclusion in cardiac rehabilitation.10,11 Meta-analytic data further indicate that resistance training improves muscle strength and quality of life in HF without impairing aerobic capacity.12 Despite this, resistance training remains underused, and direct comparisons quantifying its benefits relative to aerobic training across functional, neuromuscular, and patient-reported domains are scarce.13

Health-related quality of life is a central, patient-centred outcome in HF and is captured sensitively by disease-specific instruments such as the Kansas City Cardiomyopathy Questionnaire (KCCQ).14 Because muscle weakness contributes substantially to the daily limitations patients report, interventions that restore strength may yield disproportionate quality-of-life gains; yet the relative impact of resistance versus aerobic training on this muscle–quality-of-life axis has not been clearly established in a randomized setting.

We therefore conducted a 12-week, parallel-group randomized controlled trial comparing supervised resistance with supervised aerobic training in patients with chronic stable HF (NYHA II–III) on optimized therapy. We hypothesized that, consistent with training specificity, resistance training would produce superior improvements in muscle strength and quality of life, while aerobic training would produce superior improvements in walking distance and peak VO_2. Although change in 6-minute walk distance was the pre-specified primary outcome, this report foregrounds the neuromuscular and quality-of-life dimensions to inform whether — and for whom — resistance training should be prioritized.

MATERIALS AND METHODS

Design and ethics: This single-centre, prospective, parallel-group, two-arm randomized controlled trial was conducted at a tertiary cardiac rehabilitation unit over 12 weeks. It was performed in accordance with the Declaration of Helsinki and approved by the institutional ethics committee; all participants gave written informed consent.

Participants: Eligible patients were adults with chronic stable HF of NYHA class II–III on guideline-directed medical therapy stable for at least four weeks. Both HFrEF (LVEF ≤40%) and HFpEF were included. Exclusion criteria comprised decompensated HF, acute coronary syndrome or revascularization within three months, severe or uncorrected valvular/congenital disease, uncontrolled arrhythmia, and orthopaedic or neurological conditions precluding safe exercise. Of 168 patients screened, 140 met the criteria and were enrolled.

Randomization and blinding: Patients were randomized 1:1 to resistance training (Group B, n=70) or aerobic training (Group A, n=70) via a computer-generated sequence with concealed allocation. Outcome assessors and the statistician were blinded; supervising exercise physiologists could not be blinded to the assigned modality.

Interventions: Both arms trained three supervised sessions per week for 12 weeks, each with warm-up and cool-down. The resistance programme used progressive whole-body exercises for major upper- and lower-limb groups (8–10 exercises, 2–3 sets of 10–15 repetitions) at 50–70% of one-repetition maximum (1-RM), with loads increased as strength improved. The aerobic programme used continuous and interval treadmill or cycle-ergometer exercise at 60–70% of heart-rate reserve, progressing from 20 to 40 minutes as tolerated, guided by the Borg scale and telemetry. Sessions were supervised with cardiac monitoring and emergency facilities available.

Outcomes: The pre-specified primary outcome was change in 6-minute walk test (6MWT) distance from baseline to 12 weeks, performed per American Thoracic Society guidelines.15 Secondary outcomes — emphasized in this analysis — were muscle strength (handgrip dynamometry and upper- and lower-limb 1-RM) and quality of life (KCCQ overall summary score),14 together with peak VO_2 on symptom-limited cardiopulmonary exercise testing and safety (adverse events, HF hospitalizations). Outcomes were assessed at baseline, 6 weeks, and 12 weeks.

Statistics: The sample size was powered to detect an approximately 30-m between-group difference in 6MWT distance, allowing for 10% attrition. Data are mean ± SD, median (IQR), or n (%). Between-group comparisons used independent t-tests, chi-square or Fisher's exact tests, and Mann–Whitney U tests; within-group change used paired t-tests. Multivariable linear regression adjusted for age, sex, and baseline LVEF. Two-sided $p<0.05$ was significant.

RESULTS

Participant flow and baseline characteristics

A total of 168 patients with chronic stable heart failure (NYHA class II–III) were screened, of whom 140 met the eligibility criteria and were randomized 1:1 to aerobic training (Group A, n=70) or resistance training (Group B, n=70). Seven patients in each group were lost to follow-up or discontinued the intervention, leaving 63 patients per group (n=126) for the final 12-week analysis, a retention rate of 90% consistent with the 10% attrition anticipated in the sample-size calculation (Figure 1).

Baseline demographic and clinical characteristics were well balanced between the two groups, confirming successful randomization (Table 1). Mean age, sex distribution, NYHA class, ejection-fraction phenotype, aetiology, and NT-proBNP did not differ significantly between groups (all $p>0.05$), indicating that any 12-week between-group differences are unlikely to reflect baseline imbalance.

Table 1. Baseline demographic and clinical characteristics.

Characteristic	Group A Aerobic (n=70)	Group B Resistance (n=70)	p-value
Age (years), mean ± SD	57.4 ± 8.6	58.1 ± 8.2	0.61
Male sex, n (%)	46 (65.7)	44 (62.9)	0.72
BMI (kg/m²), mean ± SD	26.3 ± 3.4	26.8 ± 3.6	0.39
NYHA Class II, n (%)	38 (54.3)	36 (51.4)	0.74
NYHA Class III, n (%)	32 (45.7)	34 (48.6)	0.74
HFrEF (LVEF ≤40%), n (%)	49 (70.0)	47 (67.1)	0.71
HFpEF, n (%)	21 (30.0)	23 (32.9)	0.71
LVEF (%), mean ± SD	36.2 ± 7.8	35.6 ± 8.1	0.65
Ischemic aetiology, n (%)	33 (47.1)	31 (44.3)	0.74
Diabetes mellitus, n (%)	24 (34.3)	27 (38.6)	0.59
Hypertension, n (%)	41 (58.6)	39 (55.7)	0.74
NT-proBNP (pg/mL), median (IQR)	1240 (820–1980)	1310 (860–2040)	0.58

Values are mean ± SD, n (%), or median (IQR). p-values from independent t-test, chi-square test, or Mann–Whitney U test. BMI = body mass index; LVEF = left ventricular ejection fraction; HFrEF = HF with reduced ejection fraction; HFpEF = HF with preserved ejection fraction; NYHA = New York Heart Association.

Baseline functional capacity (6-minute walk test [6MWT] distance, peak VO_2), muscle strength, and Kansas City Cardiomyopathy Questionnaire (KCCQ) scores were likewise comparable, with no significant between-group differences for any parameter (Table 2).

Table 2. Baseline functional capacity, muscle strength, and quality-of-life parameters.

Parameter	Group A Aerobic (n=70)	Group B Resistance (n=70)	p-value
6MWT distance (m)	312 ± 42	310 ± 45	0.79
Peak VO_2 (mL/kg/min)	14.8 ± 2.3	14.6 ± 2.4	0.61
Handgrip strength (kg)	22.1 ± 4.6	21.8 ± 4.7	0.70
1-RM lower limb composite (kg)	38.4 ± 7.2	37.9 ± 7.5	0.68
KCCQ overall summary score	54.2 ± 11.8	53.8 ± 12.1	0.84
Resting heart rate (bpm)	78 ± 9	79 ± 10	0.55
Resting SBP (mmHg)	118 ± 12	120 ± 13	0.36

Values are mean ± SD. p-values from independent t-test. 6MWT = 6-minute walk test; 1-RM = one-repetition maximum; KCCQ = Kansas City Cardiomyopathy Questionnaire; SBP = systolic blood pressure.

Primary outcome: 6-minute walk test distance

Both groups achieved highly significant within-group improvements in 6MWT distance from baseline to 12 weeks (paired $p<0.001$ for both). The mean gain was greater after aerobic training (+60 m) than after resistance training (+40 m), and this between-group difference was statistically significant at both 6 weeks ($p=0.04$) and 12 weeks ($p=0.01$), exceeding the pre-specified clinically important difference of approximately 30 m (Table 3, Figure 2).

Table 3. Change in 6-minute walk test distance (primary outcome).

Time Point	Group A (m), Mean ± SD	Group B (m), Mean ± SD	Between-group p-value
Baseline	312 ± 42	310 ± 45	0.79
6 weeks	348 ± 38	332 ± 41	0.04
12 weeks	372 ± 36	350 ± 39	0.01
Mean change (0–12 wk)	+60 ± 24	+40 ± 22	0.01
Within-group p (0 vs 12 wk)	<0.001	<0.001	—

Between-group comparison by independent t-test; within-group comparison by paired t-test. SD = standard deviation.

Cardiopulmonary fitness: peak VO_2

Peak VO_2 increased significantly in both groups (within-group p<0.001). The improvement was substantially larger after aerobic training (+3.6 mL/kg/min, +24.3%) than after resistance training (+1.7 mL/kg/min, +11.6%), with the between-group difference significant at 6 weeks (p=0.002) and 12 weeks (p<0.001) (Table 4, Figure 3). This pattern is consistent with the physiological specificity of aerobic conditioning for central and peripheral oxygen utilization.

Table 4. Change in peak VO_2 on cardiopulmonary exercise testing.

Time Point	Group A, Mean ± SD	Group B, Mean ± SD	Between-group p-value
Baseline	14.8 ± 2.3	14.6 ± 2.4	0.61
6 weeks	16.9 ± 2.1	15.6 ± 2.3	0.002
12 weeks	18.4 ± 1.9	16.3 ± 2.2	<0.001
Mean change (0–12 wk)	+3.6 ± 1.4	+1.7 ± 1.2	<0.001
Within-group p-value	<0.001	<0.001	—

Values in mL/kg/min. SD = standard deviation; CPET = cardiopulmonary exercise testing.

Muscle strength

Muscle strength, assessed by handgrip dynamometry and limb 1-RM testing, improved significantly in both groups, but the gains were considerably larger after resistance training. Handgrip strength rose by 34.4% in Group B versus 11.3% in Group A (between-group p<0.001), with a parallel pattern for upper- and lower-limb 1-RM (Table 5, Figure 4). These results reflect the neuromuscular specificity of progressive resistance loading.

Table 5. Change in muscle strength parameters.

Parameter	Group A Baseline → 12 wk	Group B Baseline → 12 wk	p-value (12 wk)
Handgrip strength (kg)	22.1 → 24.6 (+11.3%)	21.8 → 29.3 (+34.4%)	<0.001
Lower-limb 1-RM (kg)	38.4 → 41.0 (+6.8%)	37.9 → 50.2 (+32.5%)	<0.001
Upper-limb 1-RM (kg)	16.2 → 17.4 (+7.4%)	16.0 → 21.6 (+35.0%)	<0.001
Within-group p (all parameters)	<0.01	<0.001	—

Percentages denote relative change from baseline to 12 weeks within each group. 1-RM = one-repetition maximum.

Health-related quality of life

Both groups improved significantly in KCCQ overall summary score, each exceeding the established 5-point minimal clinically important difference. The resistance group showed a larger improvement (+22.1 points, +41.1%) than the aerobic group (+17.3 points, +31.9%); the between-group difference was significant at 12 weeks (p=0.03) (Table 6, Figure 5). This suggests an additional quality-of-life benefit from resistance-based training, plausibly mediated by improved functional independence and reduced symptom burden related to muscle weakness.

Table 6. Change in quality of life (KCCQ overall summary score).

Time Point	Group A, Mean ± SD	Group B, Mean ± SD	Between-group p-value
Baseline	54.2 ± 11.8	53.8 ± 12.1	0.84
6 weeks	64.8 ± 11.2	67.1 ± 11.6	0.21
12 weeks	71.5 ± 10.4	75.9 ± 10.8	0.03
Mean change (0–12 wk)	+17.3 ± 7.9	+22.1 ± 8.4	0.001
Within-group p-value	<0.001	<0.001	—

KCCQ range 0–100; higher = better. SD = standard deviation.

Relative improvement across outcome domains

Table 7 and Figure 6 summarize the relative (percentage) improvement across all major domains, revealing a consistent, modality-specific pattern: aerobic training produced greater relative gains in cardiopulmonary measures (6MWT distance, peak VO_2), whereas resistance training produced greater relative gains in musculoskeletal and quality-of-life measures (handgrip strength, KCCQ).

Table 7. Summary of percentage improvement across key outcomes at 12 weeks.

Outcome	Group A % Change	Group B % Change	Favoured Modality
6MWT distance	+19.2%	+12.9%	Aerobic
Peak VO_2	+24.3%	+11.6%	Aerobic
Handgrip strength	+11.3%	+34.4%	Resistance
KCCQ overall score	+31.9%	+41.1%	Resistance

Percentage change = (12-week value − baseline value) / baseline value × 100.

Safety

Both modalities were well tolerated. Mild musculoskeletal discomfort was the most common adverse event and occurred more frequently with resistance training (11.1% vs 6.3%), though not significantly (p=0.34); exercise-induced hypotension was more common with aerobic training. No deaths occurred, and HF-related hospitalization was low and similar between groups (Table 8, Figure 7), supporting the safety of both supervised modalities in clinically stable patients on optimized therapy.

Table 8. Adverse events and hospitalizations during the intervention period.

Adverse Event	Group A (n=63), n (%)	Group B (n=63), n (%)	p-value
Musculoskeletal discomfort	4 (6.3)	7 (11.1)	0.34
Exercise-induced hypotension	3 (4.8)	1 (1.6)	0.31
Arrhythmic events (non-fatal)	1 (1.6)	1 (1.6)	1.00
HF hospitalization	2 (3.2)	1 (1.6)	0.56
Death (any cause)	0 (0)	0 (0)	—
Total adverse events	10 (15.9)	10 (15.9)	1.00

Values are n (%). p-values from chi-square or Fisher's exact test. HF = heart failure.

Multivariable analysis

On multivariable linear regression adjusting for age, sex, and baseline LVEF, training modality (resistance vs aerobic) remained an independent predictor of change in handgrip strength (β=5.8, 95% CI 3.9–7.7; p<0.001) and change in KCCQ score (β=4.6, 95% CI 1.2–8.0; p=0.008), while aerobic training remained an independent predictor of change in peak VO_2 (β=1.9, 95% CI 1.1–2.7; p<0.001) and change in 6MWT distance (β=18.4, 95% CI 6.2–30.6; p<0.001). The modality-specific effects therefore persisted after adjustment for these baseline confounders.

DISCUSSION

This randomized trial directly contrasts the effects of resistance and aerobic training in chronic stable HF and demonstrates a consistent, physiologically coherent dissociation: resistance training preferentially improved muscle strength and quality of life, whereas aerobic training preferentially improved walking capacity and peak VO_2. By quantifying both axes within one trial, the study clarifies the distinct therapeutic role of resistance training and directly addresses the muscle–quality-of-life dimension that aerobic-dominant rehabilitation only partially captures.

The large strength gains with resistance training (handgrip +34.4% vs +11.3%; comparable advantages for limb 1-RM) reflect the neuromuscular specificity of progressive loading and target the skeletal-muscle myopathy and sarcopenia that drive disability and adverse prognosis in HF.1,9 Because muscle wasting is an independent predictor of mortality,2 interventions that restore strength have biological as well as symptomatic plausibility. The accompanying quality-of-life benefit — a larger KCCQ improvement with resistance training (+22.1 vs +17.3 points), both groups exceeding the 5-point minimal clinically important difference16 — supports the hypothesis that strength gains translate into meaningful improvements in patients' daily functioning and symptom burden. These findings are concordant with meta-analytic evidence that resistance training improves strength and quality of life without compromising aerobic capacity.12

At the same time, aerobic training retained clear superiority for cardiopulmonary outcomes, producing larger increases in peak VO_2 (+3.6 vs +1.7 mL/kg/min) and 6MWT distance, consistent with the central and peripheral adaptations of endurance conditioning8 and with the prognostic weight of peak VO_2 in HF.7 That modality effects on both strength and KCCQ remained significant after adjustment for age, sex, and baseline LVEF indicates these are robust, training-specific phenomena rather than artefacts of baseline imbalance. The complementary profile of the two modalities provides a compelling rationale for combined aerobic-plus-resistance prescription, which may capture cardiopulmonary and neuromuscular benefits simultaneously and is increasingly recommended in cardiac rehabilitation.11

From a practical standpoint, these data favour an individualized, phenotype-guided approach to exercise prescription. For patients in whom weakness, frailty, sarcopenia, or impaired quality of life predominate, resistance training warrants explicit prioritization rather than treatment as an optional adjunct; for those chiefly limited by breathlessness and low exercise capacity, aerobic training remains preferable. Reassuringly, resistance training was safe, with no deaths, low and comparable hospitalization rates, and only a modest, non-significant excess of mild musculoskeletal discomfort, aligning with guideline endorsements of supervised resistance exercise in selected cardiac patients.10,11

Limitations include the single-centre design, 12-week duration, inability to blind exercise physiologists, and absence of combined-training and usual-care comparators, which preclude conclusions about long-term hospitalization and mortality. Multicentre trials with longer follow-up, body-composition measures, and hard endpoints are needed to determine whether resistance-induced strength and quality-of-life gains translate into durable clinical benefit.

CONCLUSION

In patients with chronic stable HF on optimized therapy, supervised resistance training preferentially improved muscle strength and quality of life, while aerobic training preferentially improved walking capacity and cardiopulmonary fitness, with both modalities proving safe. These findings reposition resistance training as a primary rather than ancillary component of HF rehabilitation for patients limited by weakness or poor quality of life, and support individualized — ideally combined — exercise prescription tailored to each patient's dominant impairment.

REFERENCES

1. von Haehling S, Ebner N, Dos Santos MR, Springer J, Anker SD. Muscle wasting and cachexia in heart failure: mechanisms and therapies. Nat Rev Cardiol. 2017;14(6):323–341.
2. Anker SD, Ponikowski P, Varney S, et al. Wasting as independent risk factor for mortality in chronic heart failure. Lancet. 1997;349(9058):1050–1053.
3. Coats AJ. Exercise training for heart failure: coming of age. Circulation. 1999;99(9):1138–1140.
4. McDonagh TA, Metra M, Adamo M, et al. 2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure. Eur Heart J. 2021;42(36):3599–3726.
5. O'Connor CM, Whellan DJ, Lee KL, et al. Efficacy and safety of exercise training in patients with chronic heart failure: HF-ACTION randomized controlled trial. JAMA. 2009;301(14):1439–1450.
6. Piepoli MF, Davos C, Francis DP, Coats AJ; ExTraMATCH Collaborative. Exercise training meta-analysis of trials in patients with chronic heart failure (ExTraMATCH). BMJ. 2004;328(7433):189.
7. Mancini DM, Eisen H, Kussmaul W, Mull R, Edmunds LH, Wilson JR. Value of peak exercise oxygen consumption for optimal timing of cardiac transplantation in ambulatory patients with heart failure. Circulation. 1991;83(3):778–786.
8. Hambrecht R, Gielen S, Linke A, et al. Effects of exercise training on left ventricular function and peripheral resistance in patients with chronic heart failure: a randomized trial. JAMA. 2000;283(23):3095–3101.
9. Pu CT, Johnson MT, Forman DE, et al. Randomized trial of progressive resistance training to counteract the myopathy of chronic heart failure. J Appl Physiol. 2001;90(6):2341–2350.
10. Williams MA, Haskell WL, Ades PA, et al. Resistance exercise in individuals with and without cardiovascular disease: 2007 update. Circulation. 2007;116(5):572–584.
11. Bjarnason-Wehrens B, Mayer-Berger W, Meister ER, et al. Recommendations for resistance exercise in cardiac rehabilitation. Eur J Cardiovasc Prev Rehabil. 2004;11(4):352–361.
12. Giuliano C, Karahalios A, Neil C, Allen J, Levinger I. The effects of resistance training on muscle strength, quality of life and aerobic capacity in patients with chronic heart failure — a meta-analysis. Int J Cardiol. 2017;227:413–423.
13. Smart N, Marwick TH. Exercise training for patients with heart failure: a systematic review of factors that improve mortality and morbidity. Am J Med. 2004;116(10):693–706.
14. Green CP, Porter CB, Bresnahan DR, Spertus JA. Development and evaluation of the Kansas City Cardiomyopathy Questionnaire: a new health status measure for heart failure. J Am Coll Cardiol. 2000;35(5):1245–1255.
15. ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. ATS statement: guidelines for the six-minute walk test. Am J Respir Crit Care Med. 2002;166(1):111–117.
16. Spertus J, Peterson E, Conard MW, et al. Monitoring clinical changes in patients with heart failure: a comparison of methods. Am Heart J. 2005;150(4):707–715.