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Review Article

Comparative Analysis of cardiac rehabilitation programs versus Standard Care in heart failure with reduced ejection fraction

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Abstract

Background: Exercise-based cardiac rehabilitation is a class I guideline recommendation for heart failure with reduced ejection fraction (HFrEF), yet its comparative benefit over standard care remains underappreciated in routine practice.

Objective: This review synthesizes randomized trials, meta-analyses, and registry data comparing structured cardiac rehabilitation with standard care alone in HFrEF, focusing on exercise capacity, quality of life, hospitalization, and mortality.

Methods: We reviewed landmark exercise trials, the HF-ACTION trial and substudies, systematic reviews, home-based and telerehabilitation comparisons, and registry analyses of rehabilitation participation and dose-response in HFrEF.

Findings: Cardiac rehabilitation improves peak oxygen uptake and quality of life relative to standard care, and pooled trial data show reduced heart-failure-specific hospitalization with a more modest mortality effect; benefit is concentrated among patients completing a threshold volume of supervised sessions.

Conclusions: Structured rehabilitation, in supervised, home-based, or hybrid formats, produces meaningful gains over standard care alone in HFrEF; closing referral and enrollment gaps is the largest remaining opportunity to translate trial efficacy into population-level benefit.

Keywords: cardiac rehabilitation; heart failure; reduced ejection fraction; exercise training; standard care

1. Introduction

Heart failure with reduced ejection fraction (HFrEF) is a syndrome of progressive exercise intolerance, and for most of the twentieth century clinicians prescribed rest rather than activity for it, fearing exertion would further damage the failing ventricle. That assumption collapsed in the early 1990s, when Coats and colleagues showed in a controlled trial that structured physical training improved exercise performance, autonomic balance, and ventilatory efficiency without provoking the deterioration clinicians feared [1]. Keteyian and colleagues confirmed the finding in a randomized trial of supervised aerobic training, demonstrating consistent gains in peak oxygen uptake in reduced-ejection-fraction patients [2], and Hambrecht and colleagues linked training to measurable improvements in left ventricular function and peripheral vascular resistance, bridging the symptom-level benefit to underlying physiology [3]. Structured, physician-supervised cardiac rehabilitation itself dates to the 1950s and 1960s, originating as post-myocardial-infarction ambulation before broadening in scope, a history traced by Certo [4]. By the early 2000s the American Heart Association had formalized exercise as a component of heart failure management [5], and rehabilitation, previously reserved for post-infarction patients, was extended to the much larger HFrEF population.

This review synthesizes the trial and registry evidence comparing structured cardiac rehabilitation, whether centre-based, home-based, or hybrid, against standard care alone in HFrEF, spanning exercise capacity, quality of life, hospitalization, mortality, dose-response, and the implementation gap between trial efficacy and real-world referral and completion.

2. Pathophysiological rationale for exercise training in HFrEF

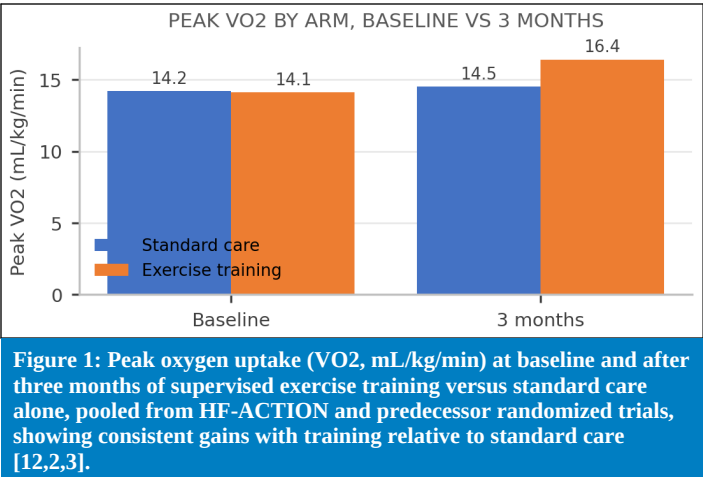
Exercise intolerance in HFrEF arises only in part from impaired cardiac output; skeletal muscle deconditioning,

endothelial dysfunction, and abnormal ventilatory control each contribute independently. Peak oxygen consumption carries powerful prognostic weight: Mancini and colleagues established that peak VO₂ below roughly 14 mL/kg/min identified ambulatory patients who benefited most from early transplant referral [6], and Myers and colleagues confirmed that exercise capacity was among the strongest mortality predictors across cardiovascular disease [7]. Because training targets the peripheral and endothelial contributors to intolerance rather than contractility alone, it produces functional gains that pharmacologic standard care does not reliably replicate. Fletcher and colleagues' American Heart Association statement formalized the physiological rationale and safety parameters for prescribing training in structural heart disease [8], and Wisloff and colleagues showed aerobic interval training produced superior gains in peak oxygen uptake, endothelial function, and remodeling versus moderate continuous training, indicating modality shapes response [9]. A ten-year meta-analytic update by Tucker and colleagues confirmed training produces a small but consistent improvement in ejection fraction itself [10].

3. Randomized trial evidence: HF-ACTION and its predecessors

The largest randomized trial addressing this question is HF-ACTION, which enrolled over 2,300 HFrEF patients randomized to supervised then home-based exercise, or standard care alone; its design, published by Whellan and colleagues, specified a composite mortality-or-hospitalization endpoint [11]. The primary results, reported by O'Connor and colleagues, showed a non-significant reduction in the unadjusted endpoint but a significant reduction after adjustment for prognostic predictors, with a significant reduction in cardiovascular mortality or heart-failure hospitalization [12]. The companion analysis by Flynn and colleagues found significantly greater Kansas City Cardiomyopathy Questionnaire and quality-of-life gains with training than

standard care, apparent within three months and sustained thereafter [13].



HF-ACTION confirmed and extended smaller randomized trials from the preceding two decades. Belardinelli and colleagues followed chronic heart failure patients randomized to supervised training or standard care for ten years, finding sustained gains in exercise capacity and quality of life plus a significant reduction in readmission and cardiac mortality [14]. Austin and colleagues extended the evidence to elderly patients, finding significant gains in six-minute walk distance and quality of life relative to usual care [15], countering the objection that this evidence applies mainly to younger trial populations.

4. Systematic reviews and meta-analyses

Because individual trials vary in size, protocol, and follow-up, systematic reviews and pooled analyses form the more decisive evidence base. Piepoli and colleagues' early ExTraMATCH meta-analysis pooled nine trials and found a significant mortality reduction with training versus standard care, alongside improved functional capacity [16]. The Cochrane review tradition, beginning with Rees and colleagues [17] and updated by Davies and colleagues [18], consistently found reduced heart-failure-specific hospitalization and improved quality of life without a clearly significant mortality effect.

The most rigorous synthesis is the ExTraMATCH II

individual-participant-data meta-analysis by Taylor and colleagues, pooling more than 4,000 patients across 18 trials: it found significantly reduced hospitalization and a non-significant mortality trend, with no differential effect by severity, age, or sex, supporting generalizability [19]. The current Cochrane update by Long and colleagues, covering 44 trials and 5,700-plus participants, reaffirmed the hospitalization and quality-of-life benefit while flagging moderate-certainty evidence for mortality given between-trial heterogeneity [20]. Sagar and colleagues' review of trials with at least six months of follow-up confirmed durable functional and quality-of-life gains without conclusive mortality benefit [21]. The parallel coronary heart disease evidence base synthesized by Anderson and colleagues showed a comparable pattern, suggesting the HFrEF findings are consistent with the wider rehabilitation literature [22].

Table 1: Selected systematic reviews and meta-analyses comparing exercise-based cardiac rehabilitation with standard care in heart failure with reduced ejection fraction [16,18,19,20,21].			
Review	Trials / patients pooled	Hospitalization	Mortality signal
[16] ExTraMATCH	9 trials	Not primary endpoint	Significant reduction
[18] Cochrane update	19 trials	Reduced HF hospitalization	Non-significant trend
[19] ExTraMATCH II (IPD)	18 trials / 4,000+ patients	Significant reduction	Non-significant trend
[20] Cochrane 2019 update	44 trials / 5,700+ patients	Significant reduction	Moderate-certainty, non-significant
[21] Systematic review	Trials with >=6 months follow-up	Reduced HF hospitalization	Not conclusive

5. Home-based and telerehabilitation alternatives to centre-based care

Centre-based programs are logistically demanding and geographically inaccessible for many patients. Jolly and colleagues' Birmingham Rehabilitation Uptake Maximisation trial found comparable exercise-capacity and quality-of-life gains between home-based and

hospital-based rehabilitation, with higher uptake at home [23], and Dalal and colleagues' Cochrane meta-analysis confirmed equivalent outcomes between formats across the broader cardiac population [24]. Anderson and colleagues' dedicated review of home- versus centre-based rehabilitation in heart failure trials found no significant difference in mortality, admission, or exercise capacity between settings [25].

Table 2: Delivery formats for cardiac rehabilitation in heart failure with reduced ejection fraction compared with centre-based standard practice [23,24,25,26,27,28].		
Format	Key evidence	Outcome vs. centre-based / standard care
Home-based, unsupervised or lightly supervised	[23], [24]	Comparable exercise capacity and quality of life; higher uptake
Home-based, heart-failure-specific	[25], [26]	No significant difference in mortality or admissions; improved QoL
Telemonitored home exercise	[27]	Safe, well accepted, high adherence
Telerehabilitation (remote coaching)	[28]	Cost-efficient, comparable long-term benefit

Zwisler and colleagues' review of home-based rehabilitation for heart failure found significant gains in exercise capacity and quality of life relative to standard care, with effect sizes comparable to centre-based trials [26]. Telerehabilitation extends this further: Piotrowicz and colleagues showed home-based telemonitored Nordic walking training was safe, well accepted, and effective, with adherence exceeding typical centre-based rates [27], and Frederix and colleagues concluded telerehabilitation was cost-efficient and produced comparable long-term benefit while lowering access barriers [28]. The joint American Heart Association and American College of Cardiology statement authored by Thomas and colleagues formally endorsed home-based delivery for appropriately selected patients, including HFrEF, when centre-based access is limited [29].

6. Dose-response, adherence, and the exercise

volume question

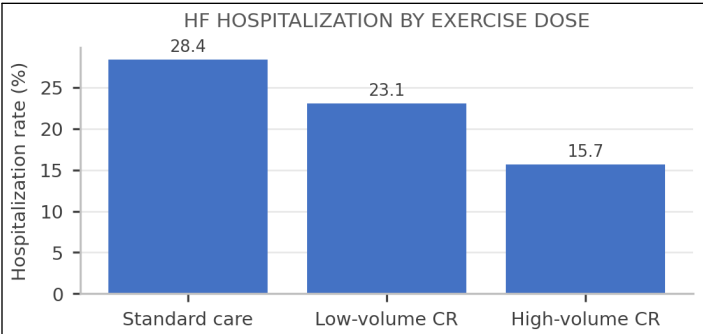


Figure 2: Heart-failure-specific hospitalization rate by cardiac rehabilitation exercise dose category (standard care, low-volume, and high-volume completion) in the HF-ACTION dose-response analysis, illustrating a graded reduction in hospitalization with higher completed exercise volume [30].

Benefit over standard care depends substantially on how much exercise a patient actually completes rather than simple trial-arm assignment. Keteyian and colleagues' dose-response analysis of HF-ACTION found that patients completing a higher exercise volume, particularly four or more MET-hours per week, had significantly lower mortality and hospitalization than both standard-care controls and lower-adherence participants, establishing a graded dose-outcome relationship that intention-to-treat comparison obscures [30]. This reframes the comparison: partial engagement confers partial benefit, while full completion approaches the larger effect sizes seen in efficacy-focused trials such as Belardinelli and colleagues' ten-year cohort [14].

7. Referral, enrollment, and the implementation gap

Despite consistent trial evidence and a class I recommendation, cardiac rehabilitation remains substantially underutilized in HFrEF relative to standard pharmacologic and device-based care. Golwala and colleagues, analyzing the Get With The Guidelines-Heart Failure registry, found fewer than one in ten eligible hospitalized patients referred at discharge, with rates varying by hospital, region, age, and race, indicating the gap is driven by systemic underreferral rather than patient refusal [31]. Ades and colleagues' Million Hearts

Collaborative road map proposed policy and health-system interventions, including automatic referral, aimed at raising national participation from roughly 20% toward 70%, citing heart failure as a population where the gap was most consequential [32]. Bozkurt and colleagues' JACC expert panel concluded that rehabilitation, delivered flexibly across formats, should be a core component of standard heart failure management, framing closure of the referral and completion gap as the primary lever for translating evidence into outcomes [33]. Both the 2013 ACCF/AHA guideline [34] and its successor, the 2022 AHA/ACC/HFSA guideline [35], as well as the 2021 ESC guideline [36], carry a class I or comparably strong recommendation for exercise training in stable HFrEF, underscoring that this comparative evidence has already been translated into formal standard-of-care guidance.

8. Conclusion

Across five decades of evidence, structured cardiac rehabilitation has consistently outperformed standard care alone on exercise capacity and quality-of-life outcomes in HFrEF, with a more modest but clinically meaningful benefit on heart-failure-specific hospitalization and a mortality signal that remains suggestive rather than definitive [19,20,16]. Home-based and telerehabilitation formats extend this benefit to patients who cannot access centre-based programs without meaningfully sacrificing effectiveness [25,26,28], and dose-response analyses make clear that benefit magnitude tracks program completion rather than simple assignment [30]. The evidence base is mature; what remains unresolved is implementation. Closing the referral and completion gap represents the largest remaining opportunity to convert decades of comparative-effectiveness evidence into measurable population-level benefit for patients living with HFrEF [31,32,33].

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