Exercise training in heart failure

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Learning objectives:

- To understand the importance of exercise and physical activity in the general management and wellbeing for people of heart failure (HF).
- To understand the key principles of exercise training prescription in people with HF.
- To be familiar with the specific considerations of exercise training prescription in specific HF populations groups including HFpEF (HF with preserved ejection fraction).
- To be aware of needs and requirements of remote delivery (home and digital supported) models of exercise training for people with HF.

Introduction

Management of heart failure (HF) requires multidisciplinary, pharmacological, and non-pharmacological strategies, one component of which is exercise training. Consistent evidence from meta-analyses and clinical trials shows that exercise training improves exercise tolerance, rates of hospitalization and health-related quality of life (HRQoL) in patients with HF,[1] although there remains some uncertainty around the effects of exercise on mortality.[2] This article aims to highlight and summarise the role of exercise training in the management of HF, and the key principles, considerations and practicalities of exercise-based cardiac rehabilitation (ExCR) or exercise training in people with HF. Whilst we emphasize the importance of integrating both exercise training and physical activity promotion as part of a comprehensive approach to the management and rehabilitation of people with HF, this paper will focus on the specific considerations for exercise training. Discussion will include (1) definitions, importance and current recommendations for exercise, physical activity and ExCR; (2) exercise prescription and considerations for alternative exercise modalities; (3) considerations for different types of HF patient, and (4) delivery models and related practicalities.

1. Exercise, physical activity & cardiac rehabilitation - definitions, importance, and current recommendations

Although exercise and physical activity are terms often used interchangeably, there are key distinctions. Physical activity is defined as any bodily movement produced by skeletal muscles, resulting in energy expenditure beyond resting expenditure, and includes occupational, household, leisure time and transportation activity as well as sports and structured exercise.[3] Exercise, a subcategory of physical activity, is planned, structured, repetitive and purposeful with the intent to improve or maintain one or more elements of physical fitness.[3]

ExCR is a complex intervention, made up of multiple components, which seeks to improve the functional capacity, HRQoL and wellbeing of participants. It is defined by the British Association for Cardiovascular Prevention and Rehabilitation (BACPR) as “the coordinated sum of activities required to influence favourably the underlying cause of cardiovascular disease, as well as to provide the best possible physical, mental and social conditions, so that the individuals may, by their own efforts, preserve or resume optimal functioning in their community and through improved health behavior, slow or reverse progression of disease.”[4] Physical activity and exercise training make up one of the core components, alongside health education, cardiovascular risk factor management and psychosocial support (Figure 1).

[Insert figure 1]

Peak oxygen consumption ($VO_{2\ peak}$), an estimate of maximal exercise capacity, is a strong predictor of survival in people with HF.[5] Several meta-analyses have demonstrated that regular exercise training or ExCR improves exercise capacity and HRQoL in patients with HF.[1,6] Meta-analysis of 21 randomised trials indicated a 30% reduction in risk of all-cause hospital admissions (risk ratio [RR] 0.70, 95% CI 0.60 to 0.83), and across 14 trials a 41% reduction in risk of hospital admission for HF (RR 0.59, 95% CI 0.42 to 0.84).[1] Pooled analysis of 17 trials with disease-specific HRQoL data (assessed using the Minnesota Living with HF Questionnaire [MLWHF]) showed an improvement with ExCR (mean difference -7.1, 95% CI -10.5 to -3.7) compared with no-exercise control.[1] A reduction in MLWHF score (reduction indicates improvement in HRQoL) of 5 or more is considered to be clinically meaningful.[7]

The current World Health Organisation (WHO) recommendations for physical activity for adults, older adults and people living with chronic conditions are at least 150-300 minutes of moderate-intensity physical activity per week. Additionally, activities aimed at muscle strengthening and improving functional balance should be undertaken on at least two-to-three days per week to enhance functional capacity and prevent falls.[8] Based on the available evidence, numerous international societies have provided strong clinical recommendations for exercise training and/or ExCR, for patients with HF as part of the overall management of HF, which are summarized in Table 1.

Table 1: International recommendations and clinical guidelines for physical activity, exercise and cardiac rehabilitation in patients with heart failure

Region (society)	Guideline recommendations	Class of recommendation[a]	Level of evidence[b]
Exercise training			
Australia/ New Zealand (NHFA & CSANZ)[9]	Regular performance of up to moderate intensity (i.e. breathe faster but not hold conversation) continuous exercise is recommended in patients with stable chronic heart failure, particularly in those with reduced LVEF, to improve physical	Strong recommendation	High

	functioning and quality of life, and to decrease hospitalization.		
Europe (ESC) [10,11]	Exercise is recommended for all patients who are able in order to improve exercise capacity, QOL, and reduce HF hospitalization.	I	A
USA (AHA/ACC/ HFSA)[12]	For patients with HF who are able to participate, exercise training (or regular physical activity) is recommended to improve functional status, exercise performance, and QoL	I	A
Scotland (SIGN)[13]	Patients with stable heart failure in NYHA class II-III should be offered a moderate-intensity supervised exercise training programme to give improved exercise tolerance and quality of life	Strong recommendation	1++
Cardiac rehabilitation			
Europe (ESC) [10,11]	A supervised, exercise-based cardiac rehabilitation programme should be considered in patients with more severe disease, frailty, or with comorbidities.	IIa	C
USA (AHA/ACC/ HFSA)[12]	In patients with HF, a cardiac rehabilitation program can be useful to improve functional capacity, exercise tolerance, and health-related QOL.	IIa	B-NR
England (NICE)[14]	Offer people with heart failure a personalized, exercise-based cardiac rehabilitation programme, unless their condition is unstable. The programme: • Should be preceded by an assessment to ensure that it is suitable for the person • Should be provided in a format and setting (at home, in the community or in the hospital) that is easily accessible for the person • Should include a psychological and educational component • May be incorporated with an existing cardiac rehabilitation programme • Should be accompanied by information about support available from healthcare professionals when the person is doing the programme	-	-

ACC: American College of Cardiology; AHA: American Heart Association; CSANZ: Cardiac Society of Australia and New Zealand; ESC: European Society of Cardiology; HFSA: Heart Failure Society of America; NHFA: National Heart Foundation of Australia; NICE: The National Institute for Health and

Care Excellence; SIGN: The Scottish Intercollegiate Guidelines Network.
[a] Class of recommendation: I – "is recommended or indicated"; IIa – "is reasonable or can be useful" Strong recommendation - "guideline group is confident that for the vast majority of people, the intervention will do more good than harm". [b]Level of evidence: A– "data derived from multiple RCT or meta-analyses"; B-NR "data derived from moderate-quality nonrandomised studies or meta-analyses of such studies"; C – "consensus of the opinion of experts and/or small studies, retrospective studies, registries"; 1++ - High-quality meta-analyses, systematic reviews of RCTs, or RCTs with a very low risk of bias.

Despite strong guideline recommendations for exercise, uptake of ExCR remains poor amongst patients with HF. Pre-COVID-19, the UK National Audit of Cardiac Rehabilitation (NACR) reported that <10% patients with HF attended ExCR,[15] and similar uptake levels have been observed in the USA and Europe.[16-17] The reasons for suboptimal uptake are complex and multilayered, with potential barriers to accessing ExCR at multiple levels described in figure 2 with proposed solutions.

[Insert figure 2]

2. Exercise prescription and alternative modalities.

Exercise training should only be initiated in individuals that are clinically stable.[18] Before commencing a training programme, it is recommended that the following assessments are performed to minimize the overall risk of exercise training in patients with HF:[11,19]

a. Risk stratification – screening and exclusion of contraindications to exercise including hypotension or hypertension at rest or during exercise, deteriorating symptoms of HF, myocardial ischaemia during low intensity exercise, uncontrolled diabetes, thrombophlebitis, new-onset atrial fibrillation/atrial flutter, recent embolism or severe pulmonary disease. Consider the mechanism of heart failure (i.e., HFrEF following MI, alcohol excess or viral infection, or HFpEF due to valvular stenosis, hypertension etc.).

b. Preliminary evaluations – assessment to identify comorbidities, HF severity, and an exercise test to determine functional capacity, and assess exercise-induced arrhythmias or haemodynamic abnormalities. The gold standard method is symptom limited cardiopulmonary exercise test (CPET) to directly measure $VO_{2\ peak}$. Since CPET is not always available in routine clinical practice, indirect or submaximal methods are proposed such as the six-minute walking test or incremental shuttle walk test (a standardized field test requiring patients walk around a 10m course in time to a set of auditory beeps that incrementally increase in speed, until they are too breathless or unable to keep up).

More frequent counselling is recommended for higher-risk patients during the initial phases of exercise training. If possible, these participants should be encouraged to attend supervised exercise sessions within an ExCR programme with gradual addition or transition to non-supervised home-based sessions once appropriate response to exercise has been identified and the patient feels confident in self-managing their exercising independently.

To reduce risk, each exercise session should include 10-15 minutes of warm up and cool down to increase blood flow to the muscles, and slowly raise/decrease heart rate. Follow-up assessments for all patients should ideally be planned at least every 3-6 months to monitor progress and review exercise recommendations.

2.1 Principles of exercise prescription

There are six general principles to exercise prescription, commonly referred to as FITT-VP. These are (F)requency; (I)ntensity; (T)ime; (T)ype; (V)olume and (P)rogression (explained in table 2). Case study examples are provided in figure 3.

There is no universal agreement on the optimal exercise training dose in HF, therefore it is recommended to opt for an individually tailored approach to exercise prescription, according to the patient's symptoms, functional limitations, comorbidities and performance in the baseline assessment (VO_{2peak}, maximal heart rate (HRmax), heart rate reserve (HRR) or Borg's 6-20 rating of perceived exertion (RPE) scale). Additional factors such as muscle strength or frailty, leisure and working routine, preferences, logistical restraints and availability of local facilities and equipment should also be taken into consideration.[11,19]

Table 2: Description of the principles of exercise prescription and example aerobic and resistance training programmes.

Principles of exercise prescription (FITT-VP)

Frequency (how often?):

- Sessions/week
- Bouts of exercise

Intensity (how hard?):

Intensity	$VO_{2\ peak}$	HR peak	HRR	RPE	1RM
• Light	<40%	<55%	<40%	10-11	<30%
• Moderate	40-69%	55-74%	40-69%	12-13	30-40%
• High	>70%	>75%	>70%	14-16	40-60%

- Moderate intensity can be monitored by the patient themselves during an activity as a level of effort where they can hold a conversation but not sing (known as the "talk test")

Time (how long?):
- Duration of exercise programme (weeks or months)
- Duration of training sessions (minutes or hours)

Type (what exercises?):
- Aerobic/endurance (walking, jogging, cycling, rowing, swimming)
- Strength or resistance training (free or machine weights, resistance bands, body weight exercises)
- Mobility, flexibility or balance (yoga, stretching)

Volume (how much?):
- The total amount of training load, based on frequency, intensity, and duration

Progression (continuous improvement):
- The process of increasing the intensity, duration, frequency, or overall volume as the individual adapts to the current training programme.

1RM - one repetition max (the maximum amount of weight that can be lifted for one repetition); HR - heart rate; HRR - heart rate reserve (the difference between max/peak heart rate and resting heart rate); RPE - rating of perceived exertion (a subjective measure of exercise intensity that ranges from 6 [no exertion] to 20 [maximal exertion]); VO2peak - peak oxygen consumption

[Insert figure 3]

2.2 Exercise modality

There are several different exercise modes that may be suitable for HF patients either alone or in combination. A meta-analysis comparing multiple exercise modes (continuous, interval, strength, and combinations of these) in patients with HF concluded that active involvement in any kind of exercise training program was sufficient to improve prognosis, HRQoL and anatomic function.[20] The following subsections outline the evidence, benefits, and key principles of five proposed exercise modalities.

2.2.1 Aerobic exercise training

Aerobic exercise refers to physical activities involving large muscle groups which results in increased heart rate and energy expenditure, at an intensity that allows metabolism of stored energy to occur mainly through aerobic glycolysis. Examples of aerobic exercises are walking, cycling, and swimming. Aerobic exercise training can be continuous, or interval based.

Continuous aerobic training is the most evaluated mode of exercise and has well-documented safety and efficacy as reflected in the clinical guidelines (Table 1). Traditionally, ExCR programmes consist of continuous aerobic exercise, at moderate intensity, which is easily performed on a cycle ergometer or treadmill. Recommended training intensities are initially 40-50% $VO_{2\ peak}$, increasing to 70-80% as fitness improves, or alternatively 40-70% HRR or RPE 10-14. In more deconditioned patients, it is recommended to begin exercise training at a low volume (i.e. lower intensity for 5-10 minutes, twice per week), and gradually increase the duration per session, then number of sessions per week as tolerance improves aiming for 20-60 min per session on 3-5 days per week at moderate-high intensity.[11,19]

Interval aerobic training consists of alternate short bouts (10-30 seconds) of moderate-high intensity aerobic exercise (50-100% peak exercise capacity), with recovery phases (60-80 seconds) performed at low intensity. There is strong emerging evidence about the benefits of this type of exercise training, showing this approach can potentially be more efficient, as it can provide greater challenge to the cardiopulmonary, metabolic and peripheral systems.[11] Interval training can be easily performed on a cycle ergometer, increasing the resistance on the bike. Circuit training is another common form of interval training applied in ExCR programmes, which typically consists of a combination of aerobic exercises (e.g. marching) and resistance exercises (e.g. chair squats, bicep curls) alternated with periods of rest or active recovery. Depending on the work/recovery intervals chosen, ~10-12 work intervals (or exercises in the case of circuit training) can be performed per 15-30 minute training session.[19]

2.2.2 HIIT (high intensity interval training)

Over recent years, there has been increasing interest in high-intensity interval training (HIIT) programmes as an alternative exercise modality for low-risk HF patients. HIIT training typically consists of alternating short intervals at high intensity (70-95% VO_{2peak} or HR_{peak}), with active recovery intervals at moderate intensity (40-60% VO_{2peak} or HR_{peak}). A meta-analysis comparing moderate intensity continuous training and HIIT in patients with HF demonstrated that HIIT was superior in improving VO_{2peak} (mean difference 1.35 mL/kg/min 95% CI 0.11 to 2.59), but no difference in effect was found for HRQoL.[21] Guidelines suggest HIIT programmes may be recommended initially for low-risk patients who wish to return to high intensity aerobic and mixed endurance sports.[11]

2.2.3 Resistance training

Resistance training is widely accepted as the most effective training method to increase muscle mass and strength. Gradual and progressive overload to the musculoskeletal system strengthens and tones muscles and increases bone mass. Given the functional consequences of HF including loss of lean body mass, muscle weakness and frailty, resistance training should also be considered to complement aerobic exercise training.[19] A recent meta-analysis showed resistance training to be safe and effective in improving both lower and upper body strength, as well as VO_{2peak} and HRQoL in patients with HF.[22]

Resistance training programmes must be individually prescribed accordingly and supervised by an exercise therapist. For determination of resistance training intensity (i.e., the amount of weight), a maximal strength test is generally unsuitable in HF patients due to the Valsalva manoeuvre. Therefore, a three-stage, progressive approach is recommended where (1) patients should perform the exercises slowly and with no or very low resistance (5-10 repetitions, RPE <12) until they are confident with the movement; (2) begin to train with a high number of reps (12-25) and low intensity (RPE 12-13) and (3) train at a higher intensity where the patient can perform 10-15 repetitions at RPE 15 without abdominal straining and symptoms.[19]

2.2.4 Aquatic

Aquatic exercise has also been shown to be safe and effective alternative mode of exercise for patients with HF, which may be useful for those with orthopaedic or neurological comorbidities.[23] This would most likely be patient led and supplementary as it is not currently included as part of UK based ExCR programmes generally.

2.2.5 Competitive and recreational sports

Prior to returning to participation in sports, a thorough evaluation using a maximal exercise test (preferably CPET) is recommended to ensure the absence of exercise-induced abnormalities, along with a progressive increase in exercise dose.

Some restrictions may apply to moderate-high intensity endurance (e.g., distance running, road cycling, rowing), mixed (e.g., tennis, hockey, football) and power sports (e.g., sprinting, weightlifting, boxing) with high demands, depending on the patients exercise tolerance, symptoms, and risk stratification. No restrictions should apply to low-intensity skill related sports such as golf, table tennis, or bowling in asymptomatic HF patients.[11]

3. HF groups with special considerations

3.1. HF with preserved ejection fraction (HFpEF)

HF has three broad phenotypes, defined based on ejection fraction (EF): i.e. reduced (<40%; HFrEF), preserved (>50%; HFpEF) or mid-range (>40-59%; HFmrEF).[10] The majority of experience and evidence of the benefits of ExCR (described above) has been collected in patients with a compromised EF – usually HFrEF (and in some cases HFmrEF) and therefore exercise training/ExCR for these phenotypes have a class I level A recommendation by the ESC (Table 3).[11]

In contrast, clinical trials of exercise training/ExCR have traditionally excluded patients with a normal (>50%) EF (HFpEF).[24] However, with increasing recognition of the importance of HF phenotypes, several ‘proof of principle’/pilot trials of exercise training/ExCR have specifically recruited HFpEF patients.[20] Although the evidence base is still emerging, the effects of exercise on exercise capacity and HRQoL appear to be similar in direction and magnitude to those seen in HFrEF. A recent comparative meta-analysis reported mean improvements in $VO_{2\ peak}$ following ExCR compared to no exercise control of 2.3 and 3.0 ml/kg/min for HFpEF and HFrEF patients, respectively.[25] This meta-analysis also showed that compared to control, HFpEF patients experienced important improvements in HRQoL assessed by the disease-specific MLWHF following ExCR participation (mean difference: -10.9, 95% CI: -6.0 to 5.9, P<0.001; a reduction in score indicting improved HRQoL). Analysis for HFrEF showed similar, clinically meaningful, improvements in MLWHF (mean difference: -8.2, 95% CI: -11.9 to -4.5, P< 0.001). Currently, there is too little data to conclude impact of ExCR on the HFpEF patients’ risk of clinical events such as hospitalisation and mortality. Hence the current ESC recommendation for ExCR for HFpEF is only ‘level C’ (Table 3) indicating the need for appropriately powered RCTs in HFpEF patients with sufficient follow-up to definitively assess the impact of exercise training on clinical outcomes.[11]

Table 3. ESC guidelines for exercise training in patients with HFrEF/HFmrEF and HFpEF[11]

	Class of recommendation	**Level of evidence**
HFrEF/HFmrEF patients		
Regular discussion about exercise participation and provision of individualised exercise prescription is recommended in all individuals with HF	I	A
ExCR is recommended in all stable individuals to improve exercise capacity, quality of life, and reduce the frequency of hospital admissions	I	A
HFpEF patients		
Moderate endurance and dynamic exercise together with lifestyle intervention and optimal treatment of cardiovascular risk factors (i.e., arterial hypertension and type 2 diabetes) are recommended	I	C

Class of recommendation: I – “is recommended or indicated”. Level of evidence: A– “data derived from multiple RCT or meta-analyses”; C – “consensus of the opinion of experts and/or small studies, retrospective studies, registries”.

Interestingly, although the health outcomes benefits appear to be similar, the biological mechanism of exercise adaptation of HFpEF and HFrEF differ (Table 4). There is evidence supporting the notion that exercise training improves peripheral mechanisms, such as improved skeletal muscle perfusion and metabolism, likely play a major role in adapting to exercise in HFpEF.[7,25,26] Conversely, exercise training in HFrEF is supported by a plethora of research trials reporting significant improvements in cardiac function and structure, and significant increase in left ventricular EF.[27] Like the diastolic change in HFpEF, this systolic improvement in HFrEF likely contributes to the observed increase in exercise capacity. While there was a significant decrease in BNP/NTproBNP following exercise training in HFrEF, no such change was observed in HFpEF. Decreases in blood biomarkers (BNP and NTproBNP) following exercise training in HF have been linked to autonomic enhancements with greater sympatho-vagal balance contributing to reduced secretion. While BNP and NTproBNP remain elevated irrespective of EF in HF, they are generally lower in HFpEF than in HFrEF with differing biomarker profiles, likely contributing to the disparity in results between the two phenotypes. It is suggested that the improvement in the $VO_{2\ peak}$ after exercise training in HFpEF patients is the expression of complex peripheral adaptation mechanisms and the consequent increase in oxygen extraction by skeletal muscle.[7,25]

Table 4. Impact on outcomes and mechanism of effect exercise training/ExCR in HFrEF/HFmrEF vs. HFpEF patients

	HFrEF (HFmrEF)	**HFpEF**
Impact on outcomes		
Exercise capacity	Increased	Increased
HRQoL	Increased	Increased
Risk of mortality/hospitalisation	Reduced	Not known*
Mechanism of effect		
Blood biomarkers (BNP/NT proBNP)	Decreased	No change
LVEF	Increased	No change
Diastolic markers (E/E’)	No change	Increased

*definitive RCTs in HFpEF needed to assess impact on clinical outcomes. HRQoL: health-related quality of life; LVEF: left ventricular ejection fraction.

In summary, whilst the health outcome benefits of exercise training/ExCR appear to be similar in HFrEF/HFmrEF versus HFpEF, the biological mechanisms are likely to differ. However, despite these mechanistic differences, the principles of exercise prescription described above, are broadly applicable to HFrEF/HFmrEF and HFpEF phenotypes.

3.2. Acute decompensated HF

To date, trials of exercise training/ExCR in HF have focused almost exclusively on chronic, stable HF patients.[24] The current literature regarding the safety and efficacy of exercise training that specifically target patients hospitalised HF is limited to a single RCT. The REHAB-HF (Rehabilitation Therapy in Older Acute Heart Failure Patients) trial randomly allocated 349 older (≥60 years) hospitalised with acute decompensated HF (both HFrEF and HFpEF) to either exercise rehabilitation intervention or attention control.[28] The primary outcome was the Short Physical Performance Battery (SPPB) with total scores that range from 0 to 12, lower scores indicating more severe physical dysfunction. At baseline, patients in each group had markedly impaired physical function, and 97% were frail or prefrail; the mean number of coexisting conditions was five in each group. The study showed that multidomain physical rehabilitation is feasible in older patients with acute decompensated HF with greater improvement in physical function than usual care (adjusted mean SPPB score at 3 months follow-up: 8.3 in the exercise group vs. 6.9, $P<0.001$). Although promising, further evidence is needed before acute decompensated HF patients can be routinely recommended exercise training.

3.3. Multimorbid HF patients

Although referred to exercise training/ExCR for their HF index diagnosis, patients typically present with multiple long-term conditions that can be cardiovascular-related (e.g., coronary heart disease/atrial fibrillation/diabetes/renal dysfunction) and/or non-cardiovascular (e.g., arthritis/cancer). This is likely to become more common as prevalence of multimorbidity is increasing in the general population with aging. The 2019 UK NACR, identified that approximately 50% of the 6,502 patients referred to ExCR had two or more comorbidities.[15] This UK audit report also showed that multimorbidity was a strong risk factor for both non-enrollment in ExCR and programme non-completion. A higher proportion of ExCR non-completers had symptoms of anxiety and depression than completers.

While programmes commonly identify and manage co-morbidities such as diabetes and arthritis in their patients, the traditional model of ‘single index diagnosis’ exercise training/ExCR needs to be revamped to better cater for the needs of patients with multimorbidity,[29] and indeed in some cases there is fairly extensive collaboration with pulmonary rehabilitation services. The increasing burden and complexity of multimorbidity may challenge the traditional model of ExCR. Personnel may not have the needed expertise, nor additional time to appropriately manage such patients; programmes could potentially partner with other specialties to ensure comprehensive chronic care. Indeed, there are not often available comprehensive rehabilitation services for common chronic conditions such as kidney disease, and ExCR may be an appropriate model. However, whilst a move to a model of ExCR delivery that more comprehensively addresses the needs of patients with heart disease and their multimorbidity might be warranted, the RCT evidence base for exercise training/ExCR for patients with multiple chronic diseases at this time remains limited.[30]

3.4. Frailty

Frailty, a syndrome characterised by a reduced physiologic reserve and impaired homeostatic tolerance to stressors, is common among patients with HFrEF and HFpEF and associated with poorer exercise tolerance and HRQoL, and greater risk of adverse cardiovascular events.[31] Exercise training/ExCR interventions appear to be efficacious in reducing the frailty burden among older individuals, including patients with HF. A sub-analysis of the large multicenter HF-ACTION trial of exercise training versus no exercise control in HFrEF, found that baseline frailty modified the treatment effect of aerobic exercise training and a greater reduction in the risk of all-cause mortality.[32] This finding highlights the potential role of routine frailty assessment using simple measurements such as hand grip strength in identifying high-risk HF patients who may be most likely to benefit from exercise training/ExCR. However, exercise programmes need to be carefully personalised to appropriately meet the needs and limited capacity of such patients.

4. Alternative exercise training delivery models

The traditional mode of delivery for exercise training/ExCR for HF over the last two decades has been supervised centre-based programmes. During the COVID-19 pandemic, alternative models of delivery including home-based and digital supported models of health care became a necessity in providing health care to patients.[33] Given the stubbornly poor global uptake of ExCR described above and accentuated by the learnings during the pandemic, there are increasing calls for more innovative delivery ‘modern models’ of exercise training and ExCR to improve patient access, including home-based, digitally supported, and hybrid (mix of home and centre).[34]

A Cochrane systematic review showed that supervised home and tele-based modes have similar benefits to centre-based ExCR programmes in terms of improvement in HRQoL and reduction in risk of clinical event outcomes.[35] A recent network meta-analysis showed similar improvements in patient reported outcomes between centre versus home-based ExCR (with or without digital technology support).[36] The frequency of home-based programmes in practice is steadily growing. For example, following demonstration of its clinical and cost effectiveness in a multicentre trial and economic modelling, the REACH-HF home-based programme is now being implemented across the UK NHS for stable patients post-discharge.[37-39]

It is important to note that the majority of evidence of home/digitally-supported models of exercise training/ExCR have been based on uncomplicated low-risk patients. Specific challenges of the remote delivery of these interventions include both reduced abilities to intensively supervise and monitor and challenges in reliability and difficulty in assessing exercise capacity to provide appropriate exercise prescription. In recognition of this, the 2019 Scientific statement from the American Association of Cardiovascular and Pulmonary Rehabilitation, American Heart Association, and American College of Cardiology, recommends home-based CR to “be a reasonable option for selected clinically stable low- to moderate-risk patients who are eligible for CR but cannot attend a traditional center-based CR program”.[40] Some key considerations in the choice for individual HF patients of a traditional centre-based versus a home-based/digitally supported model of exercise training/ExCR are summarised in Table 5.

Table 5. Pros and cons of centre-based versus home-based/digitally supported) models of exercise training /ExCR delivery for individual HF patients

	Centre-based programme	**Home-based/digitally supported programme**
Benefits	Opportunity for direct healthcare professional supervision and monitoring	Reduce barriers to patient Travel to centre not required Convenience in terms of integration of work/life roles Involvement of partner/family.

Limitations	Barriers to patient access	Challenges of remote exercise capacity assessment & exercise prescription Need for digital competency Safety considerations for high-risk/complicated patients
HF patient stratification	Can be offered to all HF patient irrespective of level of risk but (for efficiency) focus on higher risk/less stable and more complicated patients	Option for low risk/stable/uncomplicated patients

Summary/Key points

- Exercise training improves exercise tolerance, rates of hospitalization and HRQoL in patients with HF and is an important component within the overall, multidisciplinary management of HF.
- Prior to commencing exercise training, assessments to exclude contraindications to exercise, determine risk level, and evaluations of exercise capacity should be performed.
- Different exercise protocols are available (exercise modes, setting), and it is important to consider the individual's capabilities, needs, preferences and accessibility of centre-based programmes when prescribing exercise.
- The benefits of exercise training appear to be similar across the different HF phenotypes, however the biological mechanisms are likely to differ. Nevertheless, the principles of exercise prescription are broadly applicable to all phenotypes.

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Figure legend

Figure 1 – core components of cardiac rehabilitation (adapted from BACPR[4])

Figure 2 – barriers to exercise-based cardiac rehabilitation uptake and potential solutions

Figure 3 – example case studies with exercise prescriptions