

Exercise training in heart failure: from theory to practice. A consensus document of the Heart Failure Association and the European Association for Cardiovascular Prevention and Rehabilitation

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The European Society of Cardiology heart failure guidelines firmly recommend regular physical activity and structured exercise training (ET), but this recommendation is still poorly implemented in daily clinical practice outside specialized centres and in the real world of heart failure clinics. In reality, exercise intolerance can be successfully tackled by applying ET. We need to encourage the mindset that breathlessness may be evidence of signalling between the periphery and central haemodynamic performance and regular physical activity may ultimately bring about favourable changes in myocardial function, symptoms, functional capacity, and increased hospitalization-free life span and probably survival. In this position paper, we provide practical advice for the application of exercise in heart failure and how to overcome traditional barriers, based on the current scientific and clinical knowledge supporting the beneficial effect of this intervention.

Keywords Exercise training • Physical activity • Rehabilitation • Heart failure

Introduction

The 2008 European Society of Cardiology heart failure (HF) guidelines firmly recommend regular physical activity and structured exercise training (ET). This recommendation is based on the fact that ET improves exercise capacity and quality of life, does not adversely affect left ventricular remodelling, and may reduce mortality and hospitalization in patients with mild-to-moderate chronic heart failure (CHF) (recommendation class I).¹

Unfortunately, this recommendation is still poorly implemented in daily clinical practice outside specialized centres and in the

real world of HF clinics: in a recent survey among 673 hospitals in 43 European countries, only 63% reported to have implemented HF management programmes, and only 42% of these incorporated an exercise component.² Less than 20% of HF patients are participating in a cardiac rehabilitation programme according to a more recent European survey.³

Hazard of extending commonsense advice

In most clinical circumstances, and in most specialities, we advise patients to avoid stimuli that cause adverse symptoms. For example,

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a patient who gets diarrhoea with gluten-containing foods will be advised how to avoid gluten, or a patient who gets wheezing when going near a certain type of tree will be advised to avoid that tree. In HF, therefore, it is not surprising that some of our colleagues adopt this commonsense approach: if exercise causes breathlessness and other limiting symptoms, reduce exercise to a level that allows comfortable everyday life. However, scientific evidence now clearly goes against patient's and physician's intuitive prejudice.

In reality, exercise intolerance in CHF can be successfully tackled by applying ET. We need to resolve the standard clinical mindset that the occurrence of symptoms indicates that damage is being done. Instead, we need to encourage the mindset that breathlessness may be evidence of signalling between the periphery and central haemodynamic performance⁴ and regular physical activity may ultimately bring about favourable changes in myocardial function, symptoms, functional capacity, and increased hospitalization-free life span and probably survival.

In this position paper, we provide practical advice for the application of ET in HF and how to overcome traditional barriers, based on the current scientific and clinical knowledge supporting the beneficial effect of this intervention. Additional information as detailed below is provided in the Supplementary material online, Appendix:

- Pathophysiology: multifactorial origin of exercise intolerance;
- ET and systolic HF: a literature review;
- Effects on HF with preserved ejection fraction.

How to implement exercise training

In general, both healthy and diseased subjects can increase their cardiorespiratory endurance in many ways. A lifestyle approach can be adopted to promote physical exercise together with structured ET programmes; the former approach involves the promotion of common daily activities, such as brisk walking, climbing stairs (rather than taking the lift), doing more house work and gardening, and engaging in active recreational pursuits.⁵ In CHF, both approaches have been suggested; however, in the present paper only the structured physical activity (i.e. ET) approach will be discussed (as lifestyle changes are presented extensively elsewhere).^{6,7}

Implementation of ET requires appropriate patient selection, training protocol identification, intensity, and progression monitoring. These issues have mainly been addressed in stable HF patients, and a summary of available knowledge will be provided later. However, since in daily practice we also have to prescribe ET in acute HF patients, in the next chapter, we will provide a preparatory scheme for initiating ET in this setting.

Patient selection

Exercise training is recommended for stable New York Heart Association (NYHA) class I–III HF patients. Although conventional wisdom and data derived from existing clinical studies exclude the role of exercise in the management of advanced or acute HF patients, we believe that after hospitalization for exacerbation, early mobilization through an individualized exercise programme

may prevent further disability and lay good foundations for the formal ET plan.

The transition phase in the course of clinical stabilization from forced rest to the initiation of ET has been poorly described and investigated. A flow-chart is proposed here to guide the health-care (HC) provider and physician in tailoring the exercise advice according to the individual clinical condition and needs of the patient (*Figure 1*). This flow-chart covers several critical clinical and functional turning points that need to be addressed before starting regular formal ET.

Both clinical stability and early mobilization are important requisites that help achieve functional self-sufficiency and trust prior to conducting a symptom-limited exercise test and initiating regular ET. In this phase, gradual mobilization/calisthenics, respiratory training, and small muscle strength exercise can be considered alone or in combination. Each exercise modality should be tested in the individual HF patient, to verify clinical and haemodynamic tolerance, ascertain acceptability, and prove safety. Accordingly, this phase should be extremely flexible in terms of temporal and modality development.

When clinical stabilization is achieved, appropriate screening for contraindications to exercise is necessary, including medical history, clinical examination, resting electrocardiogram (ECG), a symptom-limited exercise test, and echocardiography (*Table 1*). If the clinical status of a patient is unclear and/or previous examinations/tests are inconclusive, supplementary investigations such as 24 h Holter ECG monitoring, chest X-ray, or stress echocardiography should be considered as appropriate.

Finally, the selection of the exercise modality should take into account the patient's age, concomitant disease(s), leisure and working habits, preferences and abilities, logistical restraints, and the availability of ET facilities and equipment.

Gradual mobilization

A gentle individualized gradual mobilization of the patient (known as 'calisthenic exercises') is advisable as a prologue and preparatory form of exercise, especially for severe HF patients with physical deconditioning or cachexia or after recent clinical instability. A variety of simple movements, performed without weights or equipment, intended to increase body strength and flexibility using the weight of one's own body for resistance, in combination with stretches, are advisable in these conditions. These movements should be initiated as soon as possible, since they are easy to perform and well accepted. They improve movement co-ordination and respiratory capacity.

Selection of the optimal training protocol

Identification of the appropriate and adequate level of training intensity is crucial to obtain the desired benefits while maintaining reasonable control of the related risk. A universal agreement on exercise prescription in CHF does not exist; thus, an individualized approach is recommended, with careful clinical evaluation, including behavioural characteristics, personal goals, and preferences.

Training protocols vary in a number of variables:⁸ *intensity* (aerobic and anaerobic); *type* (endurance, resistance, and strength), *method* (continuous and intermittent/interval), *application* (systemic, regional, and respiratory muscle), *control* (supervised and

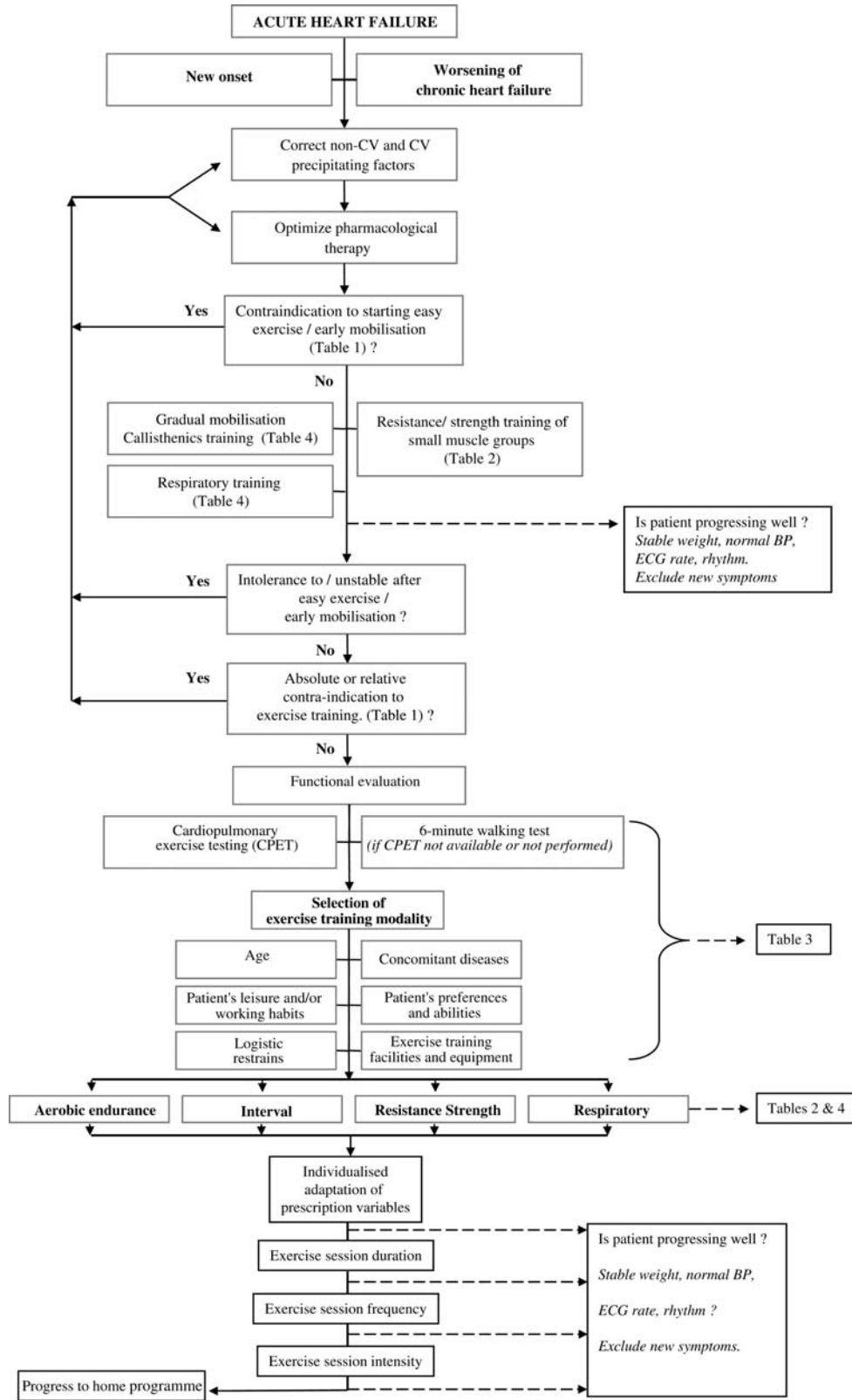


Figure 1 Flow-chart to guide tailoring an exercise training programme according to the individual clinical conditions and needs of the patient.

Table 1 Summary of contraindications to exercise testing and training (A), exercise training (B), and increased risk for exercise training (C)

(A) Contraindications to exercise testing and training
1. Early phase after acute coronary syndrome (up to 2 days)
2. Untreated life-threatening cardiac arrhythmias
3. Acute heart failure (during the initial period of haemodynamic instability)
4. Uncontrolled hypertension
5. Advanced atrioventricular block
6. Acute myocarditis and pericarditis
7. Symptomatic aortic stenosis
8. Severe hypertrophic obstructive cardiomyopathy
9. Acute systemic illness
10. Intracardiac thrombus
(B) Contraindications to exercise training
1. Progressive worsening of exercise tolerance or dyspnoea at rest over previous 3–5 days
2. Significant ischaemia during low-intensity exercise (<2 METs, <50 W)
3. Uncontrolled diabetes
4. Recent embolism
5. Thrombophlebitis
New-onset atrial fibrillation/atrial flutter
(C) Increased risk for exercise training
1. >1.8 kg increase in body mass over the previous 1–3 days
2. Concurrent, continuous, or intermittent dobutamine therapy
3. Decrease in systolic blood pressure with exercise
4. NYHA functional class IV
5. Complex ventricular arrhythmia at rest or appearing with exertion
6. Supine resting heart rate >100 b.p.m.
7. Pre-existing co-morbidities limiting exercise tolerance

non-supervised), and *setting* (hospital/centre- and home-based). Three different training modalities have been proposed with different combinations:⁹

- (1) endurance aerobic (continuous and interval);
- (2) strength/resistance;
- (3) respiratory.

Endurance aerobic training (continuous and interval)

Continuous endurance training

Continuous aerobic training is typically performed at moderate-to-high exercise intensities in steady-state conditions of aerobic energetic yield, which allows the patient to perform prolonged training sessions (up to 45–60 min duration). It is the best described and established form of training, because of its well-demonstrated efficacy and safety, and is thus highly recommended in the guidelines.¹ It is well accepted since it is easily taught and performed by patients, usually on a cycle ergometer or a treadmill.

In more deconditioned patients, it is recommended to start low and go slow (i.e. at low intensity for 5–10 min twice a week). If well tolerated, first the training duration per session and then the numbers of sessions per day are increased, aiming at

20–60 min on 3–5 days per week at moderate-to-high intensity with indefinite programme duration.

The gold standard method for exercise intensity assessment is the use of directly determined physiological descriptors of metabolic effort intensity, i.e. peak oxygen consumption ($\text{VO}_{2\text{peak}}$), by symptom-limited cardiopulmonary exercise test. Thus training intensity is usually prescribed relative to $\text{VO}_{2\text{peak}}$, $\text{VO}_{2\text{reserve}}$ ($\text{VO}_{2\text{R}}$) (i.e. the difference between the basal and $\text{VO}_{2\text{peak}}$), or at the anaerobic threshold (when clearly detected). Recommended training intensities are 40–50% at the starting point, increasing to 70–80% of the percentage $\text{VO}_{2\text{peak}}$ or $\text{VO}_{2\text{R}}$.

Since cardiopulmonary exercise testing is not always available in routine clinical practice, indirect methods have been proposed for monitoring metabolic work during a conventional stress test or a 6 min walking test, such as heart rate (HR) or HR reserve (HRR = difference between the basal and peak HR) and rating of perceived exertion (RPE). A 'training HRR range' of 40–70% HRR and 10/20–14/20 of the Borg RPE are recommended.⁶

Interval endurance training

Recently, interval (or intermittent) training has been proposed to be more effective than sessions of continuous exercise for improving exercise capacity. In contrast with the continuous training protocol, the patient is asked to alternate short bouts (10–30 s) of moderate–high intensity (50–100% peak exercise capacity) exercise, with a longer recovery (80–60 s) phase, performed at low or no workload.

Typically high- and low-intensity interval training programmes are available according to the patient's capabilities. High-intensity programmes have been performed by patients walking on a treadmill at band speeds. Each session included four 4 min bouts of high-intensity exercise (corresponding to 90–95% of their maximal exercise capacity), interspersed with 3 min recovery periods at low intensity, plus 5–10 min of warm-up and cool-down.^{10–12}

Low-intensity interval training programmes can be performed on an electrically braked cycle ergometer, which maximizes control over the patient's workload. The hard and recovery segments are 30 and 60 s in duration, respectively, and the hard segments are accomplished at 50% of the power output achieved during a ramp test or an incremental bicycle test with $10 \text{ W} \times 1 \text{ min}$ increments. If the patient has trouble tolerating a 15 min training bout using this work/recovery ratio, the durations of the segments can be adjusted to a 20/70 s ratio, respectively, or even to 10/80 s if necessary. Typically, the intensity of the first three hard segments is reduced to allow for warm-up. As the patient becomes better conditioned, the intensity of the hard segments should be increased accordingly. Depending on the work/recovery interval chosen, ~10–12 work phases can be performed per 15–30 min training session.

Resistance/strength training

Resistance/strength training (RST) is a muscle contraction performed against a specific opposing force thereby generating resistance, such as lifting weights. It gradually and progressively overloads the musculoskeletal system, so it strengthens and tones muscles and increases bone mass and has been proposed as an anabolic intervention to help prevent the wasting syndrome.

Table 2 Minimum recommendations for the implementation of a resistance/strength training programme in CHF patients

Training programme	Training objectives	Stress form	Intensity	Repetitions	Training volume
Step I - Pre-training	To learn and practise the correct implementation, to learn perception, to improve intermuscular co-ordination	Dynamic	<30% 1-RM. RPE < 12	5–10	2–3 training sessions per week, 1–3 circuits during each session
Step II - Resistance/endurance training	To improve local aerobic endurance and intermuscular co-ordination	Dynamic	30–40% 1-RM. RPE 12–13	12–25	2–3 sessions per week, 1 circuit per session
Step III - Strength training. Muscle build-up training	To increase muscle mass (hypertrophy), to improve intramuscular co-ordination	Dynamic	40–60% 1-RM. RPE < 15	8–15	2–3 sessions per week, 1 circuit per session

Modified according to Bjarnason-Wehrens *et al.*¹⁵

1-RM, one repetition maximum; RPE, rating of perceived exertion.

Functional alterations in the skeletal muscle are considered an important determinant of exercise intolerance in CHF. Furthermore, ageing is associated with a continuous decline in skeletal muscle mass, which is why elderly HF patients are at particular risk of muscle wasting.¹³ Resistance/strength training should be considered in these patients.

Although earlier concerns about a detrimental effect on left ventricular function and negative remodelling caused by increased afterload during the lifting phase of RST have not been confirmed,¹⁴ the current peer-reviewed evidence remains controversial with regard to a general recommendation to implement RST as an exercise modality for patients with CHF, due to the superiority of endurance training on parameters of exercise capacity and left ventricular function. In this regard it is important to realize that endurance exercise remains the mainstay in CHF patients and that RST can reasonably complement but not substitute.

The amount of cardiovascular stress expected during RST depends on the magnitude of the resistance [% of one repetition maximum (% 1-RM), i.e. the maximum weight that can be lifted only once], the size of the working muscle mass and finally the relation between the duration of the muscle contraction and rest period between repetitions. The pressure load will be lower the smaller the resistance (% 1-RM), the shorter the contraction period (1–3 s), and the longer the resting period between contractions. In advanced CHF or in patients with a very low exercise tolerance, RST can be safely applied if small muscle groups are trained, short bouts of work are applied, and the number of repetitions is limited with a work/recovery duration ratio of at least 1:2. The use of elastic bands (Thera-Band®) is also very suitable, but difficult to quantify.

To allow for maximal safety, initiation of an RST programme must be individually adapted to the patient by an experienced exercise therapist under medical supervision and each patient must be individually introduced into the training regimen. The minimum recommendations for the implementation of an RST are summarized in Table 2, where three progressive steps are described.¹⁵

(1) 'Instruction phase': a preliminary step should be performed, to get the patient well accustomed to the modality of the exercise, and for intermuscular co-ordination and physical

perception. These preparatory exercises must be conducted slowly, without or at a very low resistance (<30% 1-RM) until the patient is confident with the course of the movements.

- (2) 'Resistance/endurance phase': RST can be started with a high number of repetitions (12–25) and a low intensity (30–40% 1-RM), corresponding rather to a combination of endurance and resistance because of a low haemodynamic load. When the patient is confident with the exercise, he can proceed to the next phase (strength phase).
- (3) 'Strength phase': RST at higher intensity (40–60% 1-RM) in order to increase muscle mass.

During each step, the danger of the abdominal straining (Valsalva manoeuvre) and consequent blood pressure elevations should be emphasized and special attention must be paid to prescribing the appropriate level of training according to the patient's motivation level, personality, and previous experience with RST.

Determination of the intensity of resistance training

For determination of the training intensity, a maximal strength test (i.e. 1-RM) is in general unsuitable for CHF patients because it leads to Valsalva manoeuvre. Instead a graded stress test can be applied; the training intensity should be set at the level of resistance at which the patient can perform 10 repetitions without abdominal straining and without symptoms. When assessing the load for a patient, the Borg RPE scale provides the patient's own subjective stress perceptions in addition to measured physiological parameters. The load can be increased progressively according to the Borg scale: in patients with moderate risk, stress perception should be at a maximum RPE of 15.¹⁶

Respiratory training

Trials using inspiratory muscle training in CHF patients suggest that such an intervention can improve exercise capacity and quality of life, particularly in those who present with inspiratory muscle weakness (IMW).¹⁷ Hence, routine screening for IMW is advisable and specific inspiratory muscle training in addition to standard endurance training might be beneficial.

It has been suggested to start respiratory training at 30% of the maximal inspiratory mouth pressure (PI_{max}) and to readjust the intensity every 7–10 days up to a maximum of 60%.¹⁸ Training duration should be 20–30 min/day with a frequency of 3–5 sessions per week for a minimum of 8 weeks. In order to optimize the effect, it should be considered that any training stimulus, being specific to the inspiratory muscles or not (such as aerobic muscle training alone), may improve inspiratory muscle strength and functional capacity in patients with IMW. Thus in patients without IMW, high-intensity inspiratory muscle training may be necessary to affect functional capacity.

Several different protocols and devices have been used for inspiratory muscle training in different clinical settings, including isocapnic hyperpnoea, incentive spirometry, resistive pressure threshold load, and computer-controlled biofeedback trainers. Most studies in CHF have used the Threshold Inspiratory Muscle Trainer (Respironics Health Scan, Inc., Cedar Grove, NJ, USA), but when inspiratory muscle strength is preserved, devices with potential to reach higher inspiratory pressures such as the Power-Breathe (HaB International Ltd, Southam, Warwickshire, UK) might be used. These hand-held devices are relatively inexpensive and therefore permit home training. The efficacy of computer-controlled biofeedback is currently under investigation.

A general guide to proposed indications for the prescription of different training modalities (continuous endurance, interval endurance, resistance/strength, and respiratory) in stable CHF patients according to exercise capacity and clinical characteristics is given in Table 3. Arbitrary cut-points are proposed for age (< or \geq 65 years) and activity habits (mainly sedentary or not).

Table 4 summarizes the main characteristics of each form of training (endurance, interval, strength, and respiratory). Variables of interest, how to start, progression of training, optimal intensity target, exercise capacity, haemodynamic effects, respiratory effects, peripheral and other effects, advantages, limitations, safety, and setting are shown for each form of training.

Setting: hospital based vs. home based

Traditionally, HC for patients with CHF has concentrated on supervised and centre-based programmes. On the one hand, these are safe and effective, and offer optimal conditions of care; on the other hand, they are resource intensive and of limited availability. Moreover, the main issue is not the short-term efficacy but the preservation of the gained benefits over time; the principal aim is for the patient to remain active for an indefinite period of time. Thus the key to optimal long-term benefits is the identification of strategies to motivate patients to continue with exercise at home. To avoid rapid deterioration of the progress that has been achieved during a structured, supervised programme, a gradual transition to a home-based programme is necessary.¹⁹ However, it is recommended to start training in a setting of direct monitoring and supervision, especially during initial sessions and particularly when HF symptoms are severe. A supervised programme also allows for education, and close control of adherence to the prescribed therapies and provides reassurance for the patient.

Stable and well-treated patients could initiate a home-based programme after a baseline exercise test with guidance and instructions. Frequent follow-up can help assess the benefits of

Table 3 Exercise training prescription in chronic heart failure according to exercise capacity, age, and activity habit

	Young (<65 years)		Elderly (\geq 65 years)	
	Active	Sedentary	Active	Sedentary
VO_2 peak \leq 10 mL/kg/min or < 300 m at 6 MWT	CT	CT	CT	CT
	RT	RT	RT	RT
	RST	RST	RST	LIT
	LIT	LIT	LIT	
VO_2 peak > 10 to \leq 18 mL/kg/min or 300–450 m at 6 MWT	CT	CT	CT	CT
	RT	RT	RT	RT
	RST	RST	RST	
	IT			
VO_2 peak > 18 mL/kg/min or > 450 m at 6 MWT	CT	CT	CT	CT
	RT*	RT*	RT*	RT*
	RST	RST	RST	RST
	HIT	HIT	HIT	HIT

VO_2 peak assessed by cardiopulmonary exercise testing is the gold standard measure of exercise capacity, while the 6 min walk testing (6 MWT) is a valid alternative if cardiopulmonary exercise testing is not accessible. CT, continuous endurance training; LIT/HIT/IT, low/high-intensity interval endurance training; RST, resistance/strength; RT, respiratory training (*, in case of respiratory muscle weakness); 6 MWT, 6 min walk test; VO_2 peak, peak oxygen consumption; active vs. sedentary: habit is according to daily life attitude, working activity, and free time activity.

the home exercise programme, determine any unforeseen problems, and will allow the patient to advance to higher levels of exertion if lower levels of work are well tolerated.

Specific population: patients with implantable cardioverter defibrillators and/or cardiac resynchronization therapy

The literature about exercise in patients with an implantable cardioverter defibrillator (ICD) or cardiac resynchronization therapy (CRT) device is limited. However, a lot of centres are offering cardiac rehabilitation programmes for such patients and the actual evidence shows that ET can be performed safely. One randomized study reported a reduction of the number of ICD discharges in the training group and showed that the presence of non-sustained ventricular tachycardia in the presence of an ICD does not constitute a contraindication for aerobic ET.²⁰

The potential benefits of an ET programme after ICD implantation are numerous and include familiarization with the device, instruction about physical activity, psychological support, and improvement of exercise capacity if the patient suffers from exercise intolerance. It has been demonstrated that ET in CRT patients can almost double their improvement in exercise capacity and further improve haemodynamic measures and quality of life.^{21,22}

As the basis for exercise advice and prescription, a symptom-limited cardiopulmonary exercise stress test is mandatory before ET is started. In ICD patients, the information from such a test

Table 4 Main characteristics of each form of training (calisthenic/gradual mobilization, endurance, interval, strength, and respiratory)

	Gradual mobilization – Calisthenic training	Continuous endurance training	Interval endurance training	Resistance/strength training	Respiratory training
Variables of interest		VO ₂ peak, VE/VCO ₂ slope, VAT, peak SBP, peak HR pre- and post-training programme Peak SBP and peak HR pre- and post-training sessions	VO ₂ peak, VE/VCO ₂ slope, VAT, peak SBP, peak HR pre- and post-training programme Peak SBP and peak HR pre- and post-training sessions	Muscle mass (hypertrophy)	PI _{max} : sensation or respiratory work during exercise according to Borg RPE scale
How to start	Can be started as soon as the patient is mobilized Increase in exercise intensity according to RPE	Initial stage: intensity at low level (e.g. 40–50% VO ₂ peak) until an exercise duration of 10–15 min is achieved. Exercise duration and frequency of training is increased according to symptoms and clinical status Maintenance stage: usually begins after 3–6 months	Low intensity: It is recommended to start low and go slow [for the very deconditioned] e.g. start with alternation of shorter (10 s) bout of lower intensity exercise workload (50% of peak capacity) and longer recovery period (80 s) for 5–10 min	Intensity: <30% 1-RM Repetitions: 5–10 Frequency: 2–3 training sessions per week, 1–3 circuits during each session	
Progression of training		Initial stage: primary aim is to increase gradually the intensity (50 to >60 to >70% of VO ₂ peak); the secondary aim is to increase sessions duration to 15–20 min, up to 30 min Maintenance stage: usually begins after 3–6 months	High intensity: When well tolerated, first the duration of the bout of the strain (10–30 s) with shortening the recovery (80–60 s) phase, and therefore increasing the intensity (60–100%. The training session should last 15 up to 30 min Then the training frequency and duration per session are increased	Intensity: 30–50% 1-RM RPE 12–13 Repetitions: 15–25 Frequency: 2–3 training sessions per week, 1 circuits during each session	
Optimal ET intensity target	RPE < 15	RPE < 15	RPE < 15	Intensity: 40–60% 1-RM RPE < 15 Repetitions: 8–15 Frequency: 2–3 training sessions per week, 1 circuits during each session	RPE < 15
Exercise capacity		Improved Exercise tolerance (exercise time, VO ₂ peak, maximal workload), VE/VCO ₂ Rate–pressure product at VAT Submaximal exercise capacity (6 m walking test).	Improved Exercise tolerance (exercise time, VO ₂ peak, watts) Submaximal exercise capacity (6 m walking test)	Improved Exercise tolerance (exercise time, VO ₂ peak, maximal workload) and work economy (VO ₂ /WR) Submaximal exercise capacity (6 m walking test)	Improved Exercise tolerance (exercise time, VO ₂ peak, watts) Submaximal exercise capacity (6 m walking test) Ventilatory capacity
Haemodynamic effects	Unknown	Improve resting and peak cardiac output, myocardial perfusion, and diastolic function Prevent unfavourable LV remodelling, increase LVEF	High-intensity interval training increases resting LVEF	Increase resting LVEF	

Continued

Table 4 Continued

	Gradual mobilization – Calisthenic training	Continuous endurance training	Interval endurance training	Resistance/strength training	Respiratory training
Respiratory effects		Reduce excessive ventilation Improve cardiorespiratory control throughout a reduction of hypersensitivity and response of muscle reflex and chemoreflex			Improve maximal inspiratory and expiratory pressure
Peripheral effects	Unknown	Improve endothelial function, peak leg blood flow Prevent reduction in cross-sectional area of the quadriceps muscle Improve muscle strength. Reduce neuro-hormonal activation, pro-inflammatory cytokines production, oxidative stress, anabolic/catabolic imbalance, and apoptosis		Improve maximal strength in upper/lower limbs Improve peripheral endothelial function. Increase skeletal muscle mitochondrial ATP production rate and higher capillary density	
Others effects	Reduce limiting symptoms. Improve: Musculoskeletal flexibility Movement co-ordination Muscle strength Respiratory capacity To cope with daily life activities			Improve neuro-modulation, reduce inflammatory and cytokines negative effects. Also improves: Musculoskeletal flexibility Movement co-ordination Muscle strength To cope with daily life activities	
Advantages	Easy to perform, fairly good patient acceptability	Exercising at very low workloads Exact reproducibility of prescribed workload Continuous monitoring of heart rate, rhythm, and blood pressure Easy to perform in hospital environment Is a well-accepted modality of exercise	Exercising at very low or very high workloads	Besides the beneficial effects on CV adaptations during exercise, resistance exercise is beneficial in the prevention and management of musculoskeletal injuries and disorders, osteoporosis, and sarcopenia. RT also reduces susceptibility to falls and prevents or delays impaired physical function in frail and elderly persons	
Limitations	Lack of specific recommendation Thus methods are adopted from calisthenic programme for cardiac patients with preserved exercise tolerance	Cost and availability of training device outside the hospital setting. Long-term compliance	Short- and long-term compliance. Owing to the lack of available data, the routine application of high-intensity interval training in moderate-to-high-risk cardiac patients cannot be recommended at this time and requires additional study	The need for strictly tailored exercise programme on dedicated equipment limits its applicability in clinical practice. Short- and long-term compliance Owing to the lack of available data, the routine application of resistance training in moderate-to-high-risk cardiac patients cannot be recommended at this time and requires additional study	Short- and long-term compliance

Safety (Supervision is mandatory during the initial phase. Continuous or frequent clinical monitoring is also fundamental, particularly during the home training phase)

Safety is good, if progression of exercise is based on an individualized prescription that is gradual and pyramidal in nature. A proper training programme set-up needs a close assessment of exercise intensity and work-volume for early detection of adverse effects. In addition, with the use of ECG monitoring, rhythm disorders can be detected

Setting

In- and out-hospital (in a fitness centre for the less diseased patients and in the maintenance stage)

VAT, ventilatory anaerobic threshold; SBP, systolic blood pressure.

goes beyond the diagnosis of ischaemia or the determination of exercise capacity. Especially important is the chronotropic response to exercise, the presence of exercise-induced arrhythmias, HR in case of onset of an arrhythmia, the effectiveness of pharmacological HR control, and the risk of reaching an HR in the ICD intervention zone. Furthermore, such a test should help reassure the patients and their physician.

In general, ICD patients should start ET under medical supervision and the HR should be monitored, if the protocol is intended to bring the HR near the device's programmed intervention zone. Patients having experienced symptomatic arrhythmias or ICD discharges should be directed towards exercise modalities in which a short loss of consciousness due to ICD discharge might be less harmful, for example avoiding strenuous swimming or climbing heights. Theoretically, pronounced arm–shoulder movements or intense mechanical strain of the ICD pouch could also trigger inappropriate ICD shocks, but in giving advice we should be careful not to add to the list of reasons for patients to avoid exercise. Exercise level, and/or ICD programming, can be arranged to keep the maximal HR 20 beats below the ICD intervention zone.

The staff caring for ICD patients need to be made aware of the following information to reduce the risk of incidents: the underlying heart disease and the reason for ICD implantation, the triggers of arrhythmia (ischaemia and specific HR), the arrhythmic substrate, the ICD intervention HR, and the sequence of therapy (monitoring zone, anti-tachycardia pacing, and shocks). The staff should express confident understanding of the purpose of the device and that this increases, rather than decreases, safety of the patient. In case of any intervention of the device, the causes should be assessed and any changes in device programming, medications, or exercise regime should be considered. Exercise should be started again swiftly after the device interrogation to avoid the ICD discharge becoming a psychological block on future activity.

Barriers to clinical application of exercise training recommendations

In addressing adherence to application of exercise recommendations, two aspects need to be considered: firstly the adherence of HC providers to clinical guidelines (guideline adherence) and secondly the adherence of the patient to the advice of the clinician (patient adherence) (Table 5).

Guideline adherence by health-care providers

Adhering to the guidelines is a predictor of outcome in CHF; however, guideline adherence remains far from optimal regarding prescription of recommended medications and also regarding non-pharmacological treatment, including exercise.²³

Barriers for practitioners to recommend ET are related to the individual professional, the HC team, and the HC organization.²⁴ For example, poor knowledge of the HC providers about the effect of exercise might be one reason; thus, better information about the evidence base might promote better guideline adherence. The lack of availability of ET sites or the absence of financial

Table 5 Implementation of exercise training: barriers and possible practical interventions

Barriers	Approaches for improvement
In health-care system	
Lack of belief in value of ET by health-care professionals	Increase knowledge, including awareness of combined impact of Extra-MATCH meta-analysis and subsequent HF-ACTION trial (educational materials, conferences) Address exercise in medical training Publication and presentation in high impact journals and conferences Include in guidelines, consensus statement of professional organizations
Lack of ET sites/programmes	Expansion of facility availability by cost-effective use of space already allocated to preventative or therapeutic cardiology Political lobbying: approach opinion leaders, collaborate with patient organizations Include ET as quality indicator
Lack of educated personnel	Integrate exercise programme in disease management Provision of training and mentorship Multiprofessional collaboration Integrate exercise programme in disease management Create courses and accreditation on national and international levels
In patient adherence	
Social and economic factors: low educational level, low social support, work conflicts, lack of time	Increase social support and group programmes, provide tailored programmes according to available time and resources (including evenings, weekends), promote home training, provide reimbursement of travel costs
Factors related to the health-care system: adequate transportation, no reimbursement, waiting lists	Provide reimbursement of travel costs or other costs or help patients to apply for it
Condition-related factors: severity of symptoms, the level of disability, the rate of progression, and the impact of co-morbidities	Provide programmes tailored to disease severity, possibility to have several modules of different severities
Therapy-related factors: duration of exercise treatment, complexity	Discuss adherence in long term, find an exercise model/activity that appeals to patient, adapt to cognitive and physical capacities with room for change over time
Patient-related factors: attitudes towards exercise, motivation, personal beliefs, and expectations	Discuss barriers and misconceptions, provide knowledge, provide support, adapt to personal circumstances and preferences Explore with patient their true interest in medium/long-term health and survival, vs. willingness to invest now

reimbursement for enrolment of CHF patients in cardiac rehabilitation programmes can play a crucial role: organizational and political measures are needed. By integrating exercise programmes into existing HF management programmes and making referral an integral part of quality assessment of HF management, ET might be prescribed more often.

Patient adherence to treatment recommendations

Patient adherence is a multidimensional phenomenon, determined by the interplay of a set of five dimensions: social and economic factors, factors related to the HC system, factors related to the patients' condition, the therapy, and the patients themselves.²⁵ Data on rehabilitation in cardiac patients show that compliance to exercise is <50%: older age, lower socioeconomic status, female gender, psychological characteristics (such as depression), lack of motivation, and financial and medical concerns are the main determinants.²⁶ Additional reasons specific for CHF are the presence of physical symptoms and lack of energy.²⁷ This was confirmed by the results of the HF-ACTION trial, in which only

29–42% of the patients were performing ET as prescribed after 3 months.

Chronic HF patients need additional strategies to improve their adherence, which should be targeted at the barriers affecting the individual patient (such as adapting the programme to fit in with the patient's working schedule), the HC system (e.g. financial compensation), or organization of social support.

Home-based cardiac rehabilitation, using telemedicine, may help overcome some of the above-mentioned barriers²⁸ (see Supplementary material online, Appendix).

Conclusion: a long way to go...

Although much has already been achieved, there is a great deal more that we need to learn about ET. We need to know more about patient groups who are more like the patients seen in everyday clinical practice, rather than the patients who volunteer for studies. This is difficult because, by definition, it means studying patients (such as women, the elderly, and minority groups) who are often excluded from clinical trials. We also need more effective methods to improve adherence and compliance in the long term. Patients who readily promise to adhere in advance sometimes

deliver on these promises in the short term, but often cannot sustain such behavioural changes. We also need better measurements of the beneficial effects of ET, to show to patients. We need to develop streamlined ways of implementing ET on an outpatient basis, beyond the laboratories that have a special interest in exercise.

In summary, to paraphrase the late Philip Poole-Wilson, 'how can we persuade people to exercise, and what form of exercise?' Otherwise, evidence gained can only be translated to a small fraction of our patients.

Supplementary material

Supplementary material is available at *European Journal of Heart Failure* online.

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