Archives of Cardiovascular Disease (2019) 112, 723—731

Available online at ScienceDirect www.sciencedirect.com

Elsevier Masson France EM|consulte www.em-consulte.com/en

EXPERT CONSENSUS

Physical activity for patients with heart failure: Position paper from the heart failure (GICC) and cardiac rehabilitation (GERS-P) Working Groups of the French Society of Cardiology

Activité physique chez le patient insuffisant cardiaque: position du Groupe Insuffisance Cardiaque et Cardiomyopathies (GICC) et du Groupe Exercice Réadaptation Sport et Prévention (GERS-P) de la Société Française de Cardiologie

Florian Zores[a,*], Marie-Christine Iliou[b], Barnabas Gellen[c], Sophie Kubas[d], Emmanuelle Berthelot[e], Pascal Guillo[f], Fabrice Bauer[g], Nicolas Lamblin[h], Gilles Bosser[i,j], Thibaud Damy[k], Alain Cohen-Solal[l], Florence Beauvais[l]

[a] *Groupe médical spécialisé, 67000 Strasbourg, France*
[b] *Service de réadaptation cardiaque et prévention secondaire, hôpital Corentin-Celton, AP—HP, 92130 Issy-les-Moulineaux, France*
[c] *ELSAN—Polyclinique de Poitiers, 86000 Poitiers, France*
[d] *Centre Bois-Gibert, 37510 Ballan-Miré, France*
[e] *Pôle Thorax, service de cardiologie, hôpital Bicêtre, AP—HP, 94270 Le-Kremlin-Bicêtre, France*
[f] *Clinique Saint-Yves, 35044 Rennes, France*
[g] *Service de cardiologie, CHU de Rouen, 76000 Rouen, France*
[h] *Inserm, institut Pasteur, U1167, université de Lille, CHU de Lille, 59000 Lille, France*
[i] *Cardiology Department, University Hospital, 54511 Vandoeuvre-lès-Nancy, France*

Abbreviations: CR, Cardiac Rehabilitation ; ET, Exercise Training ; HF, Heart Failure ; PA, Physical Activity.

* Corresponding author: Groupe médical spécialisé, 19, rue du Fossé des Treize, 67000 Strasbourg, France.
Adresse e-mail : florian.zores@gmail.com (F. Zores).

https://doi.org/10.1016/j.acvd.2019.07.003

[j] *EA 3450, Development, Adaptation and Disadvantage, Faculty of Medicine, University of Lorraine, 54600 Villers-lès-Nancy, France*
[k] *CHU d'Henri-Mondor, AP—HP, 94010 Créteil, France*
[l] *UMR-S 942, service de cardiologie, hôpital Lariboisière, université de Paris, AP—HP, 75010 Paris, France*

Reçu le 20 mai 2019 ; reçu sous la forme révisée le 2 juillet 2019 ; accepté le 22 juillet 2019
Disponible sur Internet le 18 September 2019

KEYWORDS
Heart failure ;
Exercise ;
Cardiac rehabilitation ;
Quality of life

Summary Physical activity is important in heart failure to improve functional capacity, quality of life and prognosis, and is a class IA recommendation in the European Society of Cardiology guidelines (Ponikowski et al., 2016). The benefits of exercise training are widely recognized. Cardiac rehabilitation centres offer tailored exercise training to patients with heart failure, as part of specialized multidisciplinary care, alongside pharmacological treatment optimization and patient education. After cardiac rehabilitation, maintenance of regular physical activity long term is essential, as the benefits of exercise training vanish within a few weeks. Unfortunately, only 10% of patients benefit from a cardiac rehabilitation programme after hospitalization for acute heart failure, and the majority of patients do not pursue long-term physical activity. In this paper, two Working Groups of the French Society of Cardiology (the heart failure group [*Groupe Insuffisance Cardiaque et Cardiomyopathies*; GICC] and the cardiac rehabilitation group [*Groupe Exercice Réadaptation Sport et Prévention*; GERS-P]) discuss the obstacles to broader access to cardiac rehabilitation centres, and propose ways to improve the diffusion of cardiac rehabilitation programmes and encourage long-term adherence to physical activity.

MOTS CLÉS
Insuffisance cardiaque ;
Exercice ;
Réadaptation cardiaque ;
Qualité de vie

Résumé L'activité physique est particulièrement importante pour les patients souffrant d'insuffisance cardiaque, permettant d'améliorer la capacité fonctionnelle, la qualité de vie et le pronostic. Elle est à ce titre une recommandation de classe IA pour la Société Européenne de Cardiologie. Les bénéfices de l'exercice physique sont largement reconnus. Les centres de réadaptation cardiaque offrent un réentraînement adapté aux patients insuffisants cardiaques, dans le cadre d'une prise en charge multidisciplinaire, associé à l'optimisation du traitement pharmacologique et de l'éducation thérapeutique du patient. Après la réadaptation cardiaque, le maintien d'une activité physique régulière est essentiel, les bénéfices de l'entraînement disparaissant en quelques semaines. Malheureusement, seulement 10 % des patients bénéficient d'un programme de réadaptation cardiovasculaire après une hospitalisation pour insuffisance cardiaque aiguë, et une large majorité n'a pas d'activité physique à long terme. Dans cet article, les groupes Insuffisance Cardiaque et Cardiomyopathie (GICC) et Exercice, Réadaptation, Sport et Prévention (GERS-P) de la Société Française de Cardiologie discutent des obstacles à un accès plus large aux centre de réadaptation et proposent des moyens d'améliorer la diffusion des programme de réentrainement et d'encourager l'adhérence à long terme à l'activité physique.

Background

Regular physical activity (PA) is particularly recommended in heart failure (HF) to improve functional capacity, quality of life and prognosis [1,2]. Physical exercise is a Class I Level A recommendation in the 2016 ESC guidelines on the management of HF [3]. Exercise training (ET) for deconditioned patients who are not accustomed to PA should ideally begin in a specialized cardiac rehabilitation (CR) centre under a cardiologist's supervision. However, only 10% of patients with HF benefit from a CR programme [4,5]. In addition, once the programme is completed, the majority of patients do not continue with PA in the medium or long term [6]. The insufficient implementation of CR and the limited sustainability of PA in patients with HF require adaptations to the CR on offer to facilitate access and promote a durable and sufficient level of PA after CR.

For these reasons, two Working Groups of the French Society of Cardiology (the HF group [*Groupe Insuffisance Cardiaque et Cardiomyopathies*; GICC] and the CR group [*Groupe Exercice Réadaptation Sport et Prévention*; GERS-P]) analysed the situation in France using evidence-based data, and have identified the obstacles and suggested solutions.

Definitions

Physical activity

According to the World Health Organization, physical exercise is a movement produced by skeletal muscles that accounts for a rise in energy consumption. PA is characterized by the frequency, intensity, duration and type of physical exercise. The term ET refers to regular PA of significant intensity and duration.

ET has been a therapeutic tool in cardiology since the 1950s. The use of ET as a therapeutic approach for HF, prohibited over decades, is a more recent concept, initiated in the late 1980s [7].

Cardiac rehabilitation

CR was defined by the World Health Organization in 1964 as ''the set of measures aimed at restoring the patient's previous abilities and improving the patient's physical and mental condition so that he or she can regain by his or her own means a place in a society as normal as possible'' [8]. ET is only one component of CR, and involves various training modalities: endurance, resistance and respiratory. Patient education and therapeutic optimization are the other components. Modifications induced by the physical, educational and therapeutic approaches aim to improve health-related quality of life, morbidity and mortality.

In 2008, French legislation defined by decree the conditions for the implementation of CR centres, requiring a trained multidisciplinary team and specifically equipped facilities to claim reimbursement by social security — similar to other validated therapeutic approaches.

Benefits of exercise training in patients with heart failure

HF involves cardiac dysfunction, a chronic low-grade proinflammatory state and sympathovagal imbalance, as well as peripheral vascular and muscular abnormalities. Exercise intolerance, a key symptom in HF, favours sedentary behaviour and promotes peripheral deconditioning. ET is associated with metabolic, skeletal muscle, cardiovascular and pulmonary adaptations, characterized by increased oxygen delivery and aerobic energy production, counterbalancing—at least in part — the detrimental peripheral effects of HF. The benefits of aerobic ET in HF have been demonstrated extensively [6,9—28].

In 2019, a Cochrane meta-analysis found no change in total mortality at 1 year follow-up in patients who underwent ET compared with those who did not [1]. However, there was a reduction in both overall and HF-related hospitalizations. The ExTraMATCH II meta-analysis showed a clear benefit in terms of exercise capacity and quality of life, but no impact on HF-related mortality [2,29]. The authors highlighted the heterogeneity and poor quality of the studied ET programmes, and the short duration and low statistical power of the majority of the individual studies [29—31]. This highlights the need for patient-centred ET programmes, and the importance of encouraging adherence [30,31].

The beneficial effects of ET are present regardless of the level of left ventricular ejection fraction [1,32—37], and are correlated with patient compliance [13,38] and ET intensity [39]. Adherence is essential, as the beneficial effects of ET disappear a few weeks after stopping the training [40].

Practical modalities of exercise training in heart failure

ET should be offered to patients with HF regardless of their New York Heart Association class, including patients undergoing ventricular assistance and candidates for heart transplantation. Advanced age is not a contraindication. However, age-related co-morbidities, such as cognitive disorders, disabling neurological conditions, severe osteoarticular problems or depression, might compromise ET. Contraindications to physical exercise are mainly transient conditions, such as the acute phase of a myocardial infarction, severe cardiac arrhythmias, acute myocarditis or pericarditis, symptomatic severe aortic stenosis or mobile intracardiac thrombus [41,42].

All patients with HF should ideally be referred to a CR centre, especially after an acute decompensation. In this situation, CR may begin early under specialized supervision (Table 1).

In the cardiac rehabilitation centre

After evaluation of the baseline functional capacities, ideally using a cardiopulmonary exercise test, the initial ET workload and the minimum number of required training sessions are derived from the cardiopulmonary exercise test results. As training at the first ventilatory threshold improves peak oxygen uptake (VO2) in patients with HF, training intensity has to be high enough to ensure progress, and low enough to preserve safety and tolerance [42—44]. CR generally comprises group-based endurance, resistance, respiratory and general gymnastics sessions [45]. During CR, the patient also benefits from specialized multidisciplinary care, such as education sessions, pharmacological treatment optimization (uptitration of cardioprotective drugs and adaptation of diuretics to limit congestion), psychosocial care and social assistance [41,43].

After cardiac rehabilitation

After completion of the CR programme or in case of impossibility to participate, it is essential to advise the patients to perform PA on a daily basis [41]. The rate of long-term maintenance of regular PA is higher in patients who have participated in a CR programme than in those who have not [46]. Thirty minutes of moderate-intensity exercise, five

Table 1 The different phases of cardiac rehabilitation [45,46].

Phase 1	In-hospital rehabilitation Resumption of moderate PA at the immediate end of the acute phase Cardiologists, physiotherapists
Phase 2	20 to 40 sessions in CR centre Inpatient or outpatient setting Endurance, respiratory and resistance training Cardiologists, physiotherapists/specialized PA educators
Phase 3	Long-term maintenance No medical assistance/supervision; currently no reimbursement Fully dependent on the patient's motivation and assiduity The patients become responsible for themselves Heart and Health clubs/fitness clubs/outdoor PA

CR: cardiac rehabilitation; PA: physical activity.

times a week, is recommended, combined with two sessions of resistance training [47]. The intensity level must be determined by a cardiopulmonary exercise test performed before the patient's discharge from the rehabilitation centre or prescribed by a cardiologist [48]. Walking at a brisk pace indoors or outdoors is particularly easy to perform, as it does not require any special equipment or skills [40,47]. Some low-risk activities, such as like Tai Chi, Nordic walking and dancing, have shown benefits in HF [49]. A gradual increase in intensity and duration favours tolerance and reduces the risk of injury.

As patients with HF are often elderly and frequently deconditioned, even PA of low absolute intensity can be experienced as moderate/intense. It is generally more appropriate to assess the relative rather than the absolute intensity of the PA. The commonly used scale for the rating of perceived exertion is the Borg scale, which rates exercise intensity from 6 to 20. The average rating of perceived exertion range associated with exercise adaptation is 12—14 [48]. In the ''talk test'' or ''walk and talk test'', patients should be able to maintain a certain level of exercise and still be able to talk in full sentences. During moderate-endurance PA, the patient can still speak, but is unable to sing or whistle, and it appears to correlate with first ventilatory threshold. During more intense PA, only a few words can be pronounced.

Current situation

In Europe, only 10—15% of patients with HF are referred to phase II rehabilitation [4,45,50—53]. In France, access to CR centres is very limited: barely 20% of patients with HF benefit from any kind of in- or outpatient medical care following hospitalization for HF [5]. Most of these patients are transferred to geriatric or multipurpose rehabilitation structures, without structured ET programmes, and only 9% are referred to CR centres.

Although a regular, supervised, home-based phase III PA programme results in functional improvement and fewer rehospitalizations [54—58], there is currently no formalized phase III programme in France for patients with HF leaving a CR centre. The ''*clubs Coeur et Santé*'' (Heart and Health clubs, promoted by the French Federation of Cardiology, located on the premises of a health institution or in the municipality, and run by health professionals), which welcome patients after a CR programme, are traditionally attended predominantly by patients with coronary artery disease.

Major issues

The obstacles to CR (phase II) and the maintenance of regular PA after CR (phase III) are numerous and well identified [4,42,56,59—65] (Table 2).

Obstacles to phase II are mainly related to organization. In France, CR centres (residential and ambulatory) are mainly centre based, without clearly identified alternative structures. Moreover, CR centres are often located far outside the city centre, causing a transportation problem [60]. The increasing number of patients with HF contrasts with the lack of structure and funding [60].

The barriers to phase III result in the unresolved problem of long-term adherence to PA [56,61,62,66]. Adherence to ET is even lower in women [65]. All studies on lifestyle changes highlight this difficulty, and those dealing with HF are no exception to the rule [6]. A change of behaviour cannot be prescribed.

Patients fear PA-related symptoms that are reminiscent of HF, such as dyspnoea or tachycardia, as well as the potential negative effects of PA on the heart [59]. Thus, patients with HF undertake less moderate and vigorous PA than patients with coronary artery disease, and greatly overestimate their daily PA level [67]. Patient education is likely to be beneficial in terms of removing resistance and combating misrepresentations. Lack of consistent, clear, simple and effective messages from health professionals is also a barrier to the maintenance of home-based PA [59].

PA on prescription could be a way of promoting care in phase III as a back-up to the rehabilitation programme. In France, PA on prescription is provided by allied healthcare professionals, such as physiotherapists, health PA educators or even people certified by a sports federation. The prescription is the responsibility of the treating physician after functional assessment. There is currently no funding or reimbursement programme from social security, although some insurance companies provide financial coverage for very variable amounts. In the Swedish model, the treating doctor's visit is not mandatory, and PA can be prescribed by any qualified health professional, and is probably more individualized than the group activities often offered in France. The Swedish model increased PA in patients who received a PA prescription, but no clinical criteria have been tested [68]. The city of Strasbourg was one of the first cities to implement a ''PA on prescription'' programme in 2012. However, to date, no scientific data have been published

Table 2 Factors limiting the diffusion of exercise retraining in cases of heart failure.

Patient-related factors	Age > 75 years
	Female sex
	Co-morbidities (hypertension, stroke, COPD, anaemia)
	Not severe enough or too severe (stage I and stage IV NYHA)
	Timetable
	No support from patient's entourage
	Fear of symptoms and exercise
	Not used to ''sports'' practice
	Financial income
Physician-related factors	Lack of knowledge on the subject
	Not convinced of the benefit
	No clear message on how to do it in practice (prescription)
Organization-related factors	Not enough places in CR centres
	No clearly identified alternative structures
	Great heterogeneity of systems, clubs and activities in France
	Lack of visibility of the sector
	Lack of local structure
Socioeconomic factors	Lack of funding
	Insufficient resources
	Reimbursement (economic cost of health)
	Limited reimbursement depending on the structure
	Reimbursement limited in time
	Patient constrained by financial resources
Exercise-related factors	Lack of knowledge of recommended or non-advised activities
	Lack of knowledge about how to do it practically
	Lack of awareness of the security conditions for carrying out the exercise
Medicolegal framework-related factors	Administrative constraints
	No reimbursement without authorization
	Lack of development of PA on prescription

COPD: chronic obstructive pulmonary disease; CR: cardiac rehabilitation; NYHA: New York Heart Association; PA: physical activity.

to validate this programme, especially in patients with HF, despite the announcement of the overall inclusion of 1500 patients between 2012 and 2017.

Suggestions for improvement

Phase II

The very low number of patients with HF receiving CR and the rapid decrease in adherence require improvements in access to CR and long-term sustainability of PA in patients with HF (Table 3 and Table 4) [40,42,59,60,63,69,70].

Information for and training of practitioners are essential to ensure that a clear and consistent message is delivered to patients [40,59,63]. The publication of national recommendations is a good way to achieve this goal [40]. The easiest first step is probably to promote PA in everyday life (active trips, professional and domestic activities).

At the local level, the identification of structures providing PA to patients with HF is an essential element to facilitate guidance for patients.

The role of partners (family, friends, groups) seems important for some patients, and could facilitate adherence to PA by creating social support. A professional (e.g. nurse, health PA educator or physiotherapist) can propose PA objectives, support practice and prevent adherence loss [47,59]. Adherence will be improved if PA is enjoyable, accompanied by factual data (such as a pedometer, as part of a walking programme or on a smartphone application), chosen by the patient and based on flexible programmes, and if social needs are addressed (such as offering solutions to family obligations) [65].

Beyond long-term adherence, the main obstacle to the widespread diffusion of PA in HF is the poor accessibility of CR facilities. Improving access to rehabilitation requires facilitating local access to structures that allow adapted and supervised PA outside CR centres. Patients could be stratified into three severity levels: (1) the most severe patients (those with a risk of instability and/or for whom close monitoring is needed), should be referred to a centre allowing complex management under full hospitalization, with a cardiologist available 24 hours a day (these centres also provide the earliest possible care following cardiac decompensation, as well as full inpatient care for patients whose age or co-morbidities may make ambulatory care difficult); (2) stabilized patients still on titration of their HF therapy or who have never undergone ET could be treated on an outpatient basis in a CR facility accustomed to the management of HF, offering a complete programme of ET and patient education programmes; (3) a home-based ET programme, combined with telemonitoring and scheduled reassessments to adjust

Table 3 Suggested improvements for the dissemination of physical activity in heart failure.

Helping the doctors	Improving knowledge of the benefits of PA and the conditions of ET (dissemination of trial results, initial medical training, continuing education) Facilitating programme prescription and clear identification of factors allowing patients to be referred to an adapted CR centre: in- or outpatient CR centre Reassuring private practitioners that CR centres redirect patients to their usual physicians Facilitating realization of PA outside CR centres with an explicit prescription (type, duration, frequency and intensity of exercise) Involving general practitioners in prescribing Defining the circuit and making the structures visible
Educating patients	Explaining with appropriate and plain language Explaining the PA (unlike sport, no performance is needed) and the expected benefits Removing psychological blocks and false beliefs Motivating and supporting Offering solutions for integration into the timetable, just like a meal or a shower Offering solutions to financial issues

CR: cardiac rehabilitation; ET: exercise training; PA: physical activity.

Table 4 Communication tools to promote physical activity in heart failure.

Target	Suggested tools
Doctor	Developing knowledge of benefits and conditions of ET for patients with HF (congresses, publications, universal periodic review, internet) Prescribing CR on the discharge checklist of hospitalized patients with HF List of criteria for referral to a CR centre List of existing CR structures List of advised or discouraged activities Prescription model of PA Model certificate of no contraindication to practicing PA
Patient	Videos on the benefits of PA Videos on ''how to do it'' List of advised or discouraged activities List of existing CR structures Patient testimonial videos Smartphone applications (tips, monitoring) Types of alternative activities: exergaming, dancing, etc.
Decision makers	Political lobbying

CR: cardiac rehabilitation; ET: exercise training; HF: heart failure; PA: physical activity.

the programme, will be offered to stable patients in chronic follow-up. Increasingly more tools are being developed to improve the monitoring of patients' PA and the effectiveness of CR [71]. Home-based CR associated with telemonitoring is safe compared with CR performed in a specialized centre, has similar results, is more effective than no ET [57,62,72] and reduces CR costs [62]. Home-based CR is also relevant for patients who are very far from CR centres or whose working hours make it difficult to participate in a centre-based programme.

This stratification presupposes a skills gradation of the various CR centres, recognized by health authorities, and knowledge of the available local and regional resources by health professionals. Matching a patient's severity to the CR centre qualification would improve patient care by providing the most appropriate and safest retraining strategy [73]. Delegating tasks to paramedics trained in CR and cardiovascular prevention is another way to increase CR availability. The growing number of trained paramedics and the parallel use of telemedicine will increase the number of phase II CR places in local centres.

Phase III

Phase III is centred on self-care management. Self-sufficiency preparation during phase II is paramount [40]. The French National Authority for Health recently published a guide for PA on prescription to facilitate PA diffusion through general practitioners [40].

Existing organizations can be divided into phase III clubs, such as the Heart and Health Clubs, and free sports clubs (sports or fitness clubs that do not have specific skills for cardiology patients). Labelling structures is of importance to identify those that can deliver the practice of adapted and targeted PA and the pursuit of secondary prevention actions. It is also necessary to clarify the respective roles of nurses, physiotherapists and adapted health PA educators outside specialized CR facilities.

The development of home-based ET programmes and alternative approaches, particularly through new digital tools, telephone support, connected objects and smartphone applications, could be a way to prolong the effectiveness of CR by facilitating adherence [47,65]. The use of virtual PA (exergaming) via game consoles makes it possible to improve a patient's functional capacity and quality of life [56,58]. Nevertheless, even with this approach, adherence to exercise decreases over time [56].

Conclusions and perspectives

PA is a key element in the management of HF, allowing improvement in functional capacity and prognosis; however, its effectiveness is hampered by the limited use of CR for patients with HF and insufficient adherence.

An increase in the supply of CR requires decentralization of the ET on offer. Development of new digital tools and delegation of tasks to trained paramedics create opportunities to increase the solution available to patients with HF (e.g. by moving phase II outside the walls of CR centres). Digital tools and the expansion of community centres are also elements that can encourage the practice of PA, to improve adherence to an essential therapy that requires changes in life habits. Finally, information for patients, but above all health professionals — particularly general practitioners and independent cardiologists — is an important lever for the dissemination of PA among patients with HF.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Disclosure of interest

The authors declare that they have no competing interest.

Références

[1] Long L, Mordi IR, Bridges C, et al. Exercise-based cardiac rehabilitation for adults with heart failure. Cochrane Database Syst Rev 2019;1:CD003331.
[2] Taylor RS, Walker S, Smart NA, et al. Impact of exercise rehabilitation on exercise capacity and Quality-of-Life in heart failure: individual participant meta-analysis. J Am Coll Cardiol 2019;73:1430—43.
[3] Ponikowski P, Voors AA, Anker SD, et al. 2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure: the task force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC). Developed with the special contribution of the Heart Failure Association (HFA) of the ESC. Eur J Heart Fail 2016;18:891—975.
[4] Golwala H, Pandey A, Ju C, et al. Temporal trends and factors associated with cardiac rehabilitation referral among patients hospitalized with heart failure: findings from get with the guidelines-heart failure registry. J Am Coll Cardiol 2015;66:917—26.
[5] Tuppin P, Cuerq A, de Peretti C, et al. First hospitalization for heart failure in France in 2009: patient characteristics and 30-day follow-up. Arch Cardiovasc Dis 2013;106:570—85.
[6] Fleg JL, Cooper LS, Borlaug BA, et al. Exercise training as therapy for heart failure: current status and future directions. Circ Heart Fail 2015;8:209—20.
[7] Sullivan MJ, Higginbotham MB, Cobb FR. Exercise training in patients with severe left ventricular dysfunction. Hemodynamic and metabolic effects. Circulation 1988;78:506—15.
[8] WHO Expert Committee on Rehabilitation of Patients with Cardiovascular Diseases, World Health Organization. La réadaptation des maladies cardiovasculaires: rapport d'un comité d'experts de l'OMS (réuni à Genève du 23 au 29 juillet 1963). Genève: Organisation mondiale de la Santé; 1964 [Available at: http://apps.who.int/iris/handle/10665/37579. Accessed date: 3rd October 2018].
[9] European Heart Failure Training Group from Imperial College of Science, Technology and Medicine at the Royal Brompton National Heart & Lung Hospital, London, U.K, Experience from controlled trials of physical training in chronic heart failure. Protocol and patient factors in effectiveness in the improvement in exercise tolerance. European Heart Failure Training Group. Eur Heart J 1998;19:466—75. https://www.academic.oup.com/eurheartj/article/19/3/466/511449.
[10] Adamopoulos S, Parissis J, Karatzas D, et al. Physical training modulates proinflammatory cytokines and the soluble Fas/soluble Fas ligand system in patients with chronic heart failure. J Am Coll Cardiol 2002;39:653—63.
[11] Benda NM, Eijsvogels TM, Van Dijk AP, Hopman MT, Thijssen DH. Changes in BNP and cardiac troponin I after high-intensity interval and endurance exercise in heart failure patients and healthy controls. Int J Cardiol 2015;184:426—7.
[12] Braith RW, Welsch MA, Feigenbaum MS, Kluess HA, Pepine CJ. Neuroendocrine activation in heart failure is modified by endurance exercise training. J Am Coll Cardiol 1999;34:1170—5.
[13] Coats AJ, Adamopoulos S, Radaelli A, et al. Controlled trial of physical training in chronic heart failure. Exercise performance, hemodynamics, ventilation, and autonomic function. Circulation 1992;85:2119—31.
[14] Conraads VM, Beckers P, Vaes J, et al. Combined endurance/resistance training reduces NT-proBNP levels in patients with chronic heart failure. Eur Heart J 2004;25:1797—805.
[15] Crimi E, Ignarro LJ, Cacciatore F, Napoli C. Mechanisms by which exercise training benefits patients with heart failure. Nat Rev Cardiol 2009;6:292—300.
[16] Fiuza-Luces C, Santos-Lozano A, Joyner M, et al. Exercise benefits in cardiovascular disease: beyond attenuation of traditional risk factors. Nat Rev Cardiol 2018;15:731—43.
[17] Giallauria F, Cirillo P, Lucci R, et al. Left ventricular remodelling in patients with moderate systolic dysfunction after myocardial infarction: favourable effects of exercise training and predictive role of N-terminal pro-brain natriuretic peptide. Eur J Cardiovasc Prev Rehabil 2008;15:113—8.
[18] Giannuzzi P, Temporelli PL, Corra U, Tavazzi L, ELVD-CHF Study Group. Antiremodeling effect of long-term exercise training in patients with stable chronic heart failure: results of the

Exercise in Left Ventricular Dysfunction and Chronic Heart Failure (ELVD-CHF) Trial. Circulation 2003;108:554—9.
[19] Gielen S, Adams V, Mobius-Winkler S, et al. Anti-inflammatory effects of exercise training in the skeletal muscle of patients with chronic heart failure. J Am Coll Cardiol 2003;42:861—8.
[20] 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;283:3095—101.
[21] Hambrecht R, Niebauer J, Fiehn E, et al. Physical training in patients with stable chronic heart failure: effects on cardiorespiratory fitness and ultrastructural abnormalities of leg muscles. J Am Coll Cardiol 1995;25:1239—49.
[22] Haykowsky MJ, Liang Y, Pechter D, Jones LW, McAlister FA, Clark AM. A meta-analysis of the effect of exercise training on left ventricular remodeling in heart failure patients: the benefit depends on the type of training performed. J Am Coll Cardiol 2007;49:2329—36.
[23] Hornig B, Maier V, Drexler H. Physical training improves endothelial function in patients with chronic heart failure. Circulation 1996;93:210—4.
[24] Kitzman DW, Brubaker PH, Herrington DM, et al. Effect of endurance exercise training on endothelial function and arterial stiffness in older patients with heart failure and preserved ejection fraction: a randomized, controlled, single-blind trial. J Am Coll Cardiol 2013;62:584—92.
[25] La Rovere MT, Bersano C, Gnemmi M, Specchia G, Schwartz PJ. Exercise-induced increase in baroreflex sensitivity predicts improved prognosis after myocardial infarction. Circulation 2002;106:945—9.
[26] Mancini DM, Henson D, La Manca J, Donchez L, Levine S. Benefit of selective respiratory muscle training on exercise capacity in patients with chronic congestive heart failure. Circulation 1995;91:320—9.
[27] Passino C, Severino S, Poletti R, et al. Aerobic training decreases B-type natriuretic peptide expression and adrenergic activation in patients with heart failure. J Am Coll Cardiol 2006;47:1835—9.
[28] Thijssen DH, Cable NT, Green DJ. Impact of exercise training on arterial wall thickness in humans. Clin Sci (Lond) 2012;122:311—22.
[29] Taylor RS, Walker S, Smart NA, et al. Impact of exercise-based cardiac rehabilitation in patients with heart failure (ExTraMATCH II) on mortality and hospitalisation: an individual patient data meta-analysis of randomised trials. Eur J Heart Fail 2018;20:1735—43.
[30] Patel HC, Kaye DM. Exercise training in heart failure: a long way to go yet. Eur J Heart Fail 2018;20:1744—5.
[31] Smart NA, Taylor R, Walker S, et al. Exercise training for chronic heart failure (ExTraMATCH II): why all data are not equal. Eur J Prev Cardiol 2019;26:1229—31.
[32] Edelmann F, Gelbrich G, Dungen HD, et al. Exercise training improves exercise capacity and diastolic function in patients with heart failure with preserved ejection fraction: results of the Ex-DHF (Exercise training in Diastolic Heart Failure) pilot study. J Am Coll Cardiol 2011;58:1780—91.
[33] Gary RA, Sueta CA, Dougherty M, et al. Home-based exercise improves functional performance and quality of life in women with diastolic heart failure. Heart Lung 2004;33:210—8.
[34] Kitzman DW, Brubaker PH, Morgan TM, Stewart KP, Little WC. Exercise training in older patients with heart failure and preserved ejection fraction: a randomized, controlled, single-blind trial. Circ Heart Fail 2010;3:659—67.
[35] 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;328:189.
[36] Smart N, Haluska B, Jeffriess L, Marwick TH. Exercise training in systolic and diastolic dysfunction: effects on cardiac function, functional capacity, and quality of life. Am Heart J 2007;153:530—6.
[37] Taylor RS, Davies EJ, Dalal HM, et al. Effects of exercise training for heart failure with preserved ejection fraction: a systematic review and meta-analysis of comparative studies. Int J Cardiol 2012;162:6—13.
[38] Keteyian SJ, Leifer ES, Houston-Miller N, et al. Relation between volume of exercise and clinical outcomes in patients with heart failure. J Am Coll Cardiol 2012;60:1899—905.
[39] Yavari M, Haykowsky MJF, Savu A, et al. Volume and patterns of physical activity across the health and heart failure continuum. Can J Cardiol 2017;33:1465—71.
[40] Haute Autorité de Santé. Prescrire l'activité physique: un guide pratique pour les médecins. 2018. Available at: https://www.has-sante.fr/jcms/c_2875944/fr/prescrire-l-activite-physique-un-guide-pratique-pour-les-medecins.[accessed date: 6th December 2018].
[41] Pavy B, Iliou MC, Verges-Patois B, et al. French Society of Cardiology guidelines for cardiac rehabilitation in adults. Arch Cardiovasc Dis 2012;105:309—28.
[42] Piepoli MF, Conraads V, Corra U, et al. 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. Eur J Heart Fail 2011;13:347—57.
[43] Achttien RJ, Vromen T, Staal JB, et al. Development of evidence-based clinical algorithms for prescription of exercise-based cardiac rehabilitation. Neth Heart J 2015;23:563—75.
[44] Moe GW, Ezekowitz JA, O'Meara E, et al. The 2013 Canadian Cardiovascular Society Heart Failure Management Guidelines Update: focus on rehabilitation and exercise and surgical coronary revascularization. Can J Cardiol 2014;30:249—63.
[45] Ambrosetti M, Doherty P, Faggiano P, et al. Characteristics of structured physical training currently provided in cardiac patients: insights from the Exercise Training in Cardiac Rehabilitation (ETCR) Italian survey. Monaldi Arch Chest Dis 2017;87:778.
[46] Dibben GO, Dalal HM, Taylor RS, Doherty P, Tang LH, Hillsdon M. Cardiac rehabilitation and physical activity: systematic review and meta-analysis. Heart 2018;104:1394—402.
[47] Piercy KL, Troiano RP, Ballard RM, et al. The physical activity guidelines for Americans. JAMA 2018;320:2020—8.
[48] Mezzani A, Hamm LF, Jones AM, et al. Aerobic exercise intensity assessment and prescription in cardiac rehabilitation: a joint position statement of the European Association for Cardiovascular Prevention and Rehabilitation, the American Association of Cardiovascular and Pulmonary Rehabilitation and the Canadian Association of Cardiac Rehabilitation. Eur J Prev Cardiol 2013;20:442—67.
[49] INSERM. Activité physique: prévention et traitement des maladies chroniques. 2019. Available at: https://www.inserm.fr/information-en-sante/expertises-collectives/activite-physique-prevention-et-traitement-maladies-chroniques [accessed date: 21 June 2019].
[50] Benzer W, Rauch B, Schmid JP, et al. Exercise-based cardiac rehabilitation in twelve European countries results of the European cardiac rehabilitation registry. Int J Cardiol 2017;228:58—67.
[51] Bjarnason-Wehrens B, McGee H, Zwisler AD, et al. Cardiac rehabilitation in Europe: results from the European Cardiac Rehabilitation Inventory Survey. Eur J Cardiovasc Prev Rehabil 2010;17:410—8.
[52] Pardaens S, Willems AM, Vande Kerckhove B, De Sutter J. Participation in cardiac rehabilitation after hospitalisation for heart failure: a report from the BIO-HF registry. Acta Cardiol 2015;70:141—7.

[53] Piepoli MF, Binno S, Corra U, et al. ExtraHF survey: the first European survey on implementation of exercise training in heart failure patients. Eur J Heart Fail 2015;17:631—8.
[54] Anderson L, Sharp GA, Norton RJ, et al. Home-based versus centre-based cardiac rehabilitation. Cochrane Database Syst Rev 2017;6:CD007130.
[55] Chen YW, Wang CY, Lai YH, et al. Home-based cardiac rehabilitation improves quality of life, aerobic capacity, and readmission rates in patients with chronic heart failure. Medicine (Baltimore) 2018;97:e9629.
[56] Klompstra L, Jaarsma T, Stromberg A. Exergaming to increase the exercise capacity and daily physical activity in heart failure patients: a pilot study. BMC Geriatr 2014;14:119.
[57] Piotrowicz E, Zielinski T, Bodalski R, et al. Home-based telemonitored Nordic walking training is well accepted, safe, effective and has high adherence among heart failure patients, including those with cardiovascular implantable electronic devices: a randomised controlled study. Eur J Prev Cardiol 2015;22:1368—77.
[58] Verheijden Klompstra L, Jaarsma T, Stromberg A. Exergaming in older adults: a scoping review and implementation potential for patients with heart failure. Eur J Cardiovasc Nurs 2014;13:388—98.
[59] Albert NM, Forney J, Slifcak E, Sorrell J. Understanding physical activity and exercise behaviors in patients with heart failure. Heart Lung 2015;44:2—8.
[60] Cohen-Solal A. Ambulatory cardiac rehabilitation facilities should be present in every cardiology department. Eur J Prev Cardiol 2018;25:1704—6.
[61] Du H, Newton PJ, Budhathoki C, et al. The Home-Heart-Walk study, a self-administered walk test on perceived physical functioning, and self-care behaviour in people with stable chronic heart failure: a randomized controlled trial. Eur J Cardiovasc Nurs 2018;17:235—45.
[62] Frederix I, Solmi F, Piepoli MF, Dendale P. Cardiac telerehabilitation: a novel cost-efficient care delivery strategy that can induce long-term health benefits. Eur J Prev Cardiol 2017;24:1708—17.
[63] Jackson L, Leclerc J, Erskine Y, Linden W. Getting the most out of cardiac rehabilitation: a review of referral and adherence predictors. Heart 2005;91:10—4.
[64] Miller S, Mandrusiak A, Adsett J. Getting to the heart of the matter: what is the landscape of exercise rehabilitation for people with heart failure in Australia? Heart Lung Circ 2018;27:1350—6.
[65] Witvrouwen I, Van Craenenbroeck EM, Abreu A, Moholdt T, Krankel N. Exercise training in women with cardiovascular disease: differential response and barriers — review and perspective. Eur J Prev Cardiol 2019 [2047487319838221].
[66] 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;301:1439—50.
[67] Yates BC, Pozehl B, Kupzyk K, Epstein CM, Deka P. Are heart failure and coronary artery bypass surgery patients meeting physical activity guidelines? Rehabil Nurs 2017;42:119—24.
[68] Onerup A, Arvidsson D, Blomqvist A, et al. Physical activity on prescription in accordance with the Swedish model increases physical activity: a systematic review. Br J Sports Med 2019;53:383—8.
[69] Conraads VM, Deaton C, Piotrowicz E, et al. Adherence of heart failure patients to exercise: barriers and possible solutions: a position statement of the Study Group on Exercise Training in Heart Failure of the Heart Failure Association of the European Society of Cardiology. Eur J Heart Fail 2012;14:451—8.
[70] Pastva AM, Duncan PW, Reeves GR, et al. Strategies for supporting intervention fidelity in the rehabilitation therapy in older acute heart failure patients (REHAB-HF) trial. Contemp Clin Trials 2018;64:118—27.
[71] Inan OT, Baran Pouyan M, Javaid AQ, et al. Novel wearable seismocardiography and machine learning algorithms can assess clinical status of heart failure patients. Circ Heart Fail 2018;11:e004313.
[72] Zwisler AD, Norton RJ, Dean SG, et al. Home-based cardiac rehabilitation for people with heart failure: a systematic review and meta-analysis. Int J Cardiol 2016;221:963—9.
[73] Iliou MC. How can we increase the participation of patients in cardiac rehabilitation programmes? Eur J Prev Cardiol 2018;25:1923—4.