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Secondary prevention through comprehensive cardiovascular rehabilitation: From knowledge to implementation. 2020 update. A position paper from the Secondary Prevention and Rehabilitation Section of the European Association of Preventive Cardiology

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Abstract

Secondary prevention through comprehensive cardiac rehabilitation has been recognized as the most cost-effective intervention to ensure favourable outcomes across a wide spectrum of cardiovascular disease, reducing cardiovascular mortality, morbidity and disability, and to increase quality of life. The delivery of a comprehensive and 'modern' cardiac rehabilitation programme is mandatory both in the residential and the out-patient setting to ensure expected outcomes. The present position paper aims to update the practical recommendations on the core components and goals of cardiac rehabilitation intervention in different cardiovascular conditions, in order to assist the whole cardiac rehabilitation staff in the design and development of the programmes, and to support healthcare providers, insurers, policy makers and patients in the recognition of the positive nature of cardiac rehabilitation. Starting from the previous position paper published in 2010, this updated document maintains a disease-oriented approach, presenting both well-established and more controversial aspects. Particularly for implementation of the exercise programme, advances in different training modalities were added and new challenging populations were considered. A general table applicable to all cardiovascular conditions and specific tables for each clinical condition have been created for routine practice.

Keywords

Cardiac rehabilitation, prevention, exercise training, risk factor, heart failure, coronary artery disease, diabetes, hypertension, physical activity, acute coronary syndromes

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Background and aims

Cardiac rehabilitation is a multidisciplinary intervention, whose core components are well recognized, including patient assessment, management and control of cardiovascular risk factors, physical activity counselling, prescription of exercise training, dietary advice, psychosocial management and vocational support. The delivery of a comprehensive programme is essential to ensure favourable outcomes and expected cost-effectiveness.

In the year 2010, the Cardiac Rehabilitation Section of the European Association of Cardiovascular Prevention and Rehabilitation – now European Association of Preventive Cardiology (EAPC) – released a position paper aimed at summarizing the key steps to deliver all cardiac rehabilitation components for cardiac conditions, while highlighting key differences and exceptions for specific cardiac manifestations.[1] The greatest strengths of that document were: (a) the provision of commonly agreed cardiac rehabilitation activities applicable to all conditions as a standard reference, coupled with recommendations for specific clinical conditions, and (b) the organization of a series of tables suitable for routine practice, also presenting levels of evidence from the most robust class 1 and reference sources.

In the last years within the perimeter of the Guidelines of the European Society of Cardiology (ESC), cardiac rehabilitation has received the highest class of recommendation and level of evidence first as chronic heart failure (CHF) therapy in 2008[2] (confirmed in the 2016 update[3]), thereafter for cardiovascular prevention in clinical practice in 2016,[4] for treatment after ST-segment elevation myocardial infarction in 2017,[5] after myocardial revascularization in 2018[6] and among patients with chronic coronary syndromes (CCSs) in 2019.[7] To provide guidance on the most effective management of cardiovascular patients, there is a need to update the core components of cardiac rehabilitation intervention in traditional and new qualifying diagnoses for referral.

The aims of this 2020 position paper, now released by the Secondary Prevention and Rehabilitation Section of the EAPC, are: (a) to revise core cardiac rehabilitation components and objectives common to all clinical conditions and in specific clinical conditions, (b) to update class of recommendations and levels of evidence, and (c) to add newly established clinical conditions and special populations. The target user of this position paper is the whole organizational chart for a cardiac rehabilitation/preventive cardiology service, as described by the previous EAPC policy statement[8] (i.e. programme directors, cardiologists and other consultant professionals, physiotherapists, exercise physiologists, nurses, dieticians, psychologists, occupational therapists, pharmacists, social services experts, general practitioners, community nurses and health authorities). Methodologically, the upgrade process was based on a search strategy of English language published research, consensus documents and policy documents starting from the year 2010, by using electronic databases (e.g. MEDLINE, EMBASE, CINAHL), as selected, evaluated and reviewed by experts from the Section Nucleus and authors of the original document. Grade of recommendations and levels of evidence of different core components and operational aspects – when available – were

derived from official guidelines and literature. Limitations of the body of evidence – when present – are highlighted in the 'Issues requiring further evidence' table columns. In the development process of this position paper, individuals from cardiac rehabilitation relevant professional groups were included and the Appraisal of Guidelines for Research and Evaluation tool[9] – as far as derived rating of current cardiac rehabilitation guidelines[10] – were taken into consideration. Information on the views and preferences of the target population was derived from the literature.[11]

Core components and objectives common to all clinical conditions

In the accepted model, core components described in Table 1 constitute the usual process-based metrics for the delivery of cardiac rehabilitation activities across Europe, being common to all referred qualifying diagnoses. This position paper supports a modern appreciation of the concept of core component, defined as a 'specific area of intervention in the context of multifaceted and multidisciplinary structured cardiac rehabilitation activities, aimed (per se or in association to other areas) at obtaining clinical stabilization, cardiovascular risk reduction, disability reduction, psychosocial and vocational support, and lifestyle behaviour change including patients' adherence and self-management'. Core components are routinely delivered during phase 2 cardiac rehabilitation; however, – when appropriately selected and modulated – they could also be extended to phase 3 cardiac rehabilitation programmes. In some countries, components of cardiac rehabilitation (phase 2) are provided as an out-patient service whereas in others, mainly for historical organization of the health system, they are provided in the in-patient setting (residential). Residential cardiac rehabilitation programmes are particularly suitable for high-risk patients, who may include: (a) patients with severe in-hospital complications after acute coronary syndromes (ACSs), cardiac surgery, or percutaneous coronary intervention (PCI); (b) patients with complications after the acute event, or serious concomitant diseases at high risk of cardiovascular events; (c) clinically stable patients with advanced CHF, that is, New York Heart Association class III and IV, and/or needing intermittent or continuous drug infusion and/or mechanical support and/or after device implant; (d) patients after a recent heart transplantation; (e) patients discharged very early after the acute event, even uncomplicated, particularly if they are older, women, or frail; and finally (f) patients unable to attend a formal outpatient cardiac rehabilitation programme for any logistic reasons. In this updated position paper, targets for lipid and blood pressure control as core components of cardiac rehabilitation interventions were aligned with the 2019 ESC guidelines for the management of dyslipidaemias[12] and the 2018 ESC/European Society of Hypertension Guidelines for the management of arterial hypertension,[13] respectively. Targets for glucose control were derived from the 2019 ESC Guidelines on diabetes, pre-diabetes and cardiovascular diseases.[14] Up-titration of CHF medication was derived from the 2016 ESC guidelines.[2]

Concerning exercise training, emphasis was put on the systematic adoption of the FITT (frequency, intensity, time – duration – and type of exercise) prescription model. Type should also include the mode of training (i.e. the endurance continuous or interval modality for aerobic training, or the involvement of muscular groups for resistance/strength training), as far as leisure activities to meet patients' preferences. The possibility to include other determinations in the FITT model (i.e. grade of supervision or relation with meal-time) should be maintained. Recommendations were revised according to official EAPC statements published after the year 2010.[15,16]

The determination of exercise intensity during cardiac rehabilitation is a key issue and this position paper confirms previous indications regarding the identification of different intensity domains by direct and indirect methods.[15] Recent research,[17] however, revealed insufficient consistency between intensity domains as evaluated by different parameters obtained by cardiopulmonary exercise testing (CPET) – percentage of peak oxygen uptake (%VO_{2peak}), peak heart rate (%HR_{peak}), heart rate reserve (%HRR) and power output (%W_{peak}) – at least in patients who are able to deliver maximal effort during CPET and in which the first and second ventilatory thresholds are both detectable, thus claiming a need for adjustment. Further research is needed to obtain new indications for exercise intensity prescription and guidance for increase during cardiac rehabilitation activities; however, already by now it seems reasonable to recommend a more individualized prescription by combining different variables obtained by CPET (possibly with increased consideration of %W_{peak}), and by matching them systematically with individual rating of perceived exertion (RPE) score or talk test (preferentially). The basic recommendation is aimed at considering a moderate or moderate-to-high domain of intensity when possible, or, alternatively, different domains according to individual patient and disease features. To date, there is growing evidence that high-intensity interval training (HIIT; i.e. $\geq$85% VO_{2peak} or $\geq$85% HRR or $\geq$90% HR_{peak} interspersed with lower level exercise) appears to be more effective than moderate-intensity continuous training (i.e. 50–75% VO_{2peak} or 50–75% HRR or 50–80% HR_{peak}) in improving cardiorespiratory fitness within

Table 1. Core components and objectives common to all clinical conditions.

Components
Patient assessment • Clinical history: screening for cardiovascular risk factors, comorbidities and disabilities • Symptoms: cardiovascular disease (NYHA class for dyspnoea, CCS class for angina, and Fontaine/Rutherford class for lower extremities PAD) • Adherence: to the medical regime, adequate lifestyle, and self-monitoring (weight, BP, symptoms) • Physical examination: general health status, heart failure signs, cardiac and carotid murmurs, BP control, extremities for presence of arterial pulses and orthopaedic pathology, cerebrovascular events with/without neurological sequelae • ECG: heart rate, rhythm, repolarization changes • Cardiac imaging (two-dimensional and Doppler echocardiography): in particular left ventricular systolic and diastolic function, right ventricular systolic function and heart valve diseases evaluation when appropriate • Blood testing: routine biochemical assay, fasting blood glucose, HbA1C, total cholesterol, LDL-C, HDL-C, triglycerides, uric acid, parameters of renal function, peptides • Physical activity level: domestic, occupational and recreational needs, activities relevant to age, gender and daily life, readiness to change behaviour, self-confidence, barriers to increased physical activity, and social support in making positive changes • Evaluation of frailty by validated scores (see the Frailty subsection) • Peak exercise capacity: symptom-limited exercise testing, either on bicycle ergometer or on treadmill, by means of CPET as a gold standard. If the patient cannot do any treadmill or bicycle (not so frequent) a test like 6MWT or ISWT should be performed (but only as necessary alternative). In frail patients or patients unable to walk, the SPPB or other chair based tests should be considered. • Education: evaluation of literacy level and type of communication needed; clear, comprehensible information on the basic purpose of the CR programme and the role of each component; information and education on perception of disease, empowerment and self-management; information and motivation on target lifestyle modifications and pharmacological treatment targets. Personal rehabilitation goals (apart from what professionals set as a target) possibly added Expected outcomes: Formulation of 'tailored', patient-specific, objectives of the CR programme
Physical activity counselling • Assess the PA type and level in any patient (how many days and minutes per day are spent on average doing PA at moderate or vigorous intensity) • Explain effects of inactivity and help add PA to daily life • Explore motivation and opportunities to increase the PA level • Advise on appropriate types of activities and ways of progressing • Help to set achievable personal goals and maintain the benefits • Encourage to find some activity patients either enjoy and/or that they can include in their daily routines • Advise to cope with adverse effects (e.g. excessive shortness of breath) • Explore practical ways to overcome barriers to exercise, that is, the link between primary care and local community-based structures for activity, recreation and sport • Minimize the amount of time spent being sedentary by active travelling (cycling or walking), taking breaks from extended periods of sitting and reducing screen time • Training volume to be recommended: to perform at least 150 min a week of moderate intensity or 75 min a week of vigorous intensity aerobic PA or an equivalent combination thereof If patients are unable to engage in walking or cycling based activities then CR programmes should work with patients and carers to facilitate alternatives such as chair based exercise, wheelchair ambulation or other non-weight bearing options such as aqua aerobics or moderate intensity floor based calisthenics Expected outcomes: • Increased participation in domestic, occupational and recreational activities • Improved psychosocial well-being, prevention of disability, and enhancement of opportunities for independent self-care • Improved aerobic fitness • Improved prognosis • Reduced frailty risk
Exercise training • Exercise training should be prescribed on an individualized approach after careful clinical evaluation, including risk stratification, behavioural characteristics, personal goals and exercise preferences

(continued)

Table 1. Continued

Components
• Exercise training should be prescribed according to the FITT (frequency, intensity, time (duration) and type of exercise) model, with the possibility of including timing (FITT+T) referring to when exercise is performed in relation to meal-time • As a general advice recommend: • Frequency: most days (at least 3 days/week and preferably 6–7 days/week) for aerobic training; 2 times/week for resistance/strength training • Intensity: moderate (i.e. 45–59% of peak oxygen consumption, 50–70% of W_{peak} (above the first ventilatory threshold), 55–69% of peak heart rate, 40–59% of heart rate reserve (to be calculated on top of rest HR), 4–6 METs, or 12/20–14/20 of the Borg scale) or moderate-to-high intensity for endurance continuous training. Higher intensities of exercise bouts for endurance high intensity interval training according to the selected protocol. The 'speech rule' (i.e. the respiratory rate should allow conversation) could be considered as an additional tool to control intensity when HR cannot be used. 30–70% of the 1-RM for the upper body and 40–80% of 1-RM for lower body exercises, with 12–15 repetitions in one set for resistance/strength training • Time: at least 20–30 min (preferably 45–60 min) per session • Type: aerobic training (walking, jogging, cycling, swimming, rowing, stair climbing, elliptical trainers, and aerobic dancing), resistance/strength training, flexibility training, balance training, and inspiratory muscle training. Coordination training and other types (non-conventional) may be considered
• Arrange exercise training in order to provide an energy consumption of 1000–2000 kcal/week • During the initial phases (duration based on individual features) supervised, in-hospital exercise training programme may be recommended, especially, to verify individual responses and tolerability, clinical stability, and promptly identify signs and symptoms indicating to modify or terminate the programme. The supervision should include physical examination, monitoring of HR, BP and rhythm before, during and after exercise training. The supervised period should be prolonged in patients with new symptoms, signs, BP abnormalities and increased supraventricular or ventricular ectopy during exercise
Expected outcomes: • Increased aerobic fitness and enhanced flexibility, muscular endurance, strength and coordination • Reduction of symptoms, attenuated physiological responses to physical challenges, and improved psychosocial well-being • Decrease in cardiovascular risk and improvement of prognosis
Diet/nutritional counselling • Assessment: daily caloric intake and dietary content of fat, saturated fat, sodium and other nutrients. Assess eating habits • Adapt caloric intake to the expected consumption during intensive phase II exercise training • Education: of patient (and family members) regarding dietary goals and how to attain them; salt, lipid and water content of common foods
• Healthy food choices: • Saturated fatty acids to account for $<$10% of total energy intake, through replacement by polyunsaturated fatty acids • Trans unsaturated fatty acids: as little as possible, preferably no intake from processed food, and $<$1% of total energy intake from natural origin • $<$5 g of salt per day • 30–45 g of fibre per day, preferably from wholegrain products • $\geq$200 g of fruit per day (2–3 servings) • $\geq$200 g of vegetables per day (2–3 servings) • Fish 1–2 times per week, one of which to be oily • 30 g of unsalted nuts per day • Sugar-sweetened soft drinks and alcoholic beverages consumption must be discouraged • Consumption of alcoholic beverages should be limited to two glasses per day (20 g/day of alcohol) for men and one glass per day (10 g/day of alcohol) for women.
Expected outcome: Adherence to a healthy diet lowering CV risk
Weight control management • Assessment: weight, height, waist; analysis of nutrition habits, calories intake and physical activity • Education: provide behavioural and nutritional counselling with follow-up to monitor progress in achieving goals • Weight reduction by means of diet, exercise and behaviour modification. It is recommended in obese patients (BMI $\geq$30 kg/m^2, or waist circumference $\geq$102 cm in men or $\geq$88 cm in women), and should be considered in overweight patients (BMI $\geq$25 kg/m^2, or waist circumference $\geq$94 cm in men or $\geq$80 cm in women), particularly if associated with multiple risk factors (such as hypertension, hypercholesterolemia, smoking and insulin resistance or diabetes)
Expected outcomes: • Among subjects with healthy weight, the maintenance of weight

(continued)

Table 1. Continued

Components
• Among overweight/obese patients, elaboration of an individualized strategy to reduce 5–10% of body weight, and to modify associated risk factors • Where goal is not attained, consider referring patient to specialist in obesity/endocrinologist Lipid management Assessment: lipid profile. Modify diet, physical activity and medication therapy if appropriate Expected outcomes: • For secondary prevention in very-high-risk patients (i.e. documented ASCVD, either clinical or unequivocal on imaging), an LDL-C reduction of $\geq$50% from baseline and an LDL-C goal of $<$1.4 mmol/L ($<$55 mg/dL) are recommended • For patients with ASCVD who experience a second vascular event within 2two years (not necessarily of the same type as the first event) while taking maximally tolerated statin therapy, an LDL-C goal of $<$1.0 mmol/L ($<$40 mg/dL) may be considered • No goal for triglycerides, but $<$1.7 mmol/L ($<$150 mg/dL) indicates lower risk and higher levels indicate a need to look for other risk factors

Blood pressure management
• Assessment: BP frequently at rest. During exercise BP should be monitored when hypertension on effort is suspected. A SBP up to 200 mmHg at 100 W during exercise is advised as acceptable upper limit[25]
• Intervention:
  • Offer lifestyle intervention in high-normal BP and grade 1–2–3 hypertension
  • Consider drug treatment in high normal BP, in very high risk patients with CVD
  • Drug treatment in grade 1–2–3 hypertension
Expected outcomes:
• BP $<$140/ 90 mmHg in all patients (targeted to 130/80 mmHg or lower in most patients when treatment is well tolerated)
• SBP in the range 120–129 mmHg in most $<$65 years patients receiving BP-lowering drugs
• SBP targeted to a range of 130–139 mmHg in older patients (aged $\geq$65 years) receiving BP-lowering drugs, with close monitoring of adverse effects
• DBP target of $<$80 mmHg for all hypertensive patients, independent of the level of risk and comorbidities.

Smoking cessation • All smokers should be professionally encouraged to permanently stop smoking all forms of tobacco. Follow-up, referral to special multidisciplinary programmes and/or pharmacotherapy (including nicotine replacement) are recommended, as a stepwise strategy for smoking cessation. Structured approaches are to be used, for example, 5As: Ask, Advise, Assess, Assist, Arrange • Ask the patient about his/her smoking status and use of other tobacco products. Specify both amount of smoking (cigarettes per day) and duration of smoking (number of years) • Determine readiness to change; if ready, choose a date for quitting • Assess for PSRFs that may impede success • Intervention: provide structured follow-up. Offer behavioural advice and group or individual counselling • Offer nicotine replacement therapy and/or bupropion, varenicline • Smokers who quit smoking during hospitalization should be strongly supported to stay smoke free using the above steps in smoking cessation • Patients trying to quit smoking should be helped in maintaining weight during this period, since are more likely to put on between 3 and 5 kg in the first three months to a year • Offer assistance to avoid passive smoking • No role of e-cigarettes for smoking cessation (unclear evidence about whether e-cigarettes or other Electronic Nicotine Delivery Systems are useful and safe[26]) Expected outcome: Long-term abstinence from smoking
Psychosocial management • Assessment for PSRFs: low socio-economic status, lack of social support, stress at work and in family life, posttraumatic stress, hostility, social isolation, cognitive impairment, depression, anxiety and other mental disorders. • Adoption of a two-step evaluation of PSRFs in CR: first, to ask the patient single-item questions about distinct PSRFs and then to apply standardized questionnaires (i.e. the HeartQoL for quality of life in patients with CHD across European language groups; or HADS for anxiety/depression) • Intervention: • Provide multimodal behavioural interventions, integrating health education, physical exercise and psychological therapy, for PSRFs and coping with illness

(continued)

Table 1. Continued

Components
• Referral to psychiatrist for psychotherapy, medication or collaborative care should be considered in the case of clinically symptoms of depression, anxiety or hostility • Whenever possible, induce spouses and other family members, domestic partners, and/or significant others in such sessions (to be applied to other lifestyle measures also). Teach and support self-help strategies and ability to obtain effective social support. • Integrate systematically psychosocial management with sexual counselling when appropriate • When appropriate, provide vocational reintegration/return to work strategies of patients after an acute cardiac event
Expected outcome: Absence of clinically significant psychosocial problems and acquisition of stress management skills Work resumption and/or resumption of meaningful daily activities
Evaluation of the programme results and establishment of structured follow-up
Expected outcome: • Individual determination of success or failure for each area of intervention • Establishment of new rehabilitative goals based on successful and unsuccessful areas of intervention • Adequate transmission of information for continuing of care • Quality assurance of intervention using systematic registration on individual level Establishment of structured follow-up focused on rehabilitative goals and secondary prevention in the short and long term.

1-RM: one repetition maximum; 6MWT: six minute walking test; ASCVD: atherosclerotic cardiovascular disease; BMI: body mass index; BP: blood pressure; CCS: Canadian Class Score; CHD: coronary heart disease; CPET: cardiopulmonary exercise testing; CR: cardiac rehabilitation; CV: cardiovascular; CVD: cardiovascular disease; DBP: diastolic blood pressure; ECG: electrocardiogram; HADS: Hospital Anxiety and Depression Scale; HDL-C: high-density lipoprotein cholesterol; HbA1c: glycated haemoglobin; HR: heart rate; ISWT: incremental shuttle walk test; LDL-C: low-density lipoprotein cholesterol; MET: metabolic equivalent; NYHA: New York Heart Association; PA: physical activity; PAD: peripheral arterial disease; PSRF: psychosocial risk factor; SBP: systolic blood pressure; SPPB: short physical performance battery; W_{peak}: power output

the coronary artery disease (CAD) population,[18] even though a definite recommendation toward this type of training cannot be provided, due to lack of clear improvement in cardiovascular prognosis, nor uptake of a lifelong active lifestyle.[19,20] A further issue regarding evidence is the identification of optimal intensities for resistance/strength training: in contrast to previous studies, high intensity strength training does not seem to induce higher increments in arterial blood pressure and cardiac output, as opposed to low-intensity strength training,[21] thus potentially reconsidering the medical safety for the cardiovascular system. In subsequent tables for specific conditions, different parameters and goals for training intensity have been proposed according to available evidence, however, with the need to adapt them to local expertise and equipment.

Modern cardiac rehabilitation programmes also need to integrate a structured intervention on psychosocial risk factors (PSRFs), because of their importance in affecting cardiovascular prognosis, treatment adherence and quality of life.[22,23] At the same time, they should emphasize the importance of return to work and reduce the risk of poor vocational outcomes.[24]

Finally, the systematic evaluation of outcome parameters/goals at the end of the programme should now be considered as a real core component of modern cardiac rehabilitation interventions.

Core components and objectives in specific clinical conditions

The following sections give information on specific clinical conditions. All 'general' core components presented in Table 1 [25,26] maintain validity in each clinical condition, if not modulated and re-adapted in specific tables.

Post acute coronary syndrome and post primary coronary angioplasty

Several controlled cohort studies and meta-analyses have found a survival benefit for patients receiving cardiac rehabilitation after ACS compared with no cardiac rehabilitation (26% reduction of cardiac mortality, 18% recurrent hospitalization[27]), even in the modern era of early revascularization and statins,[28] with a proven cost-effectiveness.[29]

These benefits appear to be through direct physiological effects of exercise training and through the effects on risk factor control, lifestyle behaviour and mood. Moreover, cardiac rehabilitation promotes better adherence to a medical treatment regimen after ACS, and, particularly in the case of short hospital stay in acute wards, may ensure proper titration and monitoring of evidence-based therapies.[30]

The cardiac rehabilitation programme should be delivered by a trained multidisciplinary team led by a cardiologist with adequate experience on cardiac

rehabilitation delivery. A pre-participation and risk-assessment evaluation is required taking into account age, pre-infarction level of activity, and physical limitations. Based on these requirements, exercise-based cardiac rehabilitation is safe also in the case of recent, complex and/or multivessel PCI.[31] Comprehensive cardiac rehabilitation must include exercise training, dietary counselling, smoking cessation, risk factor modification, patient education and psychosocial support with stress management (Table 2). Nowadays, most cardiac rehabilitation is offered as an outpatient programme of 8–24 weeks' or 36 weeks' duration for 3–7 days/week. However, in-patient (residential) cardiac rehabilitation may be preferred for some cases of severe left ventricular (LV) dysfunction or comorbidities needing 24 h attention, and early enrolment seems to have better results on LV remodelling[32] and functional outcomes.[33] More detailed analyses of the optimal volume of exercise are needed and are the topic of ongoing investigations (CROS II). Referral, adherence[34] and long term sustainability of cardiac rehabilitation benefits[35] remain

Table 2. Core components of cardiac rehabilitation post acute coronary syndrome and post primary percutaneous coronary intervention.

Components	Established/agreed issues	Class (level)	Issues requiring further evidence
Patient assessment	• Clinical history: review clinical course of ACS and comorbidities • Physical examination: inspect puncture site, search other vascular atherosclerotic localizations • Evaluation: clinical condition, medications, risk factors, psychological and social aspects, exercise capabilities	I (A)	
	• Peak exercise capacity evaluation before and after CR completion: symptom limited exercise stress testing by bicycle ergometry or treadmill stress test (CPET recommended if available)	I (A)	Utility and feasibility of CPET in all CR patients
	• Assess myocardial ischaemia and viability by means of stress echo, CMR, SPECT, or PET, if not performed during acute hospital stay	IIb (C)	
	• In patients with pre-discharge LVEF $\leq$40%, repeat echocardiography 6–12 weeks after MI, and after complete revascularization and optimal medical therapy, to assess the potential need for primary prevention ICD implantation and potential function recovery. Assess the risk of arrhythmias by Holter-24 and exercise test	I (C)	
Physical activity counselling	If not otherwise specified according to individual clinical pattern, recommend patients after the end of the CR programme to accumulate at least 30 min/day, 5 days/week of moderate intensity PA (i.e. 150 min/week) or 15 min/ day, 5 days/week of vigorous intensity PA (75 min/week), or a combination of both, performed in sessions with a duration of at least 10 min. Shorter exercise sessions (i.e. $<$10 min) may also be appropriate, especially in very deconditioned individuals	I (A)	Safety of vigorous intensity and HIIT without supervision
Exercise training	The programme should include supervised medically prescribed aerobic exercise training: • Low-risk patients: see Table 1. • Moderate to high-risk patients because of left ventricular dysfunction, coronary disease severity, comorbidities, ageing: similar to low risk group but starting at 40% of the HRR • In case of asymptomatic ischemia consider 40–60% of heart rate reserve at the onset of ischaemia. Prophylactic nitroglycerine can be taken at the start of the training session in selected cases • Resistance training to increase exercise capacity and muscle strength (see Table 1)	I (B)	• Modern definition of low and moderate-to-high risk patients • Utility and best protocols of aerobic HIIT
Lipid management	After ACS if the LDL-C goal is not achieved after 4–6 weeks despite maximal tolerated statin therapy and ezetimibe, addition of a PCSK9 inhibitor is recommended		

ACS: acute coronary syndrome; CMR: cardiac magnetic resonance; CPET: cardiopulmonary exercise testing; CR: cardiac rehabilitation; HIIT: high intensity interval training; HRR: heart rate reserve; ICD: implantable cardiac defibrillator; LDL-C: low-density lipoprotein cholesterol; LVEF: left ventricular ejection fraction; MI: myocardial infarction; PA: physical activity; PET: positron emission tomography; SPECT: single-photon emission computed tomography

an issue of concern, and need more evaluation to determine the programme's appropriate organization.

CCSs

Following the evolution of guidelines, this updated position paper has replaced the previous chapter on stable coronary artery disease and elective coronary angioplasty, now referring to CCS.[7] For cardiac rehabilitation purposes (Table 3), this referral group mainly includes patients with 'stable' anginal symptoms (or atypical symptoms such as dyspnoea), symptomatic patients >1 year after initial diagnosis or revascularization, and patients with angina and suspected vasospastic or microvascular disease. In this patient population exercise-based cardiac rehabilitation is recommended as an effective means to achieve a healthy lifestyle and manage risk factors (class I A), as far as to reduce disease recurrence and the atherosclerotic process.

Cardiac rehabilitation is effective in reducing total and cardiovascular mortality and hospital admissions, whereas effects on global risk of ACS or coronary revascularization are less clear, especially in the long term, and strongly depend on adherence. Evidence also points towards beneficial effects on exercise capacity and health-related quality of life (QoL). These benefits appeared to be consistent across patient categories (including those at risk) and intervention types (comprehensive and exercise only) and independent of setting (centre based, home or combined) and publication date. However, for stable angina the level of evidence is quite low, due to limited randomized trials.[36]

Despite a potential benefit, stable coronary patients and post elective PCI patients have lower participation (referral) rates than ACS,[37] especially in those with multiple risk factors and/or low functional capacity. Patient participation in cardiac rehabilitation remains far too low, particularly in women, the elderly and the socio-economically deprived.

A key component of establishing effective secondary prevention services is teaching self-management of CCS, adopting healthy behaviours including regular exercise, controlling biomedical indices and adhering to cardioprotective medicines. As a chronic condition, it is never too late to start a secondary prevention programme with a target of a longer sustainability (phase III). In selected sub-groups, centre-based cardiac rehabilitation may be substituted for home-based rehabilitation, which is non-inferior.[38] The components and type of programme offered differ widely by country, affected mainly by disparities on standards, legislation and reimbursement. So, the best programme for these patients needs further studies.

Coronary artery or valve heart surgery

Cardiac rehabilitation programmes should be available for all patients undergoing coronary artery[6] and valve surgery,[39] including those after minimally invasive cardiothoracic surgery or aortic valve replacement.[40] Cardiac rehabilitation participation is associated with about 40% reduced mortality after coronary artery

Table 3. Core components of cardiac rehabilitation in chronic coronary syndromes.

Components	Established/agreed issues	Class (level)	Issues requiring further evidence
Patient assessment	• Clinical history: review clinical course of ACS and comorbidities • Physical examination: inspect puncture site, search for other vascular atherosclerotic localizations • Evaluation: clinical condition, medications, risk factors, psychological and social aspects, exercise capabilities • Peak exercise capacity evaluation before and after CR completion: symptom limited exercise stress testing by bicycle ergometry or treadmill maximal stress test (CPET if indicated available)	I (A)	Effectiveness of CR in special situations like spastic angina or for myocardial infarction in patients without obstructive coronary artery disease (MINOCA)
Exercise training	• Supervised medically prescribed • Early as long as possible • Combined aerobic and resistance training • 30–60 min/ session, at least 3/week • Intensity: see Table 1 • Resistance: see Table 1 for low risk patients. 30–40% 1-RM in high risk patients		• Exercise intensity above the ischaemic threshold • Role of HIIT and other types of training

1-RM: one repetition maximum; ACS: acute coronary syndrome; CPET: cardiopulmonary exercise testing; CR: cardiac rehabilitation; HIIT: high intensity interval training

bypass grafting,[28] while after heart valve surgery it improves short-term physical capacity and may positively affect return to work,[41] being also cost-effective.[42] Due to rising age and comorbidities in patients undergoing cardiac surgery, novel components of cardiac rehabilitation intervention are recommended by this updated revision, mainly regarding the need to appropriately evaluate and treat malnutrition and pain.[43] The potential utility to combine inspiratory muscle training (IMT) with aerobic and strength training (if not contraindicated after thoracotomy) was also added.[44] Patients who undergo transcatheter aortic valve implantation (TAVI) are also candidates for cardiac rehabilitation: patients admitted are commonly very old (average age >80 years), mainly women, frail in up to one-third of cases, with many comorbidities and with substantial differences in the disability profile at admission.[45] In the TAVI population – coupled with interventions to improve functional capacity and reduce frailty – special consideration of cognition and nutrition is needed to maintain autonomy and empower patients in coping with challenges of everyday life.[46] Even though a standardized approach is lacking, several trajectories to provide exercise training in this vulnerable population could be derived from available studies[45] (Table 4). Cardiac rehabilitation may be indicated after MitraClip® implantation, with a specific focus (among all other core components) on the antithrombotic strategy and specific echocardiographic controls (i.e. residual atrial septal defect, the trans-mitral gradient and a residual mitral regurgitation);[47] also in this referral group, there is strong need for further evidence on the efficacy and safety of cardiac rehabilitation programmes.

CHF

It is recommended that all patients with established CHF (regardless of left ventricular ejection fraction) should be enrolled in an exercise-based cardiac rehabilitation programme with a multi-faceted approach[3,48–51] (Table 5)[52–67]. This may also apply to patients with cardiac implantable electronic or ventricular assistant devices.[68–70] In-patient rehabilitation should begin as soon as possible after hospital admission. Then, a structured outpatient cardiac rehabilitation is crucial for the development of a lifelong approach. The aim is to improve patients' exercise capacity and symptoms in the short-term thus improving QoL and prognosis (i.e. hospital admissions) in the long-term.[71,72] This may be provided in a wide range of settings, such as CHF clinics, non-clinic settings (community health centres and general medical practices), or a combination of these. Home-based individual cardiac rehabilitation (alone or in combination with centre-based cardiac rehabilitation)[73] is also feasible using technology-based telemedicine programmes,[74] in combination with home visits and telephone support when appropriate.[75] Further research is required to investigate the impact of exercise-based cardiac rehabilitation on older and/or frail/cachectic patients and those with CHF with preserved ejection fraction[76] or non-ischaemic CHF.[77]

Cardiac transplantation

Heart transplantation (HTX) is the only definitive therapy for patients with end-stage heart failure.[78] Heart transplantation patients frequently have clinical problems in the post-operative period, such as physical deconditioning, muscular atrophy, weakness and lower maximal aerobic capacity. This is in part due to the inactivity in the preoperative period, but also due to factors such as, among others, the difference in donor/receptor body surface, heart denervation. Immunosuppressive therapy limits the physical capacity, as well.

Exercise-based cardiac rehabilitation in HTX patients (Table 6)[79] may be effective in reversing the pathophysiological consequences associated with cardiac denervation and prevent immunosuppression-induced adverse effects; moreover, it ensures short-term gains in exercise capacity, with uncertainty and need of further evidence about the longer-term benefits of exercise programmes.[80,81]

During the in-hospital phase, early mobilization – particularly in phase 1 but also in phase 2 cardiac rehabilitation – can be initiated as soon as haemodynamic reestablishment and weaning from post-transplant intravenous drugs occurs. Early mobilization programme consists of walking with progressive increase in duration and intensity with monitoring of the heart rate, blood pressure and subjective fatigue. Training of articular mobility, flexibility and resistance of the large muscular groups should also be initiated. At discharge, HTX patients should be able to walk on a level surface for a period of 40–60 min at speeds of 80–100 m/min, 4–5 times a week. Haemodynamically stable HTX recipients should perform a cardiopulmonary exercise test with ventilatory thresholds,[82] to aid in physical activity prescription. Although adequate intensity of exercise training is not yet well established,[83,84] HTX patients usually show beneficial results. The possible mechanisms of exercise training include peripheral metabolic improvements through increased oxygen extraction and haemodynamic changes, including increase in heart rate, cardiac output, endothelial function and reduction in neurohormonal activity.[82,84] Respiratory efficiency is also improved during exercise. Resistance exercises have been used to increase muscular mass and bone density, because of loss of free fat and bone mass.

Table 4. Core Components of cardiac rehabilitation following cardiac surgery – coronary artery or valve heart surgery.

Patient assessment	• Assess: wound healing, comorbidities, complication and disabilities; special focus on perioperative congestive heart failure, atrial fibrillation, glycaemic control, renal dysfunction, liver dysfunction, anaemia, and venous thromboembolism, pleural and pericardial effusion, and diaphragmatic paralysis
	• Evaluation and appropriate treatment of postoperative pain
	• Echocardiography: pericardial effusion, prosthetic function and disease at other valve sites, when appropriate
	• Exercise capacity to guide exercise prescription:
	  • Symptom limited exercise stress test as soon as possible
	  • A maximal exercise test about four weeks after surgery
	• Patient education: about anticoagulation, including drug interactions and self-management if appropriate; in-depth knowledge on endocarditic prophylaxis

Physical activity counselling	Physical activity counselling should be offered to all patients taking into account wound healing and exercise capacity (Tables 1, 2 for integration about general conditions and post ACS)

Exercise training	• Exercise training can be started in the early in-hospital phase
	• In-patient and/or out-patient exercise training programmes immediately after discharge from surgery facilities are advisable
	• Upper-body training can begin when the chest is stable, i.e. usually after six weeks
	• ET should be individually tailored according to the clinical condition, baseline exercise capacity, ventricular function and different valve surgery
	• After mitral valve replacement exercise tolerance is much lower than that after aortic valve replacement, particularly if there is residual pulmonary hypertension
	• Consider inspiratory muscle training or other respiratory physiotherapy in patients with prolonged postoperative mechanical ventilation and/or respiratory comorbidities, especially in the case of concomitant heart failure
	• In TAVI patients:
	  • Structure: three times a week sessions for eight week programme duration or once a week for six weeks in the ambulatory setting versus 4–6 days per week (2–3 sessions per day) for three weeks in a residential CR setting. Prolonged training due to age, disability, frailty, and comorbidities – also home-based – could be necessary
	  • Endurance exercise (by bicycle, treadmill, pedal exerciser, arm ergometer with very low resistance, or simple walking) as the primary training priority, administered in individualized programmes up to 30 min per session
	  • Consider workloads in Table 1 as determined at baseline CPET or based on Borg Rating of Perceived Exertion Scale
	  • Strength training (for lower extremities at weight machines or as a sit-to-stand exercise), calisthenics, respiratory and a mix of other exercises (outdoor walking, gymnastic, and aqua and spinal gymnastic) in various combinations to be considered

Diet/nutritional counselling	• Note interaction between anticoagulation and vitamin K rich food and other drugs, in particularly amiodarone • Consider evaluation of perioperative nutritional markers such as serum albumin, micronutrient (iron, folate, vitamin B12 and vitamin A), and inflammatory markers; consider vitamin B12 supplementation • Establish an appropriate postdischarge dietary regimen
Tobacco cessation	Risk of complications depends on how long before surgery the smoking habit has been changed, whether smoking was reduced or stopped completely
Psychosocial management	Pain experience, sleep disturbances, anxiety, depression, deterioration of mental health and impaired quality of life

ACS: acute coronary syndrome; CPET: cardiopulmonary exercise testing; CR: cardiac rehabilitation; ET: exercise training; TAVI: transcatheter aortic valve implantation

HIIT is a feasible, safe and effective way, as well.[79] This type of exercise should be introduced and used more frequently among a broader audience; however, HTX patients seem to respond differently, resulting mainly in peripheral improvements rather than improved cardiac function.

Traditionally, several exercise restrictions have applied to HTX patients, which seem to be based more on caution than scientific evidence. It is time to rethink the use of exercise and to offer an 'up to date' approach to exercise training.

Patients with implantable devices

Cardiac resynchronization therapy (CRT) and implantable cardioverter defibrillator (ICD) are recommended

Table 5. Core components of cardiac rehabilitation in chronic heart failure.

Components	Established/agreed issues	Class (level)	Issues requiring further evidence
Patient assessment	Clinical assessment: • Comorbidities and disabilities (renal dysfunction, diabetes, musculoskeletal disease) • Complications of recent interventions/surgery (i.e. cognitive/neurologic impairment, wound healing, haematoma) Markers of disease severity: • NYHA functional class • Pulmonary congestion, peripheral oedema, hypotension • Signs of pleural or pericardial effusion • Signs of malnutrition, cachexia/sarcopenia and disturbance of equilibrium • Reduced GFR, elevated BNP, serum electrolyte disturbances, anaemia/iron deficiency	I (C)	
	Functional assessment: • Echocardiography • CPET with respiratory gas analysis. Indicated testing protocol: Naughton or modified Bruce or small increments or ramp 5–10W/min on bicycle ergometer • Main CPET parameters: $VO_{2\ peak}$, VT_1 and VT_2 (functional capacity), VE/VCO_2 slope (ventilatory efficiency), chronotropic response, oxygen pulse, oscillatory ventilation pattern (haemodynamic impairment), tidal volume, breathing rate and breathing reserve (pulmonary comorbidities) • 1-RM and maximal inspiratory pressure • Six minute walk test may also assess exercise tolerance if CPET is not feasible	IIa (C)	
	Other tests: • Coronary angiography, haemodynamic measurements, endomyocardial biopsy, sleep test for selected patients or cardiac transplantation candidates		
	• Frailty assessment: walking speed (gait speed test), timed up-and-go test, PRISMA 7 questionnaire, Frail Score, SPPB • Cognitive function: Mini-Mental State Examination or the Montreal Cognitive Assessment	IIb (C)	
Physical activity counselling	At least 30 min/day of moderate-intensity physical activity (sufficient to provoke mild or moderate breathlessness) gradually increased to 60 min/day	I (B)	• It is recommended to include common activities into daily routine (i.e. walking instead of driving). Alignment of activity modes with individual preferences may increase adherence for sustained activity. Particular types of training (i.e. dancing, yoga, tai-chi, aquatic ET) are well accepted and beneficial to functional capacity and QoL[52,53] • The prescription of potentially strenuous and unsupervised physical activity (i.e. running or jogging) in high risk patients needs more evidence

(continued)

Table 5. Continued

Components	Established/agreed issues	Class (level)	Issues requiring further evidence
Exercise training	Aerobic or endurance training Moderate intensity continuous endurance training is recommended as baseline aerobic ET protocol. – Frequency (ET sessions per week): 2–3/week according to perceived symptoms and clinical status gradually increased to 3–5/week preferably all days per week – Intensity: ET should start at a level as low as 40% of VO_{2peak} ($\approx$ 35% $VO_{2reserve}$) in patients with low exercise capacity, recent haemodynamic decompensation or high exercise-related risk. Then gradually increased to VT_1 (50–60% VO_{2peak}), which is the safest point. Then, if well tolerated, intensity may increase close to VT_2 (65–90% VO_{2peak}), which is the limit between high-intensity and severe-intensity effort (critical power) – Time (duration of ET session): gradually increasing from 15 to 30 min at least, aiming at 45–60 min – Type: exercises that involve large muscle groups (e.g. walking, running, bicycle riding) Supervised, in-hospital training programme may be recommended, especially during the initial phases, to verify individual responses and tolerability, clinical stability and promptly identify signs and symptoms indicating to modify or terminate the ET programme.	I (A)	• The upper limits of ET intensity are not clearly defined yet. Currently, ET intensities between 70-% and 80% of VO_{2peak} are commonly prescribed • ET intensity monitoring: $\%W_{peak}$, %HRR and/or Borg RPE can be used. $\%HR_{peak}$ can be used but has a limited applicability (advanced HF with chronotropic incompetence, β-blocker use, coexisting AF).
	Interval training • Low intensity interval training may be used at the initial stages of high risk HFrEF patients. The hard ($\geq VT_1$ or at 50% workload, RPE 11–12) and recovery ($<$20 W) segments are usually 20–30 s and 40–60 s in duration. The primary aim should be to increase the duration from 15 to 30 min, with 2–3 sessions/week and 10–12 work phases per session • HIIT may then be applied to selected low-risk stable patients. A 10 min warm-up phase ($<VT_1$) is followed by high-intensity intervals ($>VT_2$, RPE $\geq$15), interrupted by recovery intervals ($<VT_1$) (times of intervals according to the protocol, i.e. 4 $\times$ 4 min or less) • Resistance/strength training is complimentary to aerobic ET, 2–3 times/week to increase muscle strength and aerobic capacity.[57] Added to interval training, it increases VO_{2peak}, while combined with endurance continuous training, it increases VO_{2peak}, muscle strength and HRQoL.[58,59] Training intensity, frequency and duration should be tailored to each patient's clinical status, stress tolerance and comorbidities. Training intensity should be determined on the basis of the one		The quality of existing evidence does not allow us to indicate whether there is a superiority of HIIT over conventional continuous ET for improving VO_{2peak}, LV function and QoL[54,55] Limited information is available on different ET type combinations.[56]

(continued)

Table 5. Continued

Components	Established/agreed issues	Class (level)	Issues requiring further evidence
	repetition maximum (1-RM). An initial instruction phase (<30% 1-RM, RPE 11–12, 5–10 repetitions) is followed by the resistance/endurance phase with high number of repetitions (12–25) and a low intensity (30–40% 1-RM, RPE 12) so as to reach the strength training/muscle build-up phase by increasing weights progressively up to 40–60% of the 1-RM (RPE >15, 8–15 repetitions). Resistance training should be performed as interval training (i.e. with appropriate rest between sets), and single muscles should be trained step by step • IMT improves exercise capacity and QoL in HFrEF patients with inspiratory muscle weakness (PI_{max} <70% of predicted value). IMT starts at 30% of PI_{max} up to a maximum of 60% by readjusting intensity every 7–10 days. Training duration should be 20–30 min/day with a frequency of 3–5 sessions per week for a minimum of eight weeks. Combinations with aerobic ET and aerobic/resistance ET have been proposed[60,61] NMES of the lower limb muscles may be an alternative for patients with advanced HFrEF. Training protocols proposed show high heterogeneity. NMES increases exercise capacity, muscle strength and QoL but is not superior to usual ET[62–64]		
Diet and nutritional counselling	Prescribe specific dietary modifications to: • Fluid restriction is temporary indicated in patients with severe HF and it needs to be balanced with diuretics and weather conditions. Renal function needs to be supervised. Modulate intake during periods of high heat and humidity, nausea/vomiting • Eat healthily, avoid excessive salt intake (<5 g/day) and maintain a healthy body weight • Abstain from or reduce alcohol (2 units/day in men; 1 unit/day in women)	I (C)	Existing research suggests a consistent benefit of MedDiet and DASH diet. Although reduction of dietary salt intake shows a trend to improve HF symptoms, no effect on patients' prognosis has been proven yet[65]
Weight control management	Weight monitoring: • The patients must be educated to weigh themselves daily and to record the data (diary/app or such) • A gain > 1.5 kg over 24 h or > 2.0 kg over two days suggests fluid retention • Involuntary non-oedematous weight loss ≥6% of total body weight within the previous 6–12 months is defined as cachexia and is associated with adverse prognosis Weight reduction: • Weight loss as an intervention has never been prospectively shown to be either beneficial or safe in HFrEF. Patients often have anorexia and gastrointestinal symptoms which may be also caused by psychological depression	I (C)	Cachexia diagnostic criteria specific to HF are poorly defined and its definition remains rather arbitrary. The effects of current medical treatment, nutritional or dietary interventions and physical activity on cachexia are still poorly evaluated. It is not known which ET modality would be beneficial in these patients

(continued)

Table 5. Continued

Components	Established/agreed issues	Class (level)	Issues requiring further evidence
	• In obese patients with HFpEF, weight loss through caloric restriction together with an exercise training programme may have incremental benefit on exercise capacity • In patients with HF with moderate degrees of obesity (BMI 35 kg/m^2), weight loss cannot be recommended • In more advanced obesity (BMI 35–45 kg/m^2), weight loss may be considered to manage symptoms and exercise capacity	IIa (C)	
Medication management	• CR programmes are optimal to implement and up-titrate HF medication, such as ACEIs/ARBs, beta blockers, MRAs, sacubitril/valsartan, ivabradine and emerging SGLT2 inhibitors • Education on indications, benefits and harms of HF medication to improve long-term adherence		
Lipid management	Routine administration of statins in patients with HF without other indications for their use (e.g. CAD) is not recommended. Because there is no evidence of harm in patients on statin treatment after the occurrence of HF, there is no need for statin discontinuation for patients already on treatment	III	
Smoking cessation	Advise smoking and recreational substances cessation. To support smoking cessation cognitive behavioural theory and psychological support may be needed	I (C)	Smoking is a risk factor for HF, but no studies have evaluated the effect of smoking cessation in HF cohorts[66]
Psychosocial management	Depression and cognitive dysfunction are common in HF, affect adherence and may lead to social isolation Psychosocial intervention and cognitive behavioural therapy combined with a structured education programme should be provided to reduce depression, social functioning and QoL Patients should be referred to specialist for psychological support. Family and HF carers should be involved. Consider referral to psychiatrist	IIa (C)	In HFrEF patients, ET significantly decreases depression symptoms. This benefit remains unclear in cases of HFpEF and combined aerobic and strength training[67] More research is needed to identify the optimal strategy to achieve optimal long-term adherence

1-RM: one repetition maximum; ACEI: angiotensin-converting enzyme inhibitor; AF: atrial fibrillation; ARB: angiotensin II receptor blocker; BMI: body mass index; BNP: brain natriuretic peptide; CAD: coronary artery disease; CPET: cardiopulmonary exercise testing; DASH: Dietary Approaches to Stop Hypertension; ET: exercise training; GFR: glomerular filtration rate; HF: heart failure; HFpEF: heart failure with preserved ejection fraction; HFrEF: heart failure with reduced ejection fraction; HIIT: high-intensity interval training; HR: heart rate; HRQoL: health-related quality of life; HRR: heart rate reserve; IMT: inspiratory muscle training; LV: left ventricular; MRA: mineralocorticoid-receptor antagonist; NMES: neuromuscular electrical stimulation; NYHA: New York Heart Association; PI_{max}: inspiratory muscle strength; QoL: quality of life; RPE: rate of perceived exertion; SGLT2: sodium/glucose cotransporter 2; SPPB: Short Physical Performance Battery; VT: ventilatory threshold

therapies in CHF.[85] As a consequence, an increasing number of individuals wearing ICD/CRT are referred to cardiac rehabilitation. The additive role of exercise training superimposed onto CRT in increasing functional capacity and improving cardiovascular prognosis – since up to one-third of patients are initially non-responder to CRT and may gain from exercise – is still unclear, due to conflicting evidence.[86,87] When prescribing exercise in CRT patients, wound evaluation in terms of both skin and heart muscle wire insertion has to be preliminary performed, and, in case, information regarding adverse events during device implantation should be collected.

Table 6. Core components of cardiac rehabilitation in cardiac transplantation.

Components	Established/agreed issues	Issues requiring further evidence

Patient assessment (and self-assessment)	• Clinical: wound healings
	• Chest X-ray: pleural effusion and diaphragmatic paralysis
	• Echocardiography: pericardial effusion
	• Exercise capacity: cardiopulmonary exercise stress test four weeks after surgery to guide detailed exercise recommendations. For testing protocols, small increments of 10W per min on bicycle ergometer, or modified Bruce protocols or Naughton protocols on treadmill are appropriate; ramp protocols for treadmill
	• Physician knowledge of the anatomical and physiological reasons for limited exercise tolerance: e.g. the immune-suppression therapy side effect (impairments of inflammatory response, metabolism, osteoporosis, steroid-associated myopathy or polyneuropathy)
	• Risk of acute rejection: rapid, appropriate treatment is necessary. Patients should be instructed to practise self-monitoring: an unusually low BP, a change of HR, unexplained weight gain or fatigue may be early signs of rejection even in the absence of major symptoms
	• Patients and physiotherapists should be educated to adhere to the recommendations concerning personal hygiene and general measures to reduce the risk of infection:
	  • Good dental hygiene, no toothbrush older than four weeks
	  • Frequent hand washing using liquid soap
	  • Avoidance of close contact with people with infectious diseases (measles, chickenpox, mumps, mononucleosis, common cold, flu)
	  • Avoidance of contact with persons having received oral polio vaccination for eight weeks
	  • If indispensable, pets in the household only under strict precautions and with limited contact with patient
	  • No gardening without gloves
	  • No contact with decaying plants, fruits, vegetables
	  • No stay near construction work and compost heaps
	  • No mould inside the home
	  • Hydroculture (hydroponics) better than potting compost in the home
	  • Avoidance of swimming in public baths	

Physical activity counselling	• Chronic dynamic and resistance exercises prevents the side-effects of immunosuppressive therapy • Exercise intensity relies more on perceived exertion than on a specific HR (due to denervation of the heart). The respiratory frequency is also important to control intensity, by using the 'speech rule' (see Table 1)	
Exercise training	• Before hospital discharge, respiratory training, active and systematic mobilization of the upper and lower limbs are advisable • After discharge, aerobic exercise may be started in the second or third week after transplant but should be discontinued during corticosteroid bolus therapy for rejection. Resistance exercise should be added after 6–8 weeks • Regimen: at least 30–40 min/day of combined resistance exercise (muscle strength) and aerobic training (walking) at moderate level, slowly progressing warm-up, closed-chain resistive activities (e.g. bridging, half-squats, toe raises, use of therapeutic bands) and walking/Nordic walking/cycling • Resistance training: 2–3 sets with 10–12 repetitions per set at 40–70% 1-RM, with a full recovery period >1 min between each set. The goal is to be able to do five sets of 10 repetitions at 70% of 1-RM • Aerobic training should start at low intensity ($VO_{2peak} < 50\%$ or 10% below anaerobic threshold) or peak work load ($<50\%$) and progressively increase	• Maintenance of results in the long-term • Outcome measures other than exercise capacity: mortality, quality of life, return to work • Protocols and expected outcomes in de novo heart recipients *vs.* more clinically stable participants

(continued)

Table 6. Continued

Components	Established/agreed issues	Issues requiring further evidence
	• HIIT: sets of short- or long-lasting exertion periods (30 s to 4 min) at high intensity (> 85% VO_{2max}), followed by short- or long-lasting recovery periods (30 s to 4 min).[79]	
Diet/nutritional counselling	Dietary infection prophylaxis – food to be avoided: • Raw meat • Raw seafood • Unpasteurized milk • Cheese from unpasteurized milk • Mouldy cheese • Raw eggs • Soft ice • Grapefruits, pomelo, ginger, turmeric (effects on calcineurin inhibitors (tacrolimus, cyclosporine) concentrations through CYP3A4)	There are good reasons to follow a Mediterranean style diet, even though controlled studies in these patients to assess the influence of nutrition on CAV or survival have not been published
Weight control management	• Avoidance of overweight is mandatory to balance the side-effects of immunosuppressants, to limit the classical cardiovascular risk factors • Obesity increases the risk of cardiac allograft vasculopathy. It should be controlled by daily exercise and healthy diet	
Lipid management	• Hyperlipidaemia increases the risk of CAV. It should be controlled by statins, daily exercise and healthy diet • Statins (pravastatin, fluvastatin) not only lowered LDL-C levels but also decreased the incidence of CAV and significantly improved survival. Ezetimibe are the second line therapy and can be added to statins under the immunosuppression concentrations control	Statins are now part of standard therapy, but dose-related myopathy and myolysis because of interaction with cyclosporine must be considered
Blood pressure monitoring	• Target BP is 130/80 mmHg • Hypertension is linked to immunosuppressive therapy and denervation of cardiac volume receptors • It is sensitive to a low-sodium diet. Treatment with amlodipine and ACEIs/ARBs are first choice, usually completed by diuretics. Beta-blockers are contra-indicated as they hamper the already delayed chronotropic response of the denervated heart during the early term but they showed the beneficial effects as a treatment more than 1–1.5 years after HTX and in the case of post-transplant heart failure development. Nifedipine and diltiazem may increase the effects of calcineurin inhibitors due to the drug interactions	
Tobacco cessation	Cessation of smoking is a prerequisite for transplantation in most centres. Psychological support may be needed so patient does not resume smoking post-transplantation	
Psychosocial management	• Clear medical information and advice on life after transplant are needed to manage challenges such as patient guilt or problems with high levels of anxiety and apprehensiveness • Careful presentation of recommendations is necessary, leaving the choice up to the patient and offering every possible support he/she may need to adjust	

1-RM: one repetition maximum; ACEI: angiotensin-converting enzyme inhibitor; ARB: angiotensin II receptor blocker; BP: blood pressure; CAV: cardiac allograft vasculopathy; HIIT: high-intensity interval training; HR: heart rate; HTX: cardiac transplantation; LDL-C: low-density lipoprotein cholesterol

For CRT-D and ICD, details regarding their setting and firing mode should be acquired, including antitachycardia pacing and shock thresholds, mode (ventilatory threshold or ventricular fibrillation), rapid onset setting and sustained arrhythmia period before device discharge. Information is essential in order to maintain exercise heart rates not exceeding ICD therapy thresholds, and ideally set between 10 and 20 beats below first line therapy thresholds. Exercise prescription should utilize one of the standard best-practice approaches

of functional evaluation and monitoring, for example VO_2, measured heart rate or rating of perceived exertion. Caution is required when prescribing exercise intensity based on estimated heart rate approaches, because of the risk of targeting the exercise heart rate above the detection threshold of the ICD; thus it is recommended that maximal heart rate be measured rather than estimated in this patient population. Conversely, for monitoring purposes of exercise intensity, RPE may be the preferred method because the chronotropic response may be impaired in people with CRT.[88] Other limiting factors associated with pacing therapy to be considered during exercise prescription and monitoring are: i) in the case of paced atrial rate (or set at a fixed rate) a blunted or delayed heart rate response to exercise may occur; and ii) electrocardiogram (ECG) changes (ST-segment depression) associated with myocardial ischaemia may not be visible, for which close clinical monitoring is required.[89]

When prescribing exercise therapy in CHF patients undergoing CRT, it is also important to consider that certain patients may even show worsening symptoms after implantation, as far as device malfunction or infections in up to 5% of cases may occur [89]: in these situations appropriate diagnosis and modulation or interruption of the exercise training programme is mandatory.

Patients with ventricular assist devices

Left ventricular assist device (LVAD) therapy has become an accepted intervention for the treatment of late-stage heart failure. LVAD therapy is commonly used as a bridge to heart transplantation, as far as the use of LVADs as a destination therapy is increasing, now providing long-term cardiac support.[90] LVAD offers patients the opportunity for enhanced QoL by improving end organ function and activity tolerance.

Advancements in device technology have led to increased portability, patient acceptance and to attendance to cardiac rehabilitation.[91] Those who may have previously been bedridden due to LVAD-related complications, once treated, are now able to participate in physical therapy. Most LVAD patients are discharged home, willing to resume a 'normal' life.

Once LVAD recipients are clinically stable (Table 7), they can start early mobilization or exercise training. At present, data on exercise training in LVAD are scarce, although it is feasible, safe and has positive effects on QoL and exercise capacity.[92] Moreover, up to now, no-one has investigated differences in indication (bridging *vs.* destination therapy), duration from LVAD implantation to start of early mobilization/exercise training, impact of pump settings on early mobilization/exercise training, differences in underlying disease leading to LVAD implantation, comorbidities and gender differences. Nonetheless, it would be unethical not to recommend any physical activity to LVAD patients (early mobilization/exercise training) and all patients should be encouraged (Table 7). Endurance training is easy to perform and the resistance training exercises on weight-lifting machines can be performed on regular fitness centre equipment, especially after cardiac rehabilitation in well educated patients.[93,94] Also, monitoring by Borg scale is easy to learn.[92]

Several mechanisms may contribute to the effect of exercise training in LVAD: improvement in central cardiac and in respiratory muscle function, increase in local blood and metabolic activity of skeletal muscle, improvement of peripheral oxygen utilization, change in mitochondrial energy metabolism, as well as combinations of these mechanisms. Therefore, translation into clinical practice should be feasible, making exercise training a promising therapy option for LVAD patients. Further evidence is needed regarding the role of exercise training in new LVAD technology, for example, in the case of pulsatile-flow system without mechanical bearings such as the HeartMate 3 device.

Peripheral artery disease

Peripheral artery disease (PAD) is a qualifying diagnosis to enter cardiac rehabilitation programmes in several European countries, particularly if the typical and disabling symptom of intermittent claudication – caused by a reduction in blood flow to the lower extremities – is present. Exercise-based cardiac rehabilitation in intermittent claudication is safe[95] and, as compared with usual care, showed a significant increase of walking ability, while there is no clear evidence on mortality and major cardiovascular events risk reduction.[96] Despite this evidence, PAD patients are referred to cardiac rehabilitation only in a minority of cases and often when associated with other cardiovascular conditions.[97]

In the modern era, cardiac rehabilitation centres should give more consideration to PAD patients as a target group, thus expanding the usual indication of intermittent claudication and considering patients with atypical symptoms or after surgical/percutaneous revascularization also.

Core components of cardiac rehabilitation in PAD (Table 8 [98,99]) should include the systematic provision of best medical pharmacological therapies.[100] Patients with PAD are at very-high risk and should be managed accordingly, particularly for lipid and blood pressure targets. Novel evidence is also emerging for the use of combined antithrombotic therapies (i.e. low dose 2.5 mg b.i.d. rivaroxaban plus aspirin[101] and ticagrelor

Table 7. Operational aspects of early mobilization and exercise training in patients with ventricular assist devices.

Instruction to reduce the risk of adverse events when exercising LVAD patients	• Individualized assessment and prescription • Pre-screening with risk stratification • Prolonged graduated warm-up and cool-down • Low-to-moderate intensity exercise training • Avoiding breath holding and Valsalva manoeuver • Avoiding any trauma, as ventricular assist device recipients are anticoagulated and often treated with antiplatelet drugs • Adaptation for comorbidities • Monitoring and supervision • Keeping the feet moving during active recovery, if appropriate • Observation of patients for 15 min post-cessation of exercise • Patient education about disease, device, treatments

Preliminary evaluation and precautions during EM in LVAD recipients	• Assessment
	  • Recent and past medical history, and level of exercise capacity previous to disease state
	  • Mental status and cognitive ability
	  • Vital signs and risk of cardiovascular instability (haemodynamic, arrhythmic, clinical)
	  • Clinical assessment (persistence of VAD-related and HF symptoms, medications have been prescribed)
	  • Particular medications, i.e. need for continuous or intermittent infusions, ventilator settings or oxygen requirements
	  • Screen range of motion, coordination, balance, strength, endurance, functional capacity (bed mobility, transfers, gait, daily living activities)
	  • Baseline haemochromocytometric, ionic and renal functional assessment. Start exercise when haemoglobin >9 g/dL, sodium >130 mEq/L, potassium >3.8 mEq/L and/or creatininaemia <1.9 mg/dL
	• Follow sternotomy (six weeks post-surgery screening of wound) and skin integrity
	• Patients should always wear a driveline stabilization belt during exercise
	• The patient should have his/her travel bag nearby at all times. It should include a back-up controller, battery clips and spare batteries
	• Make early mobilization and exercise sessions comfortable
	• Organize an appropriate place to put monitor, console-controller and batteries (visible for patient and healthcare professionals)
	• The VAD equipment location should not impede emergency procedures

How to set up an EM programme in LVAD recipients	Consider: • Positioning • Bed mobility activities • Sitting on edge of bed, in association with exercises • Transfers from bed to stretcher-chair, chair or commode • Gait, with pre-gait activities: weight shifting, stepping in place and sideways. Gait training is allowed with rolling walker • Breathlessness management and recovery strategies • Attempt to achieve a target of 11 to 14 out of 20 of the Rate of Perceived Exertion scale (Borg scale) • Patient's native heart rate should not exceed 120 beats/min during exercise, unless under physician's supervision: heart rate is not always detectable during EM/ET, and its monitoring depends on device Promote: • Low-to-moderate intensity dynamic large muscle group work • 'Walk & talk' approach is suggested Limit: • Knee lifts • Resistance training (low weight/high repetitions) and with seated exercise (reduced venous return) Avoid: • Excessive muscle fatigue • Abrupt postural changes and stooped activities • Rowing machine. • Biking at initial stages, due to increased risk of infection near ventricular assist device percutaneous line exit site
Criteria for exercise training	• Symptoms and signs compatible with exercise intolerance. • Symptomatic hypotension, extreme fatigue or claudication and new onset of neurological changes

(continued)

Table 7. Continued

contraindications in LVAD recipients	• Supine resting heart rate >100 beats/min
	• Oxygen saturation <90% (caveat: oxymetry readings might be difficult to obtain due to low pulsatility)
	• VAD complications during or after exercise sessions:
	  • Alarm activation curves, numbers and alarms should be displayed on the LVAD monitor. Significant drop in LVAD flow, or suction alarm are criteria for interrupting the session
	  • Complex and frequent ventricular arrhythmia on exertion (caveat: may be asymptomatic)
	  • Infection, mainly at the driveline site
	  • Evidence of bleeding
	  • Thrombus (usually evidenced by an increase in the number of watts/energy necessary for device working)
	• Request of VAD recipient to stop
	• Increase >1.8 kg in body mass over the previous 1–3 days
	• Implantable cardioverter–defibrillator intervention

EM: early mobilization; ET: exercise training; HF: heart failure; LVAD: left ventricular assist device

60 mg b.i.d. plus aspirin[102]) for secondary prevention in symptomatic PAD.

The evaluation of functional capacity in these patients needs to be integrated by direct testing focused on walking impairment, with the integration of both information on cardiorespiratory fitness and the pain-free walking distance. The characteristic treadmill-based exercise–rest–exercise modality of training should be optimally managed by the supervising exercise therapist, with the not easy task to decide how to progress the exercise prescription to achieve maximal benefits and long-term adherence. Finally, given the specific experiences of people living with intermittent claudication, an intensive psychosocial intervention is often crucial to ensure favourable outcomes of the cardiac rehabilitation programme. Patients need to accept the rationale of walking in spite of pain in a supervised exercise programme, as far as to include exercise in their daily battle with walking impairment and loss of independence.[103]

Core components and objectives in challenging populations

Elderly patients

Although the elderly represent an increasing proportion of patients with ACS or CHF, they are often excluded from cardiac rehabilitation programmes.[104] Their comorbidities, risk factor profile and reduced exercise capacity indicate the continued need for cardiac rehabilitation.[105] Importantly, benefits of exercise-based cardiac rehabilitation in functional capacity, behavioural characteristics and overall QoL, modification of cardiovascular risk factors and adherence to cardiac medications have been documented also in older patients, particularly in those with age-compatible preserved functional capacity, no advanced comorbidities and no disability.[106,107] Many of these favourable results may be maintained in the medium–long term.[108] Larger cohort registries including elderly patients participating in cardiac rehabilitation have also reported reduced mortality or hospitalization, even though the role of possible selection bias and hidden confounders has still not been clarified.[109,110] Although these studies demonstrate a benefit of cardiac rehabilitation in the elderly, it is doubtful whether these results may be reproducible also in very elderly or frail patients, who represent an increasing burden of hospital care.

The planning and implementation of cardiac rehabilitation in elderly patients requires a high degree of individualization, with a careful clinical evaluation beyond cardiovascular function, including psychosocial assessment, evaluation of comorbidities and, particularly in patients older than 75 years, multidimensional geriatric assessment. Such an assessment may serve to exclude disability, cognitive problems or frailty, conditions that require specific approaches and exercise intervention protocols. If these are excluded, the exercise programme intensity should be tailored to the patient's baseline functional state and based mainly on aerobic training associated with strength and balance training, flexibility exercises, secondary prevention interventions, dietary counselling, risk factor control and psychosocial management (Table 9). The main goals of cardiac rehabilitation in the aging patient are preservation of mobility, independence and mental function, prevention of sarcopenia and frailty, prevention/treatment of anxiety and depression, improvement of QoL, encouragement of social adaptation and reintegration, and return of patient to the same lifestyle as before the acute event (Table 9).

Table 8. Core components of cardiac rehabilitation in peripheral artery disease.

Components	Established/agreed issues	Class (level)	Issues requiring further evidence
Patient assessment	Clinical: • Any exertional limitation of the lower extremity muscles or any history of walking impairment, that is, fatigue, aching, numbness or pain. Primary site(s) of discomfort: buttock, thigh, calf or foot. Detection of typical intermittent claudication, that is, a reproducible discomfort or fatigue in the muscles of the lower extremity that occurs with exertion and is relieved with rest • Any poorly healing wounds of the legs or feet • Any pain at rest localized to the lower leg or foot and its association with the upright or recumbent positions – Reduced muscle mass, strength and endurance – Palpation of peripheral arteries and abdominal aorta with annotation of any bruises and inspection of feet for trophic defects – Ankle–brachial index measurement at rest: values 0.5–0.95: claudication range; 0.20–0.49: rest pain; less than 0.20: tissue necrosis. Consider decrease in ABI in response to treadmill test – Evaluation of functional capacity with CPET as a gold standard (preferably bike for better evaluation of central limitation). Use of other direct or indirect testing (including evaluation of activities of daily living) when CPET is not feasible or available – Direct evaluation of pain-free and maximal claudication distance (time) by treadmill test. Graded treadmill tests – rather than constant-load tests – and maximal distance (time) – rather than onset of claudication – as preferred way to measure change in walking impairment in response to exercise interventions		Concerning best medical treatment: • The usefulness of ACEI to improve walking ability is controversial • The incremental benefit of other treatments (cilostazol, naftidrofuryl, pentoxifylline, buflomedil, carnitine, propionyl-L-carnitine) in addition to exercise and statins is unknown Concerning functional evaluation: utility of other tests when CPET is not feasible
	– Testing to exclude occult CAD should be considered in PAD patients who are engaged in vigorous exercise protocols	IIa (C)	
	– Provision of best medical pharmacological therapies including antihypertensive, lipid-lowering and antithrombotic drugs. Statins are recommended in all patients with PAD	I (A)	
Physical activity counselling	Interval-walking until near maximal pain, lasting more than 30 min, every day or at least 3 times/week		
Exercise training	In patients with typical intermittent claudication supervised hospital- or outpatient clinic-based exercise programme is recommended to improve walking distance and time, functional status, and quality of life	I (A)	• Usefulness of SET in asymptomatic patients, with atypical leg symptoms, and in advanced stages (i.e. chronic limb ischaemia) • Proper identification of phase III programmes to maintain achieved benefits
	Three-month SET to be offered as a first-line therapy for intermittent claudication (revascularization and vasodilator therapy to be considered only if exercise provides insufficient symptom relief)[98]		
	SET should be considered as a treatment option for claudication before possible revascularization	I (B)	
	Unsupervised exercise training is recommended when supervised exercise training is not feasible or available	I (C)	Efficacy, safety, and adherence rate of different home-based

(continued)

Table 8. Continued

Components	Established/agreed issues	Class (level)	Issues requiring further evidence
			or community-based programmes • Efficacy, safety, and adherence rate of programmes based on digital health tools
	Frequency: 3–5 sessions per week		Utility of more than three sessions per week
	Intensity: • Treadmill exercise intensity (expressed by percentage of peak oxygen consumption and obtained by proper modulation of treadmill speed and grade) initiated to induce onset of claudication within 3–5 min and moderate to moderately severe claudication within 8–10 min • Severity of claudication to stop the exercise bout: near-maximal.[98]		Utility to stop the bout at mild claudication levels to improve physical adaptations and patients' adherence
	Type: • Treadmill-based exercise–rest–exercise: intermittent bouts of walking until the selected level of discomfort of the lower extremities followed by periods of rest until symptoms resolve. Exercise/rest bouts are repeated over the session • Warm-up and cool-down periods of 5–10 min each– • Combination of resistance-strength training to aerobic training: three sets of eight repetitions of exercises for seven different muscle groups at high (50% of 1-RM and then progression over four sessions to 80% of 1-RM) or low (20% of 1-RM and then progression over four sessions to 30% of 1-RM) intensity[99] • Upper-extremity aerobic exercise as an alternative to treadmill exercise to improve walking capacity		• Concerning resistance-strength training: determination of intensity as percentage of 1-RM; number of sets and repetitions; muscle groups • Proper identification of patients eligible for upper-extremity exercise • Effectiveness of pain free walking and leg cycling exercise training
	Time: • Session duration >30 to 60 min • Programme duration: minimum of 12 weeks with a goal of completing six months		• Effectiveness of session lasting 30–45 min • Effectiveness of intensive short programmes
	Progression of exercise: • Gradually throughout the programme to allow continued adaptation to the training stimulus • By manipulation of grade and speed of treadmill, duration of walking, number of bouts, work-to-rest ratio, session duration and claudication level to stop the exercise bout		Direct comparison of different schemes for exercise
Diet/nutritional counselling	Consider PAD patients are as having very high risk and manage accordingly with regard to lipid management: Provide a dietary and therapeutic regimen that achieves ≥50% LDL-C reduction from baseline and an LDL-C goal of <1.4 mmol/L (<55 mg/dL) No current statin use: this is likely to require high-intensity LDL-lowering therapy Current LDL-lowering treatment: an increased treatment intensity is required	I (B)	
	In diabetic patients with PADs, strict glycaemic control is recommended	I (C)	

(continued)

Table 8. Continued

Components	Established/agreed issues	Class (level)	Issues requiring further evidence
Blood pressure monitoring	In patients with PAD and hypertension, it is recommended to control blood pressure at < 140/90 mmHg (130/80 mmHg or lower in most patients when treatment is well tolerated)	I (A)	Usefulness of BP-lowering treatment in reducing the progression of the disease
	BP-lowering treatment is recommended to reduce cardiovascular risk in PAD patients	I (A)	
	A combination of a RAS blocker, CCB, or diuretic should be considered as initial therapy	IIa (B)	
	Beta-blockers may also be considered	IIb (C)	
Smoking cessation	Stopping smoking is exceptionally important in PAD, smoking-cessation programmes involving nicotine-replacement therapy, and the use of medications such as bupropion or varenicline should be encouraged	I (B)	
Psychosocial management	To improve patients' attitudes towards walking treatments and global cardiovascular risk reduction		

1-RM: one repetition maximum; ABI: ankle-brachial index; ACEI,: angiotensin-converting enzyme inhibitor; BP: blood pressure; CAD: coronary artery disease; CCB: calcium channel blocker; CPET: cardiopulmonary exercise testing; SET: supervised exercise training; LDL-C, low-density lipoprotein cholesterol; PAD, peripheral arterial disease; RAS: renin–angiotensin system

Frail patients

Frailty has been defined as increased vulnerability to stress characterized by declines in multiple physiologic systems predisposing to a higher risk of negative outcomes, disability and death.[111] Several instruments, encompassing the physical, nutritional, cognitive and psychosocial domains of health, have been used to evaluate frailty in community living elderly populations or in hospital settings.[112–114]

Frailty has been described in 10–50% of elderly patients admitted after an acute cardiac event, and it has proved to be an independent prognostic indicator even in these patients.[115] However, due to selection bias and to several barriers, frail patients, potential candidates to cardiac rehabilitation, are poorly represented in cardiac rehabilitation studies.[116] Therefore, the real frequency and impact of frailty on cardiac rehabilitation outcome is still unknown. Yet, to date frailty assessment has not been introduced as a standard method in elderly cardiac rehabilitation patients, and it is still uncertain which would be the optimal diagnostic tool in this setting. A recent call to action by EAPC recommended that some of these tools be adopted by cardiac rehabilitation cardiologists in their routine assessment, particularly of patients >75 years old.[116]

Cardiac rehabilitation programmes should be tailored according to the results of frailty evaluation. Exercise programmes in frail elderly patients in cardiac rehabilitation focused particularly on multicomponent interventions, mainly resistance exercises, associated with aerobic, flexibility, balance, and coordination training, tailored to the severity of frailty.[117,118] They reported improvement in physical function, functional capacity, balance and QoL and reduction of frailty and re-hospitalizations, mainly as hospital-based interventions. The independent role of balance training, nutritional supplementation and risk factor management, as the role of home-based cardiac rehabilitation or the new technologies, remains still undefined in this complex population. Prehabilitation can be useful in frail patients for improving functional recovery after interventions in very frail patients.[119]

Based on this limited experience, the exercise programme and other components of cardiac rehabilitation that can be adopted in frail elderly patients >75 years old can be schematically detailed as in Table 10. Future studies should test which type of intervention, tailored to frailty presence and severity, is more effective in improving specific outcomes (e.g. cognitive function, sureness of movement) in this population.

Women

Women benefit from comprehensive cardiac rehabilitation as much as men, however, with lower rates of both referral to and attendance of cardiac rehabilitation, and with higher mortality rates among those not referred.[120] The provision of cardiac rehabilitation in women needs to take into account that women are more likely to have a worse risk factor profile, to be obese and to have a lower exercise and functional capacity.[121] Anxiety and depression, known risk

Table 9. Core components of cardiac rehabilitation in elderly patients.

Components	Established/agreed issues	Class (level)	Issues requiring further evidence
Patient assessment	• Clinical history: cardiovascular disease (e.g. CAD, HF, atrial fibrillation, PAD, stroke, renal failure) and risk factors • Concomitant diseases (e.g. COPD, visual/hearing impairment, arthritis, osteoporosis, urinary incontinence, cognitive impairment, dementia) • ADLs and falls • Formulation of an individualized cardiac rehabilitation programme based on individual goals and internal motivation	I (A)	• Feasibility and usefulness of Multidimensional Geriatric Assessment in patients $>$ 75 years • Feasibility and usefulness of Frailty evaluation in patients $>$ 75 years
Physical activity counselling	Emphasize participation in supervised group activities to improve social integration and support	I (A)	
Exercise training	Tailored exercise recommendations: prescriptions for a given patient should: • Depend on associated comorbidities and on the baseline physical capacity and existing activity limitation • Include activities to develop endurance, strength, flexibility, coordination and balance • Start at a very low level and gradually progress to a goal of moderate activity in order to prevent exercise-induced symptoms or complications • Aerobic training workload should be prescribed initially at light to moderate intensity 35–70% of peak HR or 40–60 % of VO_{2peak}) and raised, if tolerated, to a 70–85% of peak HR or 60–80% of VO_{2peak} Frequency of sessions should range between three and four per week aiming for a duration of 30 min per session. Sometimes elderly patients require more than 12 weeks to reach optimal conditioning Resistance training is recommended on alternate days of aerobic sessions at light–moderate intensity (30–70% of 1-RM) and increased, if tolerated and in selected patients, to moderate–high intensity (70–85% 1-RM), with 8–12 repetitions involving 6–8 groups of skeletal muscles. This set may be repeated 2–3 times, if tolerated, for a total duration of 40–60 min Select exercise appropriate to musculoskeletal conditions in older patients Avoid exercises that require rapid postural variations for orthostatic hypotension risk	I (A)	Tailored exercise programme for frail patients: see the Frailty subsection
Diet/nutritional counselling	Encourage adequate caloric and protein intake	I (A)	
Weight control management	• Less likely to be severely obese than younger patients, especially those with HF which are at higher risk to develop cardiac cachexia • BMI 28–29 kg/m^2 is the target value	I (A)	
Lipid management	Benefit from lipid-lowering medication (statins) as for other patients, if comorbidities and frailty are absent	I (A)	
Blood pressure monitoring	• Target BP in older people is 130–139/80 mmHg, if tolerated. Treated values of less than 130 mmHg should be avoided • Monotherapy and low doses are advised at the onset • Caution for comorbidities and associated drugs • Weight reduction and low salt intake are part of the treatment in non-sarcopenic patients	I (A)	

(continued)

Table 9. Continued

Components	Established/agreed issues	Class (level)	Issues requiring further evidence
Smoking cessation	Encourage smoking cessation as in young adults	I (A)	
Psychosocial management	Aim to identify and reduce depression and anxiety, improve social adaptation and reintegration as well as overall quality of life	I (A)	
Home-based CR		IIb C	Whether home-based CR may improve patients' enrolment and adhesion in elderly patients is still unproven

1-RM: one repetition maximum; ADL: activities of daily living; BMI: body mass index; BP: blood pressure; CAD: coronary artery disease; COPD: chronic obstructive pulmonary disease; CR: cardiac rehabilitation; HF: heart failure; HR: heart rate; PAD: peripheral arterial disease

factors for adverse cardiac outcomes and mortality,[122] are more likely to be present in women. These gender specificities need to be taken into account in order to optimize secondary prevention in women.[123]

Diabetes mellitus

Improvement of physical fitness and physical activity through exercise interventions is recommended in the treatment/care of patients with type 1 and type 2 diabetes mellitus (T1DM and T2DM, respectively).[124] Documented effects of exercise interventions include favourable changes in glycaemic control (as evidenced by reductions in blood glycated haemoglobin by ~0.7%) and lipid profile, reductions in adipose tissue mass and blood pressure, and elevations in physical fitness.[14,125,126] An intensive lifestyle intervention (including diet and physical activity) among overweight/obese T2DM patients reduces long-term disability (incidence rate ratio 0.88), thereby elevating disability-free life expectancy, but not affecting total life expectancy.[127] However, significant lower mortality rates have been noticed in physically active T2DM patients, as opposed to sedentary T2DM patients (hazard ratio 0.61).[128] In T1DM patients, a greater physical activity level is associated with a lower risk of all-cause or cardiovascular mortality.[129]

In cardiac patients referred to cardiac rehabilitation presenting diabetes mellitus as a comorbidity, next to the evaluation of the cardiovascular risk profile and glycaemic control in the intake screening, it is recommended to execute a cardiopulmonary exercise test ahead of exercise intervention, regardless of the planned exercise type or intensity, to rule out, or allow treatment of, exercise-induced arterial hypertension and/or silent myocardial ischaemia.[130–132] Moreover, clinicians should be aware of the intake/administration of medications that are associated with elevated risk for hypoglycaemia during or after exercise (e.g. meglitinide, sulphonylurea, exogenous insulin injections), as well as the presence of nephropathy, retinopathy, peripheral or autonomic neuropathy and/or foot deformations/wounds.

In T2DM patients, it is additionally recommended to offer nutritional counselling and physical activity counselling, provide guideline-directed medical therapy, smoking cessation intervention and psychosocial support and adhere to a patient-centred care model. Recommendations for exercise and physical activity (Table 11) are not very different for T1DM patients.[14,133–137] However, T1DM patients are more prone to experience hypoglycaemic episodes after exercise training, for which high intensity interval sprint training or moderate-to-high intensity strength training is advised at the end of an aerobic training session, if permitted by cardiac conditions, as it promotes increased oxidative capacity of skeletal muscle with attenuated rates of glycogen breakdown.[138] Moreover, T1DM patients should more carefully monitor changes in blood glucose during exercise and ingest carbohydrates when hypoglycaemia is expected. In all diabetes patients under exogenous insulin injection treatment, the last insulin dose should be lowered in line with the planned activity, and close glucose monitoring during exercise should be considered with ingestion of carbohydrates when hypoglycaemia is expected.[126] Moreover, additional safety precautions should be considered during exercise training in the case of nephropathy (e.g. avoid exercise hypertension), retinopathy (e.g. avoid exercise hypertension), peripheral and autonomic neuropathy (e.g. be aware of balance disorders or disturbed blood pressure/heart rate response to exercise) and foot deformations/wounds (e.g. be aware of orthopaedic symptoms or bacterial infections).

Table 10. Core components of cardiac rehabilitation in frail patients.

Components	Established/agreed issues	Issues requiring further evidence
Patient assessment	• MGA should be performed in patients > 75 years including evaluation of comorbidities, psycho-cognitive deterioration, physical function, functional capacity, nutritional status, sarcopenia, disability and social deprivation • Frailty should be evaluated with appropriate tools in patients > 75 years	• Testing feasibility of MGA in CR environment • Standardization of Frailty tool • Evaluation of frailty as an independent prognostic indicator
Physical activity counselling	Supervised individual activities to prevent or limit disabilities. Visual and hearing impairments, comorbidities, physical limitations and cognitive status must be taken into account	
Exercise training	• Strength exercises of 6/8 major muscle groups of upper and lower extremities • Exercise starting at light–moderate intensity (30–70% of 1-RM) with 6–8 repetitions, and gradually increased to moderate–high intensity (70–85% 1-RM) and to 12 repetitions, if tolerated and permitted by session time • Two to three sets for a total duration of 40–60 min. 5–10 min allowed between different types of exercises and sets. Frequency of sessions 2/3 per week. Length of the programme at least 3–6 months • Aerobic training: in many frail patients unable to perform a baseline or cardiopulmonary exercise stress test aerobic training load should be set at a HR slightly lower than that achieved in 6minWT • Borg scale and the 'speech rule' are useful to keep resistance or aerobic training intensity within safe limits, in patients able to report symptoms during exercise • HR, BP and clinical monitoring are important for identifying symptoms, fatigue or discomfort • Balance training includes static and dynamic balance components • Expected outcome: improving physical capacity and quality of life; reducing disability, frailty level, institutionalization In extremely frail patients the intensity and frequency of exercises should be reduced. Some of these patients may only require bed mobilization and postural training or supported walking. Progression needs to be very slow	• Designing tailored type and intensity of intervention • Testing the efficiency of tailored interventions in improving specific outcomes • Balance training independent effect on long term independence and fall prevention is still uncertain
Diet/nutritional counselling	Nutritional supplementation alone (high quality proteins 15–30 g/day (e.g. whey proteins), essential amino acids 10 g/day or leucine 3 g/day) has small effects on sarcopenia/frailty, but, if combined with strength and endurance exercise, can contribute to reducing frailty severity	• Role of other micronutrients is uncertain • Benefit of iron supplementation is still to be evaluated in frail CR patients with HF
Weight control management	Effort to improve sarcopenia rather than reduce BMI, especially in HF patients at higher risk of cardiac cachexia.	
Lipid management	Benefit from lipid lowering medication (statins) should be balanced against possible risks from associated comorbidities, side effects and reduced life expectancy	
Blood pressure monitoring	Decision to treat hypertension must consider the patient's clinical status, polypharmacy and frailty. A personalized approach is advised with monitoring of drug induced complication (hypotension, fall, electrolyte imbalance, renal failure)	Whether BP-lowering treatment benefits the very frail patients is still uncertain
Psychosocial management	Transition of care to long-term geriatric centres should be evaluated individually	
Prehabilitation	In frail patients tailored exercise interventions before surgical or invasive procedures may be useful to improve post-operative functional recovery	Preliminary studies available. Standardization is needed

1-RM: one repetition maximum; 6minWT: six minute walk test; BMI: body mass index; BP: blood pressure; CR: cardiac rehabilitation; HF: heart failure; HR: heart rate; MGA: Multidimensional Geriatric Assessment; PAD: peripheral arterial disease

Table 11. Core components of cardiac rehabilitation in diabetes mellitus.

Components	Established/agreed issue	Class (level)	Issues requiring further evidence
Patient assessment	• Screening for potential DM in patients with CVD is initiated with HbA1c and FPG; OGTT added if HbA1c and FPG are inconclusive	I (A)	Further work needs to be carried out to establish the effect of sex and ethnicity on diagnostic criteria
	• An OGTT is used for diagnosing IGT	I (A)	
	• A resting ECG is indicated in patients with DM diagnosed with hypertension or with suspected CVD	I (A)	
	• Stress testing (exercise ECG, radionuclide myocardial perfusion imaging, or exercise or pharmacological stress echocardiography) or CTCA may be considered in asymptomatic patients with DM for screening of CAD. Stress testing in all patients with both DM and CVD is recommended	I (A) IIb (B)	
Diet/nutritional counselling	• Reduced caloric intake is recommended for lowering excessive body weight in pre-DM and DM	I (A)	Ethnicity and diet
	• A Mediterranean diet, rich in polyunsaturated and mono-unsaturated fats, is recommended to reduce CV outcomes	I (A)	
Physical activity counselling	Moderate-to-vigorous physical activity for $\geq$150 min/week is recommended for the prevention and control of DM, unless contraindicated, such as when there are severe comorbidities or a short remaining life expectancy	I (A)	The role and impact of sedentary behaviour remains to be studied in greater detail
Exercise training	• In T2DM patients, it is recommended to exercise at least 3–5 days/week at least 30 min per session at a moderate-to-high intensity (at least 50–70% peak oxygen uptake)	I (A)	The optimal dose of strength training in cardiac patients with DM requires further evidence
	• Two to three strength training sessions per week (add-on to aerobic training) involving large muscle groups at an intensity of 70–85% of 1-RM (8–10 repetitions) are recommended, ideally reaching at least 21 sets	I (A)	
Lipid management	• Statin therapy is recommended in patients with DM at very high CV risk, with an LDL-C target of $<$1.4 mmol/L ($<$55 mg/dL) or at least a $\geq$50% reduction in LDL-C if this target goal cannot be reached	I (A)	The optimal LDL-C level needs to be established The impact of PCSK9 antibodies on CV outcome in DM needs clarification
	• Statin therapy is recommended in patients with DM at high CV risk, with an LDL-C target of $<$1.8 mmol/L ($<$70 mg/dL)	I (A)	
	• Statins should be considered in patients with T1DM at high CV risk (microalbuminuria and/or renal disease), irrespective of the basal LDL-C level (target lowering $\geq$50%)	IIa (A)	
	• Intensification of statin therapy should be considered before the introduction of combination therapy	IIa (C)	
	• If the goal is not reached, statin combination with a cholesterol absorption inhibitor should be considered	IIa (B)	
	• In patients at very high risk, with persistent high LDL-C $\geq$140 mg/dL despite treatment with maximal tolerated statin dose, in combination with ezetimibe or in patients with statin intolerance, a PCSK9 inhibitor should be considered	IIa (B)	
Blood pressure management	• It is recommended that a patient with hypertension and DM be treated in an individualized manner, targeting a BP of 130–139/80–90 mmHg, with SBP values closer to 130 mmHg being preferable	I (A)	The effects of BP-lowering multiple drug combinations in the elderly are poorly understood
	• Lifestyle changes (weight loss if overweight, physical activity, alcohol restriction, sodium restriction, vegetables (e.g. 2–3 servings) and low-fat dairy products) are recommended in patients with DM and pre-DM with hypertension	I (A)	Optimal BP targets are unknown, particularly in young patients with T1DM, recent onset T2DM and

(continued)

Table 11. Continued

Components	Established/agreed issue	Class (level)	Issues requiring further evidence
	• A RAAS blocker (ACEI or ARB) is recommended in the treatment of hypertension in DM, particularly in the presence of microalbuminuria, albuminuria, proteinuria, or LV hypertrophy	I (A)	DM with CAD The risk and effects of microvascular complications of BP-lowering drugs are unclear
	• In patients with IFG or IGT, RAAS blockers should be preferred to beta-blockers or diuretics to reduce the risk of new-onset DM	IIa (A)	
	• Home BP self-monitoring encouraged in DM	IIa (C)	
Glucose management	• It is recommended to apply tight glucose control, targeting a near-normal HbA1c (<7.0% or <53 mmol/mol) to decrease microvascular complications in DM	I (A)	More work is needed to define a 'personalized' target for patients with DM The role of the new glucose monitoring technologies (continuous glucose monitoring and electronic ambulatory glucose) in the control of post-prandial glycaemia and glucose values needs to be defined Measuring glycaemia at 1 h instead of at 2 h during an OGTT for the diagnosis of pre-DM and DM needs validation
	• It is recommended that HbA1c targets are individualized according to duration of DM, comorbidities and age	I (C)	
	• Metformin is first-line treatment in DM without CVD	I (A)	
	• Empagliflozin or canagliflozin is recommended in DM and CVD/high CV risk to reduce CV events	I (A)	
	• Liraglutide or semaglutide is recommended in DM and CVD/high CV risk to reduce CV events	I (A)	
	• The use of self-monitoring of blood glucose is stimulated to facilitate optimal glycaemic control	IIa (A)	
	• Severe hypoglycaemia should be avoided	I (C)	
Antiplatelet therapy	• Aspirin at a dose of 75–160 mg/day is recommended as secondary prevention in DM	I (A)	Trials in patients with DM are needed to optimize antithrombotic therapy in secondary prevention
	• A P2Y12 receptor blocker is recommended in patients with DM and ACS for one year on top of aspirin, and in those subjected to PCI. In patients with PCI for ACS, it is preferable that prasugrel or ticagrelor be given	I (A)	
	• Clopidogrel is recommended as an alternative antiplatelet therapy in the case of aspirin intolerance	I (A)	
Tobacco use	Smoking cessation is obligatory and passive smoking should be avoided.	I (A)	
Psychosocial management	Screening of all diabetic patients for psychological disorders (very frequent) and adequate management according to the disorder by specialist (psychologist/psychiatrist)		Further research is required
Patient-centred care and education	• Patient-centred group-based education is recommended in patients with DM, to improve glycaemic control, DM knowledge, disease management and patient empowerment	I (A)	Further research is required to determine the effect of group- and individually-based patient education on CVD risk factors
	• Patient-centred care is recommended to facilitate shared control and decision-making within the context of patient priorities and goals	I (C)	
	• Provision of individual empowerment strategies is recommended to enhance self-efficacy, self-care, and motivation in patients with DM	IIa (B)	

1-RM: one repetition maximum; ACEI: angiotensin-converting enzyme inhibitor; ACS: acute coronary syndrome; ARB: angiotensin II receptor blocker; BP: blood pressure; CAD: coronary artery disease; CTCA: computed tomography coronary angiography; CV: cardiovascular; CVD: cardiovascular disease; DM: diabetes mellitus; ECG: electrocardiogram; FPG: fasting plasma glucose; HbA1c: haemoglobin A1c; IFG: impaired fasted glucose; IGT: impaired glucose tolerance; LDL-C: low-density lipoprotein cholesterol; LV: left ventricular; OGTT: oral glucose tolerance test; PCI: percutaneous coronary intervention; PCSK9: proprotein convertase subtilisin/kexin type 9; RAAS: renin–angiotensin–aldosterone system; SBP: systolic blood pressure; T1DM: type 1 diabetes mellitus; T2DM: type 2 diabetes mellitus

History of transient ischaemic attack/stroke

In the treatment and care of transient ischaemic attack (TIA) and stroke, exercise-based cardiac rehabilitation is important. In acute stroke, early mobilization is associated with an increased Barthel Index and shorter hospital stay for patients.[139] Following hospital discharge after stroke, exercise-based cardiac rehabilitation does lead to improvements in physical functioning and exercise capacity (and hence independence), quality of life and blood pressure, but no significant effects are noticed on long-term cardiovascular event rates and other cardiovascular risk factors, reiterating the need for optimization of exercise intervention in this population.[140] Similar results have been reported in patients recovering from TIA.[141]

In ambulatory exercise-based cardiac rehabilitation, a detailed pre-participation screening is important to rule out or treat risk factors for recurrent TIA or stroke. In this regard, patients should undergo clinical evaluation by a healthcare professional with expertise in stroke care to determine risk for recurrent stroke and initiate appropriate investigations and management strategies.[142,143]

Next to exercise training and rehabilitation, it is mandatory that patients recovering from TIA or stroke should receive a multidisciplinary treatment in which the following items are targeted: cardiovascular risk factors (body weight, blood lipid profile, glycaemic control, blood pressure), diet, oral contraceptives and hormone replacement therapy, drug use, antiplatelets and smoking behaviour. Especially for exercise training and rehabilitation, it is important that individuals with stroke undergo graded exercise testing with ECG monitoring as part of a medical evaluation before beginning an exercise programme.[143] Moreover, as patients with stroke are at an elevated risk to fall during ambulation, fall risk should be assessed and patients should be supervised closely in the first weeks of intervention.[143] In addition, neurological symptoms leading to disability and/or problematic ambulation should be examined in greater detail. Detailed exercise prescriptions can be found in Table 12. However, more evidence is still needed to identify the appropriate exercise training for the right patient at the right time window after stroke: a recent multicentre trial, indeed, revealed that low intensity aerobic exercise coupled with standard rehabilitation after 4–45 days from ischaemic or haemorrhagic stroke, did not improve functional capacity as expressed by changes in maximal walking speed and Barthel index, being conversely associated with higher rates of adverse events.[144]

History of chronic obstructive lung disease

In patients with chronic obstructive pulmonary disease (COPD), cardiovascular comorbidities are highly prevalent and associated with considerable morbidity and mortality. The coincidence is increasingly seen in the context of a 'cardiopulmonary continuum' rather than being simply attributed to shared risk factors such as smoking.[145] This leads to a relevant proportion of cardiac patients with COPD, currently around 6% to 20% in contemporary European cardiac rehabilitation programmes.[105,110] Advanced COPD stages are associated with a deterioration of exercise capacity, cachexia and skeletal muscle dysfunction, comparable to patients with heart failure.[146] COPD patients in groups B to D will benefit from pulmonary rehabilitation to improve dyspnoea, health status and exercise tolerance and to reduce exacerbations and hospitalizations.[146] COPD patients with concomitant cardiac diseases can be integrated into cardiac rehabilitation programmes, adapted to the requirements of the underlying pulmonary disease and group. Patient management (pharmacological therapy, vaccinations, oxygen therapy) should be performed in close cooperation with a pulmonologist[146] (Table 13).[147]

History of chronic kidney disease

Cardiovascular diseases remain the most common cause of morbidity and mortality in patients with chronic kidney disease (CKD).[148] Contemporary cardiac rehabilitation programmes in Europe report a prevalence of CKD of 7% in elderly (>65 years) cardiac patients.[105] Depending on the duration and classification of renal failure a moderate to severe reduction of physical capacity can be assumed, generated by renal anaemia, uraemic myopathy and polyneuropathy, disturbances in volume status, electrolyte balance and/or acid-base metabolism, physical inactivity as well as immunosuppressive therapy in patients after kidney transplantation.[149] Exercise recommendations for patients with CKD do not differ from those for cardiac patients[149] and integration into a cardiac rehabilitation programme is usually feasible (Table 14).[150] Patients receiving haemodialysis may require adapted programmes.[151] The stage-based treatment of CKD should be performed in close cooperation with the nephrologist.

Cancer patients

Cancer and cardiovascular diseases share common risk factors, including aging, smoking habit, alcohol abuse, unbalanced diet and physical inactivity, thus leading to similar strategies of prevention and the potential of 'cardio-oncology rehabilitation'. Above all, exercise is able to reduce some negative effects of cancer therapies – such as fatigue, pulmonary and immune system dysfunction, lymphoedema and cardio-toxicity[152] – as far as to limit the growth of neoplastic

Table 12. Core components of cardiac rehabilitation in patients with transient ischaemic attack/stroke.

Components	Established/agreed issue	Level of evidence	Issues requiring further evidence
Patient assessment	• Patients presenting more than two weeks following a suspected transient ischaemic attack or non-disabling ischaemic stroke may be considered as being less urgent, and should be seen by a neurologist or stroke specialist for evaluation, ideally within one month of symptom onset	C	
	• Persons at risk of stroke and patients who have had a stroke should be assessed for vascular disease risk factors (including atrial fibrillation), lifestyle management issues (diet, sodium intake, exercise, weight, alcohol intake, smoking), as well as use of oral contraceptives or hormone replacement therapy	B	
	• Patients should be assessed for neurological impairments and functional limitations when appropriate (e.g. cognitive evaluation, screening for depression, screening of fitness to drive, need for potential rehabilitation therapy, and assistance with activities of daily living), especially for patients who are not admitted to hospital	B	
Diet/nutritional counselling	• Counsel and educate to follow a Mediterranean-type diet, which is high in vegetables, fruit, whole grains, fish, nuts and olive oil and low in red meat	B	
	• Counsel and educate to have a total intake of free sugars that does not exceed 10% of total daily calorie (energy) intake	B	
	• Counsel and educate to have a daily sodium intake from all sources to no more than 2000 mg/day	A	
	• Counsel and educate patients to follow limit alcohol intake: for women, no more than 10 drinks per week, with no more than two drinks per day most days and no more than three drinks on any single occasion; for men, no more than 15 drinks per week, with no more than three drinks per day most days and no more than four drinks on any single occasion	C	
Physical activity counselling	Counsel and educate individuals with transient ischaemic attack or stroke to reduce sedentary behaviours and to work towards increased activity goals as tolerated throughout their stroke recovery	B	
Exercise training	During hospitalization and early convalescence (acute phase): • Low-level walking, self-care activities • Intermittent sitting or standing • Seated activities • Range of motion activities, motor challenge • $\approx$10 to 20 beats/min increases in resting HR; RPE $\leq$11 (6–20 scale); frequency and duration as tolerated, using an interval or work–rest approach Inpatient and outpatient exercise therapy or rehabilitation: Aerobic • Large-muscle activities (e.g. walking, graded walking, stationary cycle ergometry, arm ergometry, arm–leg ergometry, functional activities seated exercises, if appropriate • 40–65% VO_2 reserve or HR reserve; 55%–80% HR max; RPE 11–14 (6–20 scale)	A	

(continued)

Table 12. Continued

Components	Established/agreed issue	Level of evidence	Issues requiring further evidence
	• 3–5 days/week • 20–60 min/session (or multiple 10-min sessions) • 5–10 min of warm-up and cool-down activities Muscular strength/endurance • Resistance training of extremities, trunk using free weights, weight-bearing or partial weight-bearing activities, elastic bands, spring coils, pulleys • Circuit training • 1–3 sets of 10–15 repetitions of 8–10 exercises involving the major muscle groups at 50–80% of 1-RM • 2–3 days/week • Resistance gradually increased over time as tolerance permits Flexibility • Stretching (trunk, upper and lower extremities) • Static stretches: hold for 10–30 s • 2–3 days/week (before or after aerobic or strength training) Neuromuscular • Balance and coordination activities • Tai chi • Yoga • Recreational activities using paddles/sport balls to challenge hand–eye coordination • Active-play video gaming and interactive computer games • Use as a complement to aerobic, muscular strength/endurance training and stretching activities • 2–3 days/week		
Body weight	Counsel and educate patients to achieve a BMI up to 24.9 kg/m^2 or a WC of $<$88 cm for women and $<$94 cm for men	B	
Lipid management	• Patients with ischaemic stroke or transient ischaemic attack should be managed with aggressive therapeutic lifestyle changes to lower lipid levels, including dietary modification, as part of a comprehensive approach to lower risk of first or recurrent stroke unless contraindicated	B	
	• Patients with a history of ischaemic stroke or transient ischaemic attack are at very high risk of ASCVD, particularly recurrent ischaemic stroke, and should be managed accordingly (see Table 1)	A	
Blood pressure management	• For patients who have had a stroke or transient ischaemic attack, blood pressure lowering treatment is recommended to achieve a target of consistently lower than 140/90 mmHg.	B	Randomized controlled trials have not yet defined the optimal time to initiate blood pressure lowering therapy after stroke or transient ischaemic attack
	• For patients who have had a small subcortical stroke, blood pressure lowering treatment to achieve a systolic target of consistently lower than 130 mmHg is reasonable	B	
Glucose management	• Glycaemic targets should be individualized; however, lowering HbA1c values to $\leq$7% in both type 1 and type 2 diabetes and stroke or transient ischaemic attack provides strong benefits for the prevention of microvascular complications	A	
		B	

(continued)

Table 12. Continued

Components	Established/agreed issue	Level of evidence	Issues requiring further evidence
	• To achieve a target of HbA1c $\leq$7.0%, most patients with type 1 or type 2 diabetes should aim for a fasting plasma glucose or pre-prandial plasma glucose target of 4.0 to 7.0 mmol/L		
Antiplatelet therapy	• All patients with ischaemic stroke or transient ischaemic attack should be prescribed antiplatelet therapy for secondary prevention of recurrent stroke unless there is an indication for anticoagulation	A	At the present time, there is not enough evidence to guide management if a patient has a stroke while on a specific antiplatelet agent
	• Acetylsalicylic acid (80–325 mg daily), combined acetylsalicylic acid (25 mg) and extended-release dipyridamole (25 mg/200 mg twice daily) or clopidogrel (75 mg daily) are all appropriate options and selection should depend on the clinical circumstances	A	
Tobacco use	Smoking cessation is obligatory and passive smoking should be avoided	A	
Oral contraceptives and hormone replacement therapy	Oestrogen-containing oral contraceptives or hormone replacement therapy should be discouraged or discontinued in female patients	B	
Drug use	Individuals with stroke and known recreational drug use that may increase the risk of stroke (such as cocaine, amphetamines) should be counselled to discontinue use if not prescribed for medical indications	C	
Psychosocial management	In selected patients		

1-RM: one repetition maximum; ASCVD: atherosclerotic cardiovascular disease; BMI: body mass index; HbA1c: haemoglobin A1c; HR: heart rate; RPE: rating of perceived exertion; WC: waist circumference

cells.[153] Moreover, cancer survivors have an increased risk of relapses, second cancers, cardiovascular diseases, fatigue, bone loss and psychosocial distress, all conditions in which structured exercise training has documented beneficial effects.[154] For these reasons, active cancer patients and cancer survivors referred to cardiac rehabilitation programmes (independently from the cardiovascular diagnosis for referral) should receive appropriate exercise programmes in a multidisciplinary approach (see Gilchrist et al.[25] for detailed prescription, which is outside the scope of the present position paper).

As a form of general advice, endurance training can sometimes be difficult to sustain for frail and debilitated cancer patients. In this situation strength training, due to its greater anabolic potential, may be an appropriate starting point for an exercise programme.[155] The application of strength training in the upper body may improve pain and disability especially in patients treated for breast and head cancer, with the need for appropriate balance between intensity, that is, the percentage of one repetition maximum and training volume (intensity, number of repetitions and sets). Concerning aerobic training, specific attention should be paid to intensity, since efforts classified as below the first ventilatory threshold could be vigorous or even unsustainable in cancer patients with cachexia or treatment-related symptoms. Finally, IMT could be useful in thoracic cancer patients and could be routinely prescribed in this patient population.[154]

Non-adherent patients

Adherence is the extent to which a person's behaviour – taking medication, following a diet and executing lifestyle changes – corresponds with the agreed recommendations from a healthcare provider.[156] Adherence is a more innovating concept than compliance, which implies patients passively following the doctor's orders and treatment plans not based on a therapeutic

Table 13. Core components of cardiac rehabilitation in patients with chronic obstructive lung disease.

Components	Established/agreed issue
Patient assessment	• Spirometry (airflow limitation should be classified based on post-bronchodilatator FEV1 (GOLD grade 1 to 4)) • Symptoms should be assessed based on the modified MRC dyspnoea scale, and the COPD assessment tool. Together with the history of exacerbations, COPD can be grouped in stages A to D. • Cardiopulmonary exercise testing (exercise capacity, differentiation of the leading cause of a reduced exercise capacity, definition of training zones based on the first ventilatory threshold) is the preferred exercise test, in addition to six minute walk test • Echocardiography (exclusion/diagnosis of pulmonary hypertension; cor pulmonale)
Physical activity counselling	Introduction to peak flow-based self-management
Exercise training	ET prescriptions should depend on the baseline level of physical capacity and the COPD severity. The programme should include endurance (interval training), resistance exercise (especially lower body exercise), breathing exercise and instruction into postures to help shift and cough up phlegm Patients with measurable obstruction should be advised to use a bronchodilator medication before starting the exercise. In the case of post-bronchodilator FEV1: • More than 75%, the patient can be integrated into the regular CR exercise training regime • Less than 75% $>$ 50% the level of endurance exercise should be reduced by 10–15% • Less than 50%, participation in low dose endurance/interval cycle ergometer training as well as gymnastics • Borg-Dyspnoea-Scale value $\leq$5, breathing rate $\leq$20/min is advisable • Less than 30%, O_2 saturation should not exceed values less than 90%
Educational programme	Self-management of COPD and cardiac disease
Diet/nutritional counselling	Nutritional supplement therapy to improve undernutrition and to prevent progression and exacerbation of COPD and supress inflammatory response[147]
Smoking cessation	Stopping smoking is a particularly important intervention and all forms of treatment programme should be offered

COPD: chronic obstructive pulmonary disease; CR: cardiac rehabilitation; ET: exercise training; FEV1: forced expiratory volume in one second; MRC: Medical Research Council

alliance. Good adherence to evidence-based medication regimens in CAD is related to at least one-third risk reduction of all-cause mortality,[157] while unsatisfactory adherence rates (defined as a medication possession ratio or a proportion of treatment days covered lower than 80%) are associated with increased cardiovascular events in a wide range of cardiac conditions including ACS, CHF and PAD,[158–160] as far as in major traditional risk factors such as arterial hypertension.[161]

The evaluation of adherence levels, screening for non-adherence, and promotion of global adherence to pharmacologic therapies and lifestyle should be included among core components of a modern cardiac rehabilitation programme. Patients with advanced age or multiple comorbidities often display high non-adherence rates during the cardiac rehabilitation programme,[30] with related need for a targeted intervention. Similarly to smoking cessation intervention, a Five As model for facilitating adherence could be applied: Ask (identify and document adherence status for every patient at every rehabilitation programme), Advise (recommend every patient to take the whole prescribed drug regimen and adopt all lifestyle changes), Assess (evaluate in every patient their adherence levels, causes, barriers and consequences on morbidity and mortality), Assist (adopt counselling and pharmacotherapy simplification – for instance by using fixed-dose combinations[162] – to help patients in maintaining satisfactory adherence levels), and Arrange (schedule appropriate follow-up for continuing adherence evaluation).

When appropriately delivered and integrated with secondary prevention intervention, participation in cardiac rehabilitation programmes may provide better medication adherence, as confirmed by the EUROASPIRE IV survey[163] in patients after ACS and/or revascularization procedures.

Future perspectives

The EAPC's core components for cardiac rehabilitation represent the best possible actions to provide coordinated and tailored activities of secondary prevention in a wide context of cardiovascular diseases, by considering the whole pattern of medical risk management and cardioprotective drugs, structured exercise, and lifestyle modification/psychosocial intervention. This 2020 publication includes nine traditional core

Table 14. Core components of cardiac rehabilitation in patients with chronic kidney disease.

Components	Established/agreed issue
Patient assessment	• Risk factors (hypertension, diabetes, family history of kidney disease) and symptoms of CKD (e.g. proteinuria) • Risk stratification according to the KDIGO 2012 categories (low, moderate, high, very-high risk, based on albuminuria A1–A3, and glomerular filtration rate G1 to G5) should be performed
Exercise training	The programme should include a combination of endurance and resistance exercise (especially lower body exercise) and activities to develop flexibility, coordination and body awareness. See Gollie et al.[150] for other programme details For a given patient, ET should depend on the baseline level of physical capacity and the CKD severity. In low to high risk patients, the CKD usually does not affect the exercise programme, which should be deduced by the heart disease. In very high risk CKD and haemodialysis patients ET may have to be adopted Special advices for haemodialysis patients: • To avoid injury of the arteriovenous fistula and pain in the shunt-arm: the puncture-area should be protected with dressing while exercising • Patients should not wear wristwatches or wristbands • BP should not be measured on the shunt-arm side • HR can more easily be measured on the shunt-arm side • Avoid exercises (gymnastics and resistance exercises) which include pressing on the arms and/or holding the arms in head up position • ET should be performed on the day between haemodialysis treatments Special advice for patients after kidney transplantation • Consider the vulnerability of the kidney transplant in the fossa iliaca directly under the abdominal wall, the reduced perfusion of the transplant and adverse effects of the immunosuppressive therapy • Avoid exercises performed in face down position and extreme stretching exercises for the upper part of the body
Educational programme	Self-management of CKD and cardiac disease
Diet/nutritional counselling	• In patients with higher stage of the CKD hyper-phosphataemia and hypocalcaemia have to be considered and the intake of foods rich in phosphate (e.g. milk products, eggs and meat) should be reduced, whereas calcium supplementation is recommended • The intake of food rich in potassium (e.g. fresh fruits, nuts, fruit juice) should be reduced • The supplementation of a vitamin D analogue (calcitol, afacitol or paracitol) should be considered in stage V CKD; supplementation of water soluble vitamins should be considered
Lipid management	Patients with CKD are considered to be at high (stage 3 CKD) or very-high risk (stage 4–5 CKD or on dialysis) of CVD, and should be managed accordingly
Blood pressure monitoring	Arterial hypertension as the leading risk factor should properly be detected and treated, according to CKD-specific targets

BP: blood pressure; CKD: chronic kidney disease; CVD: cardiovascular disease; ET: exercise training; HR: heart rate

components (i.e. patient assessment, physical activity counselling, exercise training, diet/nutritional counselling, weight control management, lipid management, blood pressure management, smoking cessation, and psychosocial management) to be considered among seven major clinical conditions (i.e. post ACS/post primary coronary angioplasty, CCSs/elective coronary angioplasty, coronary artery/valve heart surgery, CHF, cardiac transplantation, diabetes mellitus and PAD), while adding new challenging populations (i.e. frail, CRT, ventricular assist device, non-adherent and cancer patients) to the five of the 2010 edition. To date, there is insufficient evidence to provide clear core components in other specific populations such as pulmonary hypertension[164] and grown-up congenital heart patients.

One of the major challenges in providing cardiac rehabilitation core components to cardiovascular patients – due to the complexity of the referred population – is how to integrate disease- or risk factor- or lifestyle-specific guidelines within the same patient with different combinations of diseases and/or risk factors. Future research and education activities will be devoted not only to ensuring the proper delivery of all core components to patients, but also to how to reach homogeneity of prescription and how to harmonize different interventions. According to a European survey on exercise intervention, a significant variance is still

present between clinicians when defining exercise intensity, duration, volume and type, meaning that in clinical practice the same cardiovascular (risk) patient can receive very different exercise prescriptions when consulting different clinicians.[165] This is actually of no surprise, because tailoring the exercise prescription can be very difficult, in which the following factors/aspects should be taken into account: patient phenotype, prevalent disease and risk factors, medication intake and exercise response/capacity. In order to assist clinicians in the tailoring of exercise prescription, a digital decision support system ('EXPERT tool') has therefore been developed and made available,[166] thus being a potential facilitator of the application of recommendations.

Importantly, there is still considerable potential to further reduce cardiovascular morbidity and mortality by increasing uptake and fully integrating secondary prevention and cardiac rehabilitation. Despite a class I A indication in major contemporary ESC guidelines, referral and uptake of cardiac rehabilitation remains low in Europe. The EUROASPIRE IV survey[163] illustrates that only half of eligible coronary patients were referred and a minority attended a cardiac rehabilitation programme. Integration of the patients' perspective and tailoring of the programmes based on patients' preference may help to increase uptake and incentives to cardiologists for prescribing structured cardiac rehabilitation programmes.

In 2020 telerehabilitation could be more than a 'future perspective' and available information supports the continued expansion of evidence-based, home-based cardiac rehabilitation programmes. Recent network meta-analysis has shown favourable results on mortality for centre-based cardiac rehabilitation only;[167] however, given the limitations of network meta-analyses this study does not question the value of telerehabilitation in general. The choice of participating in a more traditional and supervised centre-based programme or a home-based programme may reflect local availability and consider the preference of the individual patient.[38] In this context, the use of digital health tools supporting cardiac telemedicine can be of additional value in the provision of secondary prevention and help to individualize cardiac rehabilitation programmes. The Fit@Home study – a randomized, controlled clinical trial comparing home-based and centre-based cardiac rehabilitation in ischaemic heart disease patients[168] – indicated that the former was non-inferior to the latter in terms of VO_{2peak} improvement. Similarly, the Telerehab III randomized, controlled trial compared the efficacy and cost-efficiency telerehabilitation in addition to classical cardiac rehabilitation versus classical cardiac rehabilitation alone,[169] and patients receiving also telerehabilitation did better in terms of physical fitness improvement. As a result, cardiac telemedicine has been described as one of the ways to tackle current gaps in secondary prevention.[170] There remain, however, some challenges/barriers for large-scale digital health deployment in cardiology.[171] These include patient-related barriers for digital health deployment, physician-related barriers for digital health deployment, legal and ethical issues, interoperability and technical issues and lack of reimbursement. Addressing these challenges is the key in order to enable large-scale implementation of digital health in daily clinical practice. The next update of this position paper – expected for the year 2026 – will probably have more data to provide practical recommendations on this topic.

Summary box

Main updates from previous 2010 version of the position paper

- Global update of traditional core components of cardiac rehabilitation
- New challenging populations added (i.e. frail patients, TAVI and MitraClip patients, patients with cardiac implantable electronic devices, patients with ventricular assistant devices, cancer patients, non-adherent patients)
- Targets for lipid and blood pressure aligned with the 2019 ESC guidelines on dyslipidaemias and the 2018 ESC/ESH Guidelines for the management of arterial hypertension
- Optimal intensity during aerobic and resistance/strength training activities discussed according to available evidence
- Consideration of resistance/strength training and inspiratory muscle training in chronic heart failure
- Recommendation about multicomponent interventions in exercise programmes for frail elderly patients: mainly resistance exercises, associated with aerobic, flexibility and balance training
- High intensity interval training as a feasible, safe and effective modality of exercise after cardiac transplantation
- Extended indication of cardiac rehabilitation in peripheral artery disease patients (from intermittent claudication to atypical symptoms and after revascularization)
- Higher grade of recommendation for resistance/strength training in diabetes mellitus
- More emphasis on evaluation/treatment of psychosocial risk factors and vocational/return to work aspects
- Proposition of the 5As model (Ask, Advise, Assess, Assist, Arrange) to improve adherence during cardiac rehabilitation activities

Author contribution

MA, AA, UC, CD, DH, IF, MCI, RP, JPS, CV, HV, MW and MFP contributed to the conception or design of the work, contributed to the acquisition, analysis or

interpretation of data for the work, drafted the manuscript and critically revised the manuscript. BBW, TB, ACS, VC, PD, WD, DG, AG, HK, NK, JL, MM, JN, MS and ADOZ critically revised the manuscript. All gave final approval and agree to be accountable for all aspects of work ensuring integrity and accuracy.

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