European Journal of Preventive Cardiology

Review

European Journal of Preventive Cardiology
2016, Vol. 23(16) 1715–1733

DOI: 10.1177/2047487316657669
ejpc.sagepub.com
SAGE

A review of guidelines for cardiac rehabilitation exercise programmes: Is there an international consensus?

Kym Joanne Price[1], Brett Ashley Gordon[1,2], Stephen Richard Bird[1] and Amanda Clare Benson[1]

Abstract

Background: Cardiac rehabilitation is an important component in the continuum of care for individuals with cardiovascular disease, providing a multidisciplinary education and exercise programme to improve morbidity and mortality risk. Internationally, cardiac rehabilitation programmes are implemented through various models. This review compared cardiac rehabilitation guidelines in order to identify any differences and/or consensus in exercise testing, prescription and monitoring.

Methods: Guidelines, position statements and policy documents for cardiac rehabilitation, available internationally in the English language, were identified through a search of electronic databases and government and cardiology society websites. Information about programme delivery, exercise testing, prescription and monitoring were extracted and compared.

Results: Leading cardiac rehabilitation societies in North America and Europe recommend that patients progress from moderate- to vigorous-intensity aerobic endurance exercise over the course of the programme, with resistance training included as an important adjunct, for maintaining independence and quality of life. North American and European guidelines also recommend electrocardiograph-monitored exercise stress tests. Guidelines for South America and individual European nations typically include similar recommendations; however, those in the United Kingdom, Australia and New Zealand specify lower-intensity exercise and less technical assessment of functional capacity.

Conclusion: Higher-intensity aerobic training programmes, supplemented by resistance training, have been recommended and deemed safe for cardiac rehabilitation patients by many authorities. Based on research evidence, this may also provide superior outcomes for patients and should therefore be considered when developing an international consensus for exercise prescription in cardiac rehabilitation.

Keywords

Cardiac rehabilitation, cardiovascular disease, guidelines, exercise therapy, exercise test, exercise

Received 15 December 2015; accepted 11 June 2016

Introduction

Cardiovascular disease (CVD) is a leading contributor to global mortality and morbidity. Internationally, it is the cause of approximately a third of total yearly deaths,[1] with mortality rates in high-income countries ranging from 20% to 50%.[2,3] CVD is responsible for approximately 20% of the worldwide disease burden.[1]

Cardiac rehabilitation promotes secondary prevention of CVD and is an essential component of care for all cardiac patients.[4,5] It is a coordinated physical, social and psychological intervention that favourably influences the underlying risk factors in order to stabilise, slow or reverse disease progression, and facilitates the ability of the patient to preserve or resume an active and functional contribution to the community.[6,7] Cardiac rehabilitation promotes a healthy and active

[1]Discipline of Exercise Sciences, School of Health and Biomedical Sciences, RMIT University, Melbourne, Victoria, Australia
[2]Discipline of Exercise Physiology, La Trobe Rural Health School, La Trobe University, Bendigo, Victoria, Australia

Corresponding author:
Kym Joanne Price, Discipline of Exercise Sciences, School of Health and Biomedical Sciences, RMIT University, PO Box 71, Bundoora, Victoria 3083, Australia.
Email: kym.price@rmit.edu.au

lifestyle, with the aim of improving quality of life through: increased cardiac function; increased exercise tolerance; decreased cardiovascular symptoms; reduced levels of anxiety, depression and stress; return to work; and maintaining independence in activities of daily living.[5,6,8] Structured exercise has been identified as being central to the success of cardiac rehabilitation.[9–11]

Strong, consistent positive evidence exists for exercise-based cardiac rehabilitation for patients with stable angina pectoris,[7,10] myocardial infarction (MI)[7,10,12] and coronary revascularisation.[7,10] Cardiac rehabilitation is also recommended for patients who have undergone heart transplant[13] or valvular surgery,[14] in addition to those suffering chronic heart failure.[15] Meta-analyses have shown significant reductions in both all-cause and cardiac mortality from exercise-based rehabilitation compared to standard medical care without structured exercise training or advice, with the reduction associated with long-term rather than short-term follow-up.[7,12] Exercise-based cardiac rehabilitation results in a significantly lower risk of fatal and non-fatal re-infarction through improved cardiac and coronary vascular function, as well as improved CVD risk factor profiles when compared to cardiac rehabilitation without an exercise component.[12]

Cardiac rehabilitation services exist in fewer than 40% of countries throughout the world, with programmes available in 68% of the countries defined as high income by the World Bank.[8] This figure falls to only 22% in low- and middle-income countries, where the majority of deaths due to CVD occur.[16] The density of cardiac rehabilitation programmes varies from the equivalent of one programme for every 0.1 million inhabitants in the United States (US)[8] to one programme for every 2.2 million inhabitants throughout Latin America[16] and one programme for 164 million inhabitants in Bangladesh, where there is a single facility to service the entire population.[8] Guidelines for the provision of cardiac rehabilitation have not been established in many of the nations providing this service.

The purpose of this review is to compare national guidelines for outpatient cardiac rehabilitation from around the world alongside those prepared by leading cardiovascular scientific societies, and provide insight into any differences and/or consensus in patient eligibility, programme delivery and exercise testing, prescription and monitoring that exist.

Methods

National guidelines, position statements and policy documents for exercise-based outpatient cardiac rehabilitation were searched from the earliest date available to July 2015 using PubMed and Google Scholar databases. The search terms ''cardiac rehabilitation'', ''guidelines'', ''policy'' and ''position statement'' were combined and searched alone and by country. Government and cardiology society websites for countries that were known to have cardiac rehabilitation services were also examined, along with reference lists of identified guidelines and review articles. Only those guidelines, position statements and policy documents available in English were included. Only resistance training recommendations for Germany have been published in English; however, guidelines covering all aspects of cardiac rehabilitation have been translated and summarised in a review article published by Karoff et al.,[17] and the information presented was utilised in the current review. Where non-English-language guidelines or position statements were located, the authors were contacted to confirm that an English version was not available. Document analyses of the guidelines, position statements and policy documents were undertaken to extract the relevant information for this review.

Results

Guidelines, position statements and policy documents for outpatient cardiac rehabilitation from 18 individual countries or regions were identified in the English language and included for review. The American Heart Association (AHA) and the American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR) have issued a joint scientific statement detailing the core components of cardiac rehabilitation programmes,[18] with more comprehensive guidelines having been published by the AACVPR (with AHA endorsement).[19] The Canadian Association of Cardiac Rehabilitation (CACR) have also developed detailed guidelines.[20] A position statement has been prepared by the European Association of Cardiovascular Prevention and Rehabilitation (EACPR),[21] with several individual European countries also producing their own guidelines. In the Australasian region, Australia and New Zealand each have their own guidelines, prepared by the respective National Heart Foundations, in conjunction with the Australian Cardiovascular Health and Rehabilitation Association (ACRA) in Australia.[22–24] A joint position statement by the South American Society of Cardiology and the Inter-American Committee on Cardiovascular Prevention encompasses the whole of South America.[25] In Asia, English-language cardiac rehabilitation guidelines have only been published in Japan. The World Health Organization (WHO) Expert Committee on Rehabilitation after Cardiovascular Diseases prepared guidelines for the provision of cardiac rehabilitation in 1993.[4] This document has an emphasis on developing countries, but still contains information that is relevant

to high-income countries. Published guidelines were also located for Brazil, Columbia, Cuba, Denmark, Estonia, Germany, Italy, Poland, Spain, Switzerland, Israel, and South Korea, but these have been excluded from this review as they were not available in English and funding was not available for translators.

Cardiac rehabilitation throughout the world follows the same progression from hospitalisation after an acute event through to recovery and on-going maintenance. Cardiac rehabilitation is commonly divided into either three or four phases, with the content of these phases varying between nations, as detailed in Supplementary Table 1.

Programme eligibility and delivery

Aspects of programme delivery detailed in cardiac rehabilitation guidelines include patient eligibility, pre-participation medical assessment, required personnel and responsibility for prescription and supervision of exercise and educational interventions (Supplementary Table 2). Acute coronary conditions that are eligible for cardiac rehabilitation are listed in Supplementary Table 2, while patients with peripheral arterial disease (PAD) are additionally included in the eligible patient lists for Austria,[26] Europe,[21,27] France,[28] Ireland,[5] Japan[29] and South America.[25] Medical and physical evaluations are recommended in all guidelines, with measurement of heart rate, blood pressure, body mass index and waist girth all being common. Furthermore, resting 12-lead electrocardiograph (ECG) prior to the commencement of cardiac rehabilitation is specified for Austria,[26] Canada,[20] Europe,[21] England,[30] France,[28] Germany,[31] Japan,[29] Scotland[32] and the US.[18,19]

Recommendations throughout the world are for a multidisciplinary involvement in the delivery of cardiac rehabilitation programmes. Australian guidelines additionally specify the inclusion of an Aboriginal health worker within indigenous communities,[22] while in New Zealand, a Maori disease state management nurse is included as a member of the cardiac rehabilitation team.[24] The AACVPR guidelines identify that exercise training be prescribed by a physician to obtain Medicare benefits, but there is no additional information to encompass non-Medicare beneficiaries.[19] Recommendations in Australia,[22] Canada,[20] Austria,[26] Germany,[31] New Zealand,[24] Northern Ireland,[33] The Netherlands[34] and the United Kingdom (UK)[35] specify that exercise programming and supervision are the responsibility of a physiotherapist or a staff member trained in exercise prescription, such as a sport scientist or exercise physiologist. The AACVPR guidelines specify a minimum number of sessions during which each patient should be directly supervised, depending on their assessed level of risk and their progress.[19] This recommendation has also been included in the Irish guidelines[5] and adapted in those for South America.[25] Staff-to-patient ratios vary throughout the world, depending on the stage of rehabilitation, the intensity of exercise programming and the available staff.

Psychological evaluation and counselling are recommended in all nations, with stress management and relaxation interventions also common. Educational topics covered during cardiac rehabilitation programmes routinely include the management of cardiovascular risk factors, nutritional and physical activity advice, smoking cessation and vocational counselling.

The duration of outpatient rehabilitation programmes differs between nations (Tables 1 and 2), varying from a minimum of 3 weeks in Germany with extension only in exceptional circumstances[17] to as long as 12 months in Austria, depending on the status of the participant.[26]

Exercise and functional assessment

Considerable variation exists in the specificity and technical skill of exercise testing recommended in cardiac rehabilitation guidelines internationally, as shown in Tables 1 and 2. An ECG-monitored exercise stress test is recommended by the AHA and AACVPR,[18,19] CACR[20] and EACPR.[21] Guidelines for Japan,[29] South America[25] and the majority of the European countries reviewed[26–28,31,34] also include this recommendation for pre-programme exercise testing. Despite these recommendations by leading cardiovascular societies, less technical exercise testing, in the form of either a 6–minute walk test or shuttle walk test, form the standard for the determination of functional capacity in Australasia and the UK.[22,24,30,32,33,36] However, these nations do acknowledge that an ECG-monitored exercise stress test should be performed for high-risk patients (those with decompensated heart failure, uncontrolled arrhythmias or experiencing angina at rest or with minimal exertion)[24,32] or for patients wishing to participate in a high-intensity exercise programme (>75% maximal heart rate (HR_{max})).[32]

Monitoring during exercise training sessions

Heart rate monitoring and/or the Borg Rating of Perceived Exertion Scale[37] are frequently recommended, with the monitoring of blood pressure during exercise and the observation of signs and symptoms, such as excessive breathlessness or fatigue, chest pain and light-headedness, also being widely specified.

The AACVPR guidelines for the US have detailed a progression from continuous to intermittent ECG

Table 1. Recommendations for exercise testing, prescription and monitoring in outpatient cardiac rehabilitation programs for independent regions and nations, including leading cardiac rehabilitation organisations.

Country	Type of exercise	Intensity of exercise	Duration and frequency of sessions	Programme length	Exercise testing and monitoring	Expectations for additional activity
Leading cardiology and cardiac rehabilitation organizations						
Europe (European Association of Cardiovascular Prevention and Rehabilitation)[21,27]	**Aerobic endurance training** (e.g. walking, jogging, cycling, swimming, rowing, stair climbing, elliptical trainer, aerobics)	50–80% VO_{2max} (close to anaerobic threshold) 50–80% HR_{peak} or 40–60% HRR RPE 10–14	≥20–30 minutes per session ≥3 sessions per week (preferably 6–7)	2–16 weeks	**Exercise testing** Symptom-limited exercise test **Monitoring** Observation of symptoms HR monitoring BP monitoring ECG monitoring during initial stages or for patients with new symptoms	Equivalent of 30 minutes of moderate-intensity walking per day
	Resistance training	To moderate fatigue	10–15 reps per set 2 sessions per week			
Canada (Canadian Association of Cardiac Rehabilitation)[20]	**Aerobic endurance training**	40–85% HRR	20–40 minutes per session 3–5 sessions per week	≥12 weeks	**Exercise testing** Graded exercise test (Bruce protocol) with ECG monitoring **Monitoring** HR monitoring BP monitoring RPE ECG monitoring at discretion of medical director (progress from continuous monitoring to intermittent as appropriate for risk level of patient) Respiratory rate if indicated Arterial oxygen saturation	Encouraged to engage in lighter forms of physical activity on days when not attending a formal exercise session in order to accumulate 30–60 minutes of moderate- to vigorous-intensity on most days of the week
	Aerobic interval training	Not specified				
	Resistance training	30–40% 1RM for upper body 50–60% 1RM for lower body	1–3 sets of 12–15 reps for 6–10 different exercise for both upper and lower body 2–3 sessions per week			
	Flexibility training	Not specified	Static stretching: ≥4 reps per exercise, 15–60 seconds per stretch PNF stretching: 6-second contraction followed by 10–30 second assisted stretch			

(continued)

Table 1. Continued

Country	Type of exercise	Intensity of exercise	Duration and frequency of sessions	Programme length	Exercise testing and monitoring	Expectations for additional activity
United States (American Heart Association, American Association of Cardiovascular and Pulmonary Rehabilitation)[18,19,70]	**Aerobic endurance training** (e.g. walking, treadmill, cycling, steps, rowing)	40–80% VO_{2peak} or HR_{max} based on maximal exercise test RPE 11–16	20–60 minutes per session 3–5 sessions per week	≤36 sessions	**Exercise testing** Symptom-limited exercise test strongly recommended **Monitoring** Observation of symptoms HR monitoring BP monitoring RPE ECG (progress from continuous monitoring to intermittent as appropriate for risk level of patient)	Home-based physical activity to achieve 30–60 minutes per day of moderate-intensity activity on at least 5 days of the week
	Resistance training (e.g. calisthenics, hand weights, pulleys, dumbbells, free weights, machine weights)	To moderate fatigue (RPE 11–13) 50% 1RM progressing to 60–70% 1RM	1–3 sets of 10–15 reps for 8–10 different exercises 2–3 sessions per week (non-consecutive days)			
	Flexibility training (static stretching with emphasis on lower back and thigh)	To point of mild discomfort	3–5 reps per exercise, 30–90 seconds for each stretch as tolerable 2–3 sessions per week (non-consecutive days)			
Independent nations and regions						
Japan (Japanese Circulation Society)[29]	**Aerobic endurance training** (e.g. aerobics, cycling)	At anaerobic threshold (40–60% VO_{2peak}, 40–60% HRR, RPE 12–13)	15–60 minutes per sessions 1–3 sessions per week	5 months (first 5 months following treatment)	**Exercise testing** Exercise stress test **Monitoring** HR monitoring BP monitoring RPE ECG monitoring recommended if chest pain is experienced	3–4 days per week of home-based training prescribed through the programme

(continued)

Table 1. Continued

Country	Type of exercise	Intensity of exercise	Duration and frequency of sessions	Programme length	Exercise testing and monitoring	Expectations for additional activity
Australia (National Heart Foundation of Australia, Australian Cardiovascular Health and Rehabilitation Association)[6,22,23,42]	**Aerobic endurance training** (e.g. walking, cycling, treadmill, dancing) **Resistance training**	Low- to moderate-intensity physical activity As appropriate	30–60 minutes per session (NSW) 1–2 sessions per week Not specified	3–12 weeks	**Exercise testing** 6-minute walk test (NSW) Symptom-limited maximal exercise stress test recommended prior to high-intensity programme or for high-risk patients **Monitoring** Observation of symptoms HR monitoring BP monitoring RPE ECG monitoring for high-intensity programmes or high-risk patients (VIC) Respiratory rate if indicated	At least 30 minutes of light- to moderate-intensity physical activity on most days of the week through home-based activities
New Zealand (New Zealand Guidelines Group, National Heart Foundation of New Zealand)[24]	**Aerobic endurance training** **Resistance training**	40–75% VO_{2max} Low intensity and high reps	30–45 minutes per session 3–5 sessions per week Not specified	6–12 weeks	**Exercise testing** Exercise stress test (not necessary for low-risk patients undertaking supervised low- to moderate-intensity exercise training) **Monitoring** Observation of symptoms HR monitoring	At least 30 minutes of moderate physical activity on most days of the week

(continued)

Table 1. Continued

Country	Type of exercise	Intensity of exercise	Duration and frequency of sessions	Programme length	Exercise testing and monitoring	Expectations for additional activity
South America (South American Society of Cardiology, Inter-American Committee of Cardiovascular Prevention and Rehabilitation)[25]	**Aerobic endurance training**	60–80% HR_{max} or 50–70% HRR (beginning at lower limit of range) At anaerobic threshold	30–60 minutes per session 2–5 sessions per week	1–5 months	**Exercise testing** Exercise stress test with ECG monitoring (or 6–minute walk test) **Monitoring** ECG (progress from continuous monitoring to intermittent as appropriate for risk level of patient)	Not specified
	Aerobic interval training	Not specified				
	Resistance training	Load sufficient to cause fatigue for final 3 reps	6–15 reps per muscle group at an interval of 20–60 seconds 2–3 sessions per week			
	Flexibility training	Not specified	At end of each session			
World Health Organization (emphasis on developing countries)[4]	**Aerobic endurance training** (e.g. stationary cycle, rowing, stepping as part of a circuit) **Resistance training** (e.g. light weights and pulley exercises for upper body as part of a circuit) **Flexibility training** (calisthenics)	High intensity (60–75% peak work capacity or 70–85% HR_{peak}) Low/moderate intensity HR <20 bpm above resting HR (symptom and observation limited)	20–30 minutes per session ≥3 sessions per week 30–60 minutes including 15 minutes of calisthenics at beginning of session ≥2 sessions per week	≥6–8 weeks	**Exercise testing** Treadmill exercise test **Monitoring** For basic and intermediate facilities: HR monitoring RPE For advanced facilities: as above, plus ECG (progress from continuous monitoring to intermittent as appropriate for risk level of patient)	Home-based, moderate-intensity activity or walking for 30 minutes per day plus twice-daily calisthenics

VO_{2max}: maximal oxygen uptake; HR_{peak}: peak heart rate; HRR: heart rate reserve; RPE: rating of perceived exertion (based on Borg 6–20 scale); reps: repetitions; HR: heart rate; BP: blood pressure; ECG: electrocardiograph; 1RM: one-repetition maximum; PNF: proprioceptive neuromuscular facilitation; VO_{2peak}: peak oxygen uptake; HR_{max}: maximum heart rate; NSW: New South Wales (Australian state); VIC: Victoria (Australian state).

Table 2. Recommendations for exercise testing, prescription and monitoring in outpatient cardiac rehabilitation programmes for European nations.

Country	Type of exercise	Intensity of exercise	Duration and frequency of sessions	Programme length	Exercise testing and monitoring	Expectations for additional activity
Europe (European Association of Cardiovascular Prevention and Rehabilitation)[21,27]	**Aerobic endurance training** (e.g. walking, jogging, cycling, swimming, rowing, stair climbing, elliptical trainer, aerobics)	50–80% VO_{2max} (close to anaerobic threshold) 50–80% HR_{peak} or 40–60% HRR RPE 10–14	≥20–30 minutes per session ≥3 sessions per week (preferably 6–7)	2–16 weeks	**Exercise testing** Symptom-limited exercise test **Monitoring** Observation of symptoms HR monitoring BP monitoring ECG monitoring during initial stages or for patients with new symptoms	Equivalent of 30 minutes of moderate-intensity walking per day
	Resistance training	To moderate fatigue	10–15 reps per set 2 sessions per week			
Austria (Austrian Cardiac Society)[26]	**Aerobic endurance training**	50–70% symptom-limited HR 80–90% of HR at anaerobic threshold	Phase II: 10–30 minutes per session 3 sessions per week Phase III: 20–50 minutes per session 2 sessions per week	Phase II: 4–6 weeks Phase III: 6–12 month (depending on the status of the patient)	**Exercise testing** Maximal ergometry including exercise ECG **Monitoring** Not specified	Phase III: minimum of 20–40 minutes per week (1 session) progressing to minimum of 3 sessions by second half of this phase, exercising at same intensity as during supervised sessions
	Resistance training	<50% 1RM progressing to 60–80% 1RM	1–2 sets of 8–15 reps for 6–8 muscle groups 2 sessions per week			
	Flexibility training	Not specified	Not specified			
Belgium (Belgian Society of Cardiology)[38]	**Aerobic endurance training** **Aerobic interval training**	45–85% VO_{2peak} 60–90% HR_{max} Not specified	40–60 minutes per session 3–5 sessions per week	12 weeks (but may continue for up to 38 weeks if required)	**Exercise testing** Maximal exercise test Submaximal test (if maximal test is contraindicated) **Monitoring** ECG monitoring advised for high-risk patients	Not specified
	Resistance training (dynamic with machine weights)	50–60% 1RM Weight that can be lifted for 8–10 reps	1–3 sets for 8–10 exercises			

(continued)

Table 2. Continued

Country	Type of exercise	Intensity of exercise	Duration and frequency of sessions	Programme length	Exercise testing and monitoring	Expectations for additional activity
England (Department of Health, National Institute for Health and Care Excellence, National Health Service)[30]	Not specified	Moderate intensity	For sufficient time to result in a safe and appropriate physiological challenge within the session At least 2 sessions per week	6–12 weeks	**Exercise testing** Functional capacity testing (ergometer test or walking/step tests) **Monitoring** HR monitoring BP monitoring RPE Rate-pressure product	30 minutes of exercise on 5 days of the week
France (French Society of Cardiology)[28]	**Aerobic endurance training**	60% HRR (constant intensity)	20–60 minutes per session 3–6 sessions per week	≥20 sessions	**Exercise testing** Exercise stress test (maximal or symptom limited) 6–minute walk test **Monitoring** HR monitoring BP monitoring Telemetry monitoring (for initial training sessions)	Equivalent of 30 minutes of moderate-intensity walking per day
	Aerobic interval training	Up to 2 minutes at 80–95% VO_{2max}, 1–4 minutes of active recovery (20–30% VO_{2max})				
	Resistance training (dynamic)	30–50% 1RM	10–15 reps, 8–10 different exercises (20–30 minutes) 2–3 sessions per week			
	Flexibility training (gymnastics exercises)	Not specified	Not specified			
Germany[a] (German Federation for Cardiovascular Prevention & Rehabilitation)[17,31]	**Resistance training** (dynamic)	Pre-training: <30% MVC Muscular endurance training: 30–50% MVC (RPE 12–13) Hypertrophy/strength training: 40–60% MVC (RPE ≤15)	Pre-training: 1–3 sets of 5–10 reps Muscular endurance training: 1 set of 12–25 reps Hypertrophy/strength training: 1 set of 8–15 reps 2–3 sessions per week	3 weeks (with extensions only in exceptional circumstances)	**Exercise testing** Exercise stress test (symptom limited) **Monitoring** HR monitoring RPE BP monitoring (before and after session) Observation of symptoms ECG (during early stages of programme)	Not specified

(continued)

Table 2. Continued

Country	Type of exercise	Intensity of exercise	Duration and frequency of sessions	Programme length	Exercise testing and monitoring	Expectations for additional activity
Ireland (Irish Association of Cardiac Rehabilitation)[5]	**Aerobic endurance training**	40–80% VO_{2peak} 50–85% HR_{max} 40–70% HRR RPE 13–16	30 minutes per session ≥2 sessions per week	≥6 weeks	**Exercise testing** Functional capacity testing using Bruce protocol, 6–minute walk test, shuttle walk test or Chester step test **Monitoring** ECG (progress from continuous monitoring to intermittent as appropriate for risk level of patient)	Not specified
	Resistance training (dynamic)	Pre-training: <30% MVC Muscular endurance training: 30–50% MVC (RPE 12–13) Hypertrophy/strength training: 40–60% MVC (RPE ≤15)	Pre-training: 1–3 sets of 5–10 reps Muscular endurance training: 1 set of 12–25 reps Hypertrophy/strength training: 1 set of 8–15 reps 2–3 sessions per week			
The Netherlands (Royal Dutch Society for Physical Therapy)[34,41]	**Aerobic endurance training**	Increase from 50–80% VO_{2max}/HRR (determined by maximal or symptom-limited test)	20–30 minutes per session 3–5 sessions per week	Not specified	**Exercise testing** Maximal or symptom-limited exercise test with ECG monitoring Functional exercise capacity test (shuttle walk test or 6–minute walk test) **Monitoring** HR monitoring BP monitoring RPE ECG monitoring for complex conditions	Moderate-intensity endurance training (RPE 11–13) for 45–60 minutes preferably on every day for reduction of cardiovascular risk factors
	Aerobic interval training	4–minute blocks, 80–90% VO_{2peak}/HRR, 3 minutes of active recovery (40–50% VO_{2peak}/HRR)				
	Resistance training (circuit training and functional exercises)	Increase from 50 to 70–80% 1RM	1–3 sets of 10–15 reps for 8–10 exercises 2–3 sessions per week			
Northern Ireland (Clinical Resource Efficiency Support Team)[33]	**Aerobic endurance training** (e.g. cycling, walking)	Low to moderate intensity	20–30 minutes per session 2 sessions per week	≥8 weeks	**Exercise testing** Functional exercise capacity test (e.g. shuttle walk test) Exercise stress test with ECG recommended for high-risk patients or high-intensity exercise programmes **Monitoring** HR monitoring RPE	Additional home exercise programme
	Resistance training	Not specified	Not specified			

(continued)

Table 2. Continued

Country	Type of exercise	Intensity of exercise	Duration and frequency of sessions	Programme length	Exercise testing and monitoring	Expectations for additional activity
Scotland (Scottish Intercollegiate Guidelines Network)[32]	**Aerobic endurance training** **Resistance training**	Low to moderate intensity Not specified	Long-duration sessions ≥2 sessions per week Single set of 10–15 reps per exercise 2–3 sessions per week	≥8 weeks	**Exercise testing** Functional exercise capacity test (shuttle walk test or 6–minute walk test) Maximal exercise test with exercise ECG only recommended for high-risk patients or high-intensity activity **Monitoring** HR monitoring RPE	Not specified
United Kingdom (Association of Chartered Physiotherapists in Cardiac Rehabilitation, British Association for Cardiovascular Prevention and Rehabilitation)[35,39]	**Aerobic endurance training** **Resistance training** **Flexibility training** (static, ballistic or PNF stretches)	Moderate intensity 40–70% HRR RPE 11–14 30–40% 1RM for upper body 50–60% 1RM for lower body Progress to 50–80% 1RM for both To point of tightness	20–60 minutes per session 2–3 sessions per week 2–4 sets of 8–12 reps for 8–10 muscle groups 2–4 sessions per week 2–4 reps, accumulating 60 seconds per stretch 2–3 sessions per week	4–24 weeks (depending on the status of the patient)	**Exercise testing** Functional capacity test (6–minute walk test/shuttle walk test/Chester step test or submaximal or symptom-limited ergometer test – no ECG monitoring) **Monitoring** Observation of symptoms HR monitoring BP monitoring RPE Oxygen saturation by pulse oximetry if indicated by condition	Not specified

(continued)

Table 2. Continued

Country	Type of exercise	Intensity of exercise	Duration and frequency of sessions	Programme length	Exercise testing and monitoring	Expectations for additional activity
Wales[b] (Welsh Assembly Government, Aneurin Bevan Health Board)[36]	Not specified	Not specified	Session duration not specified 2 sessions per week	$\geq$8 weeks	**Exercise testing** Functional capacity test (6-minute walk test/shuttle walk test/Chester step test/ergometer test) Exercise tolerance test **Monitoring** Not specified	Not specified

VO_{2max}: maximal oxygen uptake; HR_{peak}: peak heart rate; HRR: heart rate reserve; RPE: rating of perceived exertion (based on Borg 6–20 scale); reps: repetitions; HR: heart rate; BP: blood pressure; ECG: electrocardiograph; 1RM: one-repetition maximum; VO_{2peak}: peak oxygen uptake; HR_{max}: maximum heart rate; MVC: maximum voluntary contraction; PNF: proprioceptive neuromuscular facilitation.
[a]Only resistance training recommendations for cardiac rehabilitation have been published in English for Germany. Recommendations for aerobic endurance training were not located in English for inclusion in this review.
[b]The policy document for cardiac rehabilitation in Wales contains limited exercise prescription recommendations and does not refer to other guidelines for this information.

monitoring over a number of sessions according to the risk level of the patient.[19] These recommendations are also incorporated into the guidelines for Canada,[20] Ireland[5] and South America.[25] The EACPR guidelines specify the use of ECG monitoring during the initial sessions of the rehabilitation programme and for patients experiencing new symptoms.[21] The European countries France[28] and Germany[31] follow the recommendation of the EACPR, while the guidelines for Belgium[38] and The Netherlands[34] advise ECG monitoring only for high-risk patients, including implantable cardioverter–defibrillator (ICD) recipients and those with heart failure and a history of arrhythmias.

Recommendations for exercise prescription in outpatient rehabilitation exercise programmes

Aerobic endurance training. The recommendation for aerobic exercise is a feature of all of the international guidelines and position statements reviewed; however, differences are evident in the intensity of exercise, as well as the duration and frequency of training sessions (Tables 1 and 2).

Guidelines prepared by the leading scientific societies recommend that patients progress from moderate- to vigorous-intensity aerobic exercise, increasing to 80% of the maximal aerobic capacity (VO_{2max}) or HR_{max} in the US[18,19] and Europe,[27] and 85% of the heart rate reserve (HRR) in Canada,[20] over the course of their rehabilitation programme. With the exception of the UK[39] and France,[28] which specify moderate-intensity aerobic training only,[39] individual European nations include progression to vigorous-intensity aerobic training as in the EACPR document. Similarly, South American guidelines correspond with those produced in North American nations.[25] In comparison, the guidelines from Australia[22] and Japan[29] recommend that aerobic training sessions within the cardiac rehabilitation programmes should consist of light- to moderate-intensity exercise, with a maximum of 60% of the VO_{2max} or HRR specified in Japan.[29]

Aerobic interval training is proposed as an alternative to continuous aerobic exercise in the national guidelines for France,[28] The Netherlands,[34] Belgium,[38] South America[25] and Canada.[20] However, there is no consensus on the optimal work-to-rest ratios for this type of training.

The frequency of aerobic exercise sessions recommended varies considerably between guidelines (Tables 1 and 2). The AHA, AACVPR, EACPR and CACR guidelines all recommend a minimum of three sessions per week. Within Europe, guidelines for the individual nations correspond with these recommendations, with the UK and Austria as exceptions. Conversely, the guidelines for Australia,[22] Austria,[26]

Japan[29] and the countries of the UK[33,36,39] all recommend three or fewer weekly sessions, which, when combined with the minimum duration of each session, might not achieve the recommended 150 minutes of moderate-intensity exercise.[40] The low number of sessions detailed in some national guidelines is balanced by the inclusion of an expectation that patients will complete a minimum of 30 minutes of moderate-intensity, home-based physical activity on most days of the week to supplement their supervised training sessions.[4,19,20,22,26,29,30,34]

Resistance training. Detailed recommendations for resistance training are not routinely included in cardiac rehabilitation guidelines to the same level as aerobic exercise prescription (Tables 1 and 2). It is incorporated in the AHA and AACVPR guidelines,[18,19] as well as those of the CACR[20] and EACPR.[21] All European nations and South America have included detailed recommendations for resistance training, with a separate document specifically for resistance training having been published for Germany.[31] In comparison, resistance training is omitted altogether from the guidelines for Japan,[29] while in Australia,[22] New Zealand[24] and Northern Ireland,[33] there is limited prescription information to support the inclusion of resistance training.

Safety precautions for resistance training are incorporated into some guidelines. In Canada,[20] the US,[19] Germany,[31] Ireland,[5] Northern Ireland[33] and Scotland,[32] it is recommended that patients consistently participate in a supervised aerobic training programme for between 2 and 6 weeks without complications prior to commencing resistance training, in order to assess the patient's response to exercise and to enable them to develop the skills to self-monitor their exercise intensity.[5,32] In addition, the Northern Ireland[33] and Scotland[32] guidelines also specify that resistance training is only suitable for those patients who have been stratified into low- to moderate-risk categories (those without MI complications or exercise-related symptoms[32]). All guidelines recommend that assessment prior to resistance training is via a multiple-repetition maximum test, which is less likely to lead to abdominal straining or blood pressure elevations than a single-repetition maximal strength test, but will still provide a baseline in order to guide prescription.[31]

Resistance load is prescribed either as a percentage of the patient's maximum strength as determined by their estimated one-repetition maximum, with this load varying between 30% and 80%,[5,20,26,28,31,38,39,41] or based on the patient's level of fatigue within the exercise set.[19,25,27] The German recommendations (which are also incorporated into the Irish guidelines[5]) include prescriptions for improving both muscular endurance and hypertrophy.[31]

Flexibility training. Similar to strength training, flexibility training is not routinely specified as a component of the exercise programme for cardiac rehabilitation (Tables 1 and 2). The WHO guidelines,[4] in addition to those for Austria,[26] France[28] and South America,[25] include flexibility training as a recommendation, but prescription information is not stated. In comparison, the UK,[39] US[19] and Canadian[20] guidelines detail the number of repetitions and duration of each stretch, and that flexibility training should be incorporated into the rehabilitation programme for two to three sessions each week.

Long-term maintenance of exercise training

Recommendations for the maintenance phase of cardiac rehabilitation, which commences once the patient has completed their outpatient programme, are incorporated into guidelines and position statements for the provision of outpatient cardiac rehabilitation (Supplementary Table 1), with the exception of Belgium.[38] Specialised maintenance exercise programmes contribute to long-term cardiac health care and, in Germany,[17] Canada[20] and the US,[19] may be conducted in rehabilitation facilities or hospitals with reduced supervision and monitoring, rather than what occurs in outpatient rehabilitation programmes. Otherwise, they might occur in community settings, as recommended in the UK[30,32,33,36,39] and Australasia.[6,24,42]

Recommendations for cardiac rehabilitation for different clinical conditions

Guideline documents for cardiac rehabilitation typically contain recommendations for exercise training common to all cardiac patients, with there being little variation in exercise prescription details between clinical conditions. However, in some instances, additional considerations relevant to specific patient groups are provided. Patients who have undergone cardiac surgery are recommended to avoid strenuous upper extremity exercise until the wound is stable.[19,21,29,34] For both heart transplant and ICD patients, the use of target heart rate may not be appropriate for the determination of exercise intensity.[19] Where heart rate is utilised for ICD patients, the target should be set at 10–20 beats per minute below the detection threshold of the device.[5,20,39] Heart transplant patients undergoing corticosteroid therapy for rejection are recommended to discontinue exercise training during this treatment.[21] Intermittent walking programmes are recommended for patients with PAD, with intensity governed by their claudication symptoms.[5,19-21,25,29,34,39]

Heart failure, however, may be considered separately to other cardiac conditions. The AHA,[43]

EACPR,[44] Canadian Cardiovascular Society[45] and Exercise and Sports Science Australia[46] have all issued documents focused on exercise training for heart failure patients, while this patient group is included as a special population within general cardiac rehabilitation guidelines for other nations. The recommended prescription for aerobic exercise for these patients typically does not differ greatly from that for other cardiac populations, but aerobic interval training is highlighted as being particularly effective.[20,28,39] Resistance training is generally recommended to be undertaken with a reduced load and increased repetitions.[21,31,34,45] Progression over the course of the cardiac rehabilitation programme should be gradual, with small increases in frequency and intensity.[19,21,25]

Discussion

Aerobic endurance training is the foundation for the exercise component of cardiac rehabilitation programmes. It improves cardiorespiratory fitness and functional capacity, reduces disease-related symptoms and favourably influences coronary risk factors, contributing to a reduction in mortality among MI survivors.[19,20] Recommendations for aerobic endurance training are universally incorporated into guidelines for cardiac rehabilitation; however, the intensity at which this exercise should be performed varies between nations. Leading scientific societies for cardiac rehabilitation recommend a progression from moderate- to vigorous-intensity throughout the course of the rehabilitation programme.[18–20,27] However, in Australia and the UK, recommendations are for light- to moderate-intensity aerobic exercise.[22,32,33,39] This is also the recommendation of the WHO for developing countries, in which access to equipment for monitoring and training is restricted.[4] In addition, countries in Australasia and the UK recommend less vigorous assessment of physical capacity prior to the commencement of a cardiac rehabilitation programme, rather than ECG-monitored exercise stress tests, as are standard in the guidelines of other nations.

Residential rehabilitation programmes, as are available in France, Germany and Austria, have been particularly successful. The testing and training equipment, along with the availability of highly trained staff in these programmes, make it possible for them to offer inpatient support to high-risk patients and provide high-intensity, high-frequency exercise rehabilitation sessions.[3,17]

Ensuring patient safety throughout cardiac rehabilitation is paramount, and is more easily attained with lower-intensity exercise, which has a reduced reliance on technology and equipment for risk stratification and monitoring,[4,6] Lower-intensity exercise also leads to reduced programme and implementation costs, and is thought to be more acceptable to a broader population, including older adults or those with physical limitations.[4,6,47] Evidence for lower-intensity exercise[6] is based on four randomised controlled trials conducted prior to 1999, reporting that higher-intensity exercise had small, positive relationships with maximal physical work capacity after the 8-week,[48–50] 12-week[51] and 52-week[47] interventions, and no significant differences were observed over the longer term.[6] However, as cardiac patients may have a reduced exercise capacity and consequently perform daily activities at a higher percentage of their peak VO_2 compared with those without CVD,[52] aerobic exercise interventions prescribed at higher relative intensities may be more beneficial for returning the patient to their previous capacities earlier.

Concerns have been raised in the literature as to the efficacy of cardiac rehabilitation in the UK (where moderate-intensity aerobic endurance exercise in two to three sessions per week is recommended[39]) for improving patient mortality, morbidity and cardiac risk factors,[53,54] Recent moderate- to vigorous-intensity interventions conducted with coronary artery disease patients in a supervised cardiac rehabilitation setting in Belgium,[55] Italy,[56–59] Germany,[60] Canada[61] and the US[62–65] resulted in significant improvements in exercise capacity (as measured by maximal exercise testing or field tests such as the 6–minute walk test and incremental shuttle walk test) in comparison to a non-exercising control group.[55-57,61,64,65] Improvements in cardiovascular risk factors, including lipid profile,[56,64] blood pressure[56,57,64] and body mass,[64,65] were also reported. In comparison, light- to moderate-intensity training interventions have led to little or no improvement in exercise capacity[66–68] and morbidity[69] compared to non-exercising controls.

Dynamic resistance training is also beneficial for patients participating in cardiac rehabilitation, leading to an increase in physical strength and improved independence in activities of daily living, and positively influencing quality of life.[31,70] Studies have shown that combined resistance training and aerobic training is superior to aerobic training alone in promoting increases in skeletal muscle mass, along with reductions in body fat via an improved resting metabolic rate.[71] The addition of resistance training to a cardiac rehabilitation programme may also optimise responses to aerobic training as a result of increased muscle strength, leading to more favourable effects on exercise capacity.[71] Despite this evidence, aerobic training is still the primary focus of many guidelines for cardiac rehabilitation internationally, with complete prescription details for resistance training included in only 11 out of 18 of the guidelines that were reviewed, perhaps due to a perceived risk of complications as a result of

blood pressure increases during resistance training.[31] While there are some cardiovascular conditions that contraindicate resistance training, the AHA have issued a scientific statement detailing that resistance training can be initiated at a low intensity, provided patients have a functional capacity of ≥4 metabolic equivalents (METs).[70] This recommendation, along with that which is included in several guidelines for patients to first complete a period of supervised aerobic training in order to ensure safety,[19,20,31] lend strength to the inclusion of resistance training as a core component of cardiac rehabilitation exercise programming.

Exercise testing is a widely employed component of patient assessment prior to the commencement of cardiac rehabilitation. The main scientific societies for cardiac rehabilitation,[18–21] including the AHA, AACVPR, EACPR and CACR, strongly recommend that patients undergo a symptom-limited, ECG-monitored exercise stress test in order to identify any abnormal signs or symptoms present during exercise and determine any contraindications to higher exercise intensities, in addition to establishing peak exercise capacity in order to enable individualised exercise prescription.[21,52,72] However, guidelines for countries in Australasia and the UK recommend such formal testing of exercise capacity only for high-risk patients or those undertaking a high-intensity exercise programme, while low- to moderate-risk patients are instead assessed using submaximal tests, such as timed walk tests.[5,22,24,32,33,39] Timed walk tests, which include the 6-minute walk and incremental walk tests, are not considered to be equivalent substitutes for traditional exercise testing,[73] as intensity of effort may be variable due to the self-pacing nature of the test, and outcomes correlate only modestly with VO_{2max}.[72] Both the 6-minute walk test and incremental shuttle walk test may also exhibit a ceiling effect in patients with high levels of physical performance, where stride length or maximal walking speed may limit their performance.[74,75]

Although ECG monitoring of exercise training sessions is not associated with the rate of adverse events,[76] its use is beneficial in detecting significant exercise-induced changes, monitoring patient compliance with respect to heart rate and increasing patient self-confidence.[19] However, the use of ECG monitoring does not eliminate the need for educating patients in self-monitoring techniques.[20] The AACVPR have provided recommendations for the level of ECG monitoring based on the risk level of the patient and their progress through the programme, commencing with continuous monitoring and decreasing to intermittent monitoring as appropriate.[19] These recommendations allow a balance to be achieved between patient safety and increased programme cost as a result of ECG use.[65] In contrast, the majority of other guidelines for cardiac rehabilitation recommend ECG monitoring only for high-risk patients or those in the early stages of their participation.

Ongoing physical activity and the maintenance of health-related lifestyle changes are required in order to sustain the beneficial effects of a cardiac rehabilitation programme.[3,19] Longitudinal training studies have demonstrated that supervised exercise performed over a number of years maintains functional capacity in patients with coronary artery disease[77] or chronic heart failure.[78] Ten years of moderate exercise training was found to additionally improve quality of life in individuals with heart failure,[78] while 7 years of moderate- to vigorous-intensity training in coronary artery disease patients was also shown to improve lipid profiles.[77] Separate guidelines for the maintenance phase of cardiac rehabilitation are not available. Instead, this is incorporated briefly into the recommendations for outpatient rehabilitation programmes – in all countries except Belgium[38] – in the form of encouragement to continue with regular physical activity in order to meet physical activity guidelines, with referrals to home walking programmes or attendance at local gymnasiums, sports clubs or community groups.

Conclusion

Key cardiology and cardiac rehabilitation organisations, including the AHA, AACVPR, CACR and EACPR, endorse a progression from moderate- to vigorous-intensity aerobic exercise in conjunction with resistance training in order to obtain improvements in functional capacity, physical strength, cardiac risk factors and quality of life. This higher-intensity exercise prescription recommendation is supported by ECG-monitored exercise stress testing prior to programme commencement as standard practice, as well as the use of ECG monitoring during exercise training sessions in the AACVPR guidelines, in order to ensure the safety of participants and individualised exercise prescription. In comparison, the guidelines throughout Australasia, the UK, France and Japan recommend lower-intensity aerobic exercise and/or less technical exercise testing, with a reduced focus on resistance training.

While a reduced reliance on equipment and technology in lower-intensity exercise programmes may increase the accessibility of these cardiac rehabilitation programmes, exercise interventions in coronary artery disease patients based on recommendations of moderate to vigorous intensity have shown greater improvements in cardiorespiratory fitness and cardiac risk factors than lower-intensity interventions, when compared to usual care without an exercise component. The superior outcomes and demonstrated safety of

these higher-intensity interventions lend support for an international consensus for exercise prescription in cardiac rehabilitation programmes to include higher-intensity aerobic exercise in conjunction with resistance training, following ECG-monitored exercise stress testing and exercise monitoring. Countries that recommend lower-intensity aerobic exercise with a minimal focus on resistance training should look to reviewing the recent evidence and consider the potential of modifying their recommendations where the cost is not prohibitive.

Author contribution

KJP, BAG, SRB and ACB contributed to the conception or design of the work. KJP, BAG, SRB and ACB contributed to the acquisition, analysis or interpretation of the data for the work. KJP drafted the manuscript. KJP, BAG, SRB and ACB critically revised the manuscript. All gave final approval and agree to be accountable for all aspects of work ensuring integrity and accuracy.

Acknowledgement

The corresponding author is supported by a RMIT University PhD scholarship.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

1. Mendis S, Puska P and Norrving B. *Global Atlas on Cardiovascular Disease Prevention and Control*. Geneva: World Health Organisation. Available at: http://www.who.int/cardiovascular_diseases/publications/atlas_cvd/en/ (2011, accessed 9 March 2015).
2. Grace SL, Bennett S, Ardern CI, et al. Cardiac rehabilitation series: Canada. *Prog Cardiovasc Dis* 2014; 56: 530–535.
3. Bjarnason-Wehrens B, McGee H, Zwisler AD, et al. Cardiac rehabilitation in Europe: Results from the European Cardiac Rehabilitation Inventory Survey. *Eur J Cardiovasc Prev Rehabil* 2010; 17: 410–418.
4. World Health Organization Expert Committee. Rehabilitation after cardiovascular diseases, with special emphasis on developing countries. *World Health Organ Tech Rep Ser* 1993; 831: 1–122.
5. McCreery C, Cradock K, Fallon N, et al. *Cardiac Rehabilitation Guidelines 2013*. Dublin: Irish Association of Cardiac Rehabilitation. Available at: http://www.iacr.info/about/guidelines/ (2013, accessed 24 March 2015).
6. Goble AJ and Worcester MUC. *Best Practice Guidelines for Cardiac Rehabilitation and Secondary Prevention*. Carlton, Australia: Department of Human Services Victoria. Available at: http://www.health.vic.gov.au/nhpa/downloads/bestpracticecardiacrehab.pdf (1999, accessed 10 March 2015).
7. Oldridge N. Exercise-based cardiac rehabilitation in patients with coronary heart disease: Meta-analysis outcomes revisited. *Future Cardiol* 2012; 8: 729–751.
8. Turk-Adawi K, Sarrafzadegan N and Grace SL. Global availability of cardiac rehabilitation. *Nat Rev Cardiol* 2014; 11: 586–596.
9. Huang K, Liu W, He D, et al. Telehealth interventions versus center-based cardiac rehabilitation of coronary artery disease: A systematic review and meta-analysis. *Eur J Prev Cardiol* 2015; 22: 959–971.
10. Anderson L, Oldridge N, Thompson DR, et al. Exercise-based cardiac rehabilitation for coronary heart disease: Cochrane systematic review and meta-analysis. *J Am Coll Cardiol* 2016; 67: 1–12.
11. Clark RA, Conway A, Poulsen V, et al. Alternative models of cardiac rehabilitation: A systematic review. *Eur J Prev Cardiol* 2015; 22: 35–74.
12. Lawler PR, Filion KB and Eisenberg MJ. Efficacy of exercise-based cardiac rehabilitation post-myocardial infarction: A systematic review and meta-analysis of randomized controlled trials. *Am Heart J* 2011; 162: 571–584.
13. Rosenbaum AN, Kremers WK, Schirger JA, et al. Association between early cardiac rehabilitation and long-term survival in cardiac transplant recipients. *Mayo Clin Proc* 2016; 91: 149–156.
14. Goel K, Pack QR, Lahr B, et al. Cardiac rehabilitation is associated with reduced long-term mortality in patients undergoing combined heart valve and CABG surgery. *Eur J Prev Cardiol* 2015; 22: 159–168.
15. Lewinter C, Doherty P, Gale CP, et al. Exercise-based cardiac rehabilitation in patients with heart failure: A meta-analysis of randomised controlled trials between 1999 and 2013. *Eur J Prev Cardiol* 2015; 22: 1504–1512.
16. Anchique Santos CV, Lopez-Jimenez F, Benaim B, et al. Cardiac rehabilitation in Latin America. *Prog Cardiovasc Dis* 2014; 57: 268–275.
17. Karoff M, Held K and Bjarnason-Wehrens B. Cardiac rehabilitation in Germany. *Eur J Cardiovasc Prev Rehabil* 2007; 14: 18–27.
18. Balady GJ, Williams MA, Ades PA, et al. Core components of cardiac rehabilitation/secondary prevention programs: 2007 update: A scientific statement from the American Heart Association Exercise, Cardiac Rehabilitation, and Prevention Committee, the Council on Clinical Cardiology; the Councils on Cardiovascular Nursing, Epidemiology and Prevention, and Nutrition, Physical Activity, and Metabolism; and the American Association of Cardiovascular and Pulmonary Rehabilitation. *Circulation* 2007; 115: 2675–2682.
19. American Association of Cardiovascular and Pulmonary Rehabilitation. *Guidelines for Cardiac Rehabilitation and Secondary Prevention Programs*, 5th ed. Champaign, IL: Human Kinetics, 2013.

20. Stone JA, Arthur HM, Suskin N, et al. *Canadian Guidelines for Cardiac Rehabilitation and Cardiovascular Disease Prevention: Translating Knowledge into Action*, 3rd ed. Winnipeg, Canada: Canadian Association of Cardiac Rehabilitation, 2009.
21. Piepoli MF, Corra U, Benzer W, et al. Secondary prevention through cardiac rehabilitation: From knowledge to implementation. A position paper from the Cardiac Rehabilitation Section of the European Association of Cardiovascular Prevention and Rehabilitation. *Eur J Cardiovasc Prev Rehabil* 2010; 17: 1–17.
22. National Heart Foundation of Australia and Australian Cardiac Rehabilitation Association. *Recommended Framework for Cardiac Rehabilitation*. Australia: National Heart Foundation of Australia. Available at: http://www.heartfoundation.org.au/images/uploads/publications/Recommended-framework.pdf (2011, 2004, accessed 11 February 2015).
23. Woodruffe S, Neubeck L, Clark RA, et al. Australian Cardiovascular Health and Rehabilitation Association (ACRA) core components of cardiovascular disease secondary prevention and cardiac rehabilitation 2014. *Heart Lung Circ* 2015; 24: 430–441.
24. Heart Foundation and New Zealand Guidelines Group. *Evidence-Based Best Practice Guideline: Cardiac Rehabilitation*. Wellington: New Zealand Guideline Group. Available at: http://www.health.govt.nz/publication/cardiac-rehabilitation-guideline (2002, accessed 2 March 2015).
25. Herdy AH, Lopez-Jimenez F, Terzic CP, et al. South American guidelines for cardiovascular disease prevention and rehabilitation. *Arq Bras Cardiol* 2014; 103: 1–31.
26. Niebauer J, Mayr K, Tschentscher M, et al. Outpatient cardiac rehabilitation: The Austrian model. *Eur J Prev Cardiol* 2013; 20: 468–479.
27. Piepoli MF, Corra U, Benzer W, et al. Secondary prevention through cardiac rehabilitation: Physical activity counselling and exercise training: Key components of the position paper from the Cardiac Rehabilitation Section of the European Association of Cardiovascular Prevention and Rehabilitation. *Eur Heart J Suppl* 2010; 31: 1967–1974.
28. Pavy B, Iliou MC, Verges-Patois B, et al. French Society of Cardiology guidelines for cardiac rehabilitation in adults. *Arch Cardiovasc Dis* 2012; 105: 309–328.
29. Japanese Circulation Society Joint Working Group. Guidelines for rehabilitation in patients with cardiovascular disease (JCS 2012). *Circ J* 2014; 78: 2022–2093.
30. Strategic Commissioning Development Unit. *Service Specification for Cardiac Rehabilitation Services*. London: Department of Health England. Available at: http://webarchive.nationalarchives.gov.uk/20130107105354/http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/Browsable/DH_117507 (2010, accessed 3 July 2015).
31. Bjarnason-Wehrens B, Mayer-Berger W, Meister ER, et al. Recommendations for resistance exercise in cardiac rehabilitation. Recommendations of the German Federation for Cardiovascular Prevention and Rehabilitation. *Eur J Cardiovasc Prev Rehabil* 2004; 11: 352–361.
32. Scottish Intercollegiate Guidelines Network. *Cardiac Rehabilitation: A National Clinical Guideline*. Edinburgh: Scottish Intercollegiate Guidelines Network. Available at: http://www.scotphn.net/wp-content/uploads/2015/11/Cardiac_Rehabilitation.pdf (2002, accessed 11 February 2015).
33. McVeigh G, Bleakney G, Cupples M, et al. *Guidelines for Cardiac Rehabilitation in Northern Ireland*. Belfast: Clinical Resource Efficiency Support Team. Available at: http://www.gain-ni.org/index.php/guidelines-for-cardiac-rehabilitation-in-northern-ireland (2006, accessed 12 March 2015).
34. Royal Dutch Society for Physical Therapy. KNGF clinical practice guideline for physical therapy in patients undergoing cardiac rehabilitation. *Dutch J Phys Ther* 2011; 121: 1–47.
35. British Association for Cardiovascular Prevention and Rehabilitation. *The BACPR Standards and Core Components for Cardiovascular Disease Prevention and Rehabilitation 2012*. 2nd ed. London: British Cardiovascular Society. Available at: http://www.bacpr.com/resources/46C_BACPR_Standards_and_Core_Components_2012.pdf (2012, accessed 8 April 2015).
36. Aneurin Bevan Health Board. *Cardiac Rehabilitation Service Protocol*. Caerleon: Aneurin Bevan Health Board. Available at: http://www.wales.nhs.uk/sitesplus/documents/986/AB%20HB%20CR%20Service%20Protocol%20-%20040211.pdf (accessed 22 March 2015).
37. Borg G. *Borg's Perceived Exertion and Pain Scales*. Champaign, IL: Human Kinetics, 1998.
38. Dendale P, Dereppe H, Sutter JD, et al. Position paper of the Belgian Working Group on Cardiovascular Prevention and Rehabilitation: Cardiovascular rehabilitation. *Acta Cardiol* 2008; 63: 673–681.
39. Probert H, Barritt H, Breen S, et al. *Standards for Physical Activity and Exercise in the Cardiovascular Population*. 3rd ed. Manchester: Association of Chartered Physiotherapists in Cardiac Rehabilitation. Available at: http://acpicr.com/sites/default/files/ACPICR%20Standards%202015.pdf (2015, accessed 7 March 2015).
40. World Health Organization. *Global Recommendations on Physical Activity for Health*. Geneva: World Health Organization. Available at: http://www.who.int/dietphysicalactivity/factsheet_recommendations/en/ (2010, accessed 29 April 2015).
41. Achttien RJ, Staal JB, van der Voort S, et al. Exercise-based cardiac rehabilitation in patients with coronary heart disease: A practice guideline. *Neth Heart J* 2013; 21: 429–438.
42. NSW Department of Health. *NSW Chronic Care Program: Implementing Rehabilitation for Chronic Disease – Volume 2*. Sydney: NSW Department of Health. Available at: http://www0.health.nsw.gov.au/policies/gl/2006/pdf/GL2006_022.pdf (2006, accessed 17 March 2015).

43. Pina IL, Apstein CS, Balady GJ, et al. Exercise and heart failure: A statement from the American Heart Association Committee on Exercise, Rehabilitation, and Prevention. *Circulation* 2003; 107: 1210–1225.
44. Piepoli MF, Conraads V, Corra U, et al. Exercise training in heart failure: from theory to practice. A consensus document of the Heart Failure Association and the European Association for Cardiovascular Prevention and Rehabilitation. *Eur J Heart Fail* 2011; 13: 347–357.
45. Moe GW, Ezekowitz JA, O'Meara E, et al. The 2013 Canadian Cardiovascular Society heart failure management guidelines update: Focus on rehabilitation and exercise and surgical coronary revascularization. *Can J Cardiol* 2014; 30: 249–263.
46. Selig SE, Levinger I, Williams AD, et al. Exercise & Sports Science Australia Position Statement on exercise training and chronic heart failure. *J Sci Med Sport* 2010; 13: 288–294.
47. Oberman A, Fletcher GF, Lee J, et al. Efficacy of high-intensity exercise training on left ventricular ejection fraction in men with coronary artery disease (The Training Level Comparison Study). *Am J Cardiol* 1995; 76: 643–647.
48. Goble AJ, Hare DL, Macdonald PS, et al. Effect of early programmes of high and low intensity exercise on physical performance after transmural acute myocardial infarction. *Br Heart J* 1991; 65: 126–131.
49. Worcester MC, Hare DL, Oliver RG, et al. Early programmes of high and low intensity exercise and quality of life after acute myocardial infarction. *BMJ* 1993; 307: 1244–1247.
50. Rechnitzer PA, Cunningham DA, Andrew GM, et al. Relation of exercise to the recurrence rate of myocardial infarction in men: Ontario Exercise-Heart Collaborative Study. *Am J Cardiol* 1983; 51: 65–69.
51. Blumenthal JA, Rejeski WJ, Walsh-Riddle M, et al. Comparison of high- and low-intensity exercise training early after acute myocardial infarction. *Am J Cardiol* 1986; 61: 26–30.
52. Mezzani A, Hamm LF, Jones AM, et al. Aerobic exercise intensity assessment and prescription in cardiac rehabilitation: A joint position statement of the European Association for Cardiovascular Prevention and Rehabilitation, the American Association of Cardiovascular and Pulmonary Rehabilitation and the Canadian Association of Cardiac Rehabilitation. *Eur J Prev Cardiol* 2013; 20: 442–467.
53. Sandercock GR, Cardoso F, Almodhy M, et al. Cardiorespiratory fitness changes in patients receiving comprehensive outpatient cardiac rehabilitation in the UK: A multicentre study. *Heart* 2013; 99: 785–790.
54. West RR, Jones DA and Henderson AH. Rehabilitation after myocardial infarction trial (RAMIT): Multi-centre randomised controlled trial of comprehensive cardiac rehabilitation in patients following acute myocardial infarction. *Heart* 2012; 98: 637–644.
55. Pattyn N, Vanhees L, Cornelissen VA, et al. The long-term effects of a randomized trial comparing aerobic interval versus continuous training in coronary artery disease patients: 1-year data from the SAINTEX-CAD study. *Eur J Prev Cardiol* 2016; 23: 1154–1164.
56. Belardinelli R, Paolini I, Cianci G, et al. Exercise training intervention after coronary angioplasty: The ETICA trial. *J Am Coll Cardiol* 2001; 37: 1891–1900.
57. Giallauria F, Cirillo P, Lucci R, et al. Left ventricular remodelling in patients with moderate systolic dysfunction after myocardial infarction: Favourable effects of exercise training and predictive role of *N*-terminal pro-brain natriuretic peptide. *Eur J Cardiovasc Prev Rehabil* 2008; 15: 113–118.
58. La Rovere MT, Bersano C, Gnemmi M, et al. Exercise-induced increase in baroreflex sensitivity predicts improved prognosis after myocardial infarction. *Circulation* 2002; 106: 945–949.
59. Iellamo F, Legramante JM, Massaro M, et al. Effects of a residential exercise training on baroreflex sensitivity and heart rate variability in patients with coronary artery disease: A randomized controlled study. *Circulation* 2000; 102: 2588–2592.
60. Hambrecht R, Walther C, Mobius-Winkler S, et al. Percutaneous coronary angioplasty compared with exercise training in patients with stable coronary artery disease: A randomized trial. *Circulation* 2004; 109: 1371–1378.
61. Arthur HM, Smith KM, Kodis J, et al. A controlled trial of hospital versus home-based exercise in cardiac patients. *Med Sci Sports Exerc* 2002; 34: 1544–1550.
62. Kalapura T, Lavie CJ, Jaffrani W, et al. Effects of cardiac rehabilitation and exercise training on indexes of dispersion of ventricular repolarization in patients after acute myocardial infarction. *Am J Cardiol* 2003; 92: 292–294.
63. Ades PA, Pashkow FJ, Fletcher G, et al. A controlled trial of cardiac rehabilitation in the home setting using electrocardiographic and voice transtelephonic monitoring. *Am Heart J* 2000; 139: 543–548.
64. Gordon NF, English CD, Contractor AS, et al. Effectiveness of three models for comprehensive cardiovascular disease risk reduction. *Am J Cardiol* 2002; 89: 1263–1268.
65. Carlson JJ, Johnson JA, Franklin BA, et al. Program participation, exercise adherence, cardiovascular outcomes and program cost of traditional versus modified cardiac rehabilitation. *Am J Cardiol* 2000; 86: 17–23.
66. Oerkild B, Frederiksen M, Hansen JF, et al. Home-based cardiac rehabilitation is an attractive alternative to no cardiac rehabilitation for elderly patients with coronary heart disease: results from a randomised clinical trial. *BMJ Open* 2012; 2: e001820.
67. Kovoor P, Lee AKY, Carrozzi F, et al. Return to full normal activities including work at two wks after acute myocardial infarction. *Am J Cardiol* 2006; 97: 952–958.
68. Maddison R, Pfaeffli L, Whittaker R, et al. A mobile phone intervention increases physical activity in people with cardiovascular disease: Results from the HEART randomized controlled trial. *Eur J Prev Cardiol* 2015; 22: 701–709.

69. Sandström L and Ståhle A. Rehabilitation of elderly with coronary heart disease – Improvement in quality of life at a low cost. *Adv Physiother* 2009; 7: 60–66.
70. Williams MA, Haskell WL, Ades PA, et al. Resistance exercise in individuals with and without cardiovascular disease: 2007 update: A scientific statement from the American Heart Association Council on Clinical Cardiology and Council on Nutrition, Physical Activity, and Metabolism. *Circulation* 2007; 116: 572–584.
71. Marzolini S, Oh PI and Brooks D. Effect of combined aerobic and resistance training versus aerobic training alone in individuals with coronary artery disease: A meta-analysis. *Eur J Prev Cardiol* 2012; 19: 81–94.
72. Fletcher GF, Ades PA, Kligfield P, et al. Exercise standards for testing and training: A scientific statement from the American Heart Association. *Circulation* 2013; 128: 873–934.
73. Arena R, Myers J, Williams MA, et al. Assessment of functional capacity in clinical and research settings: a scientific statement from the American Heart Association Committee on Exercise, Rehabilitation, and Prevention of the Council on Clinical Cardiology and the Council on Cardiovascular Nursing. *Circulation* 2007; 116: 329–343.
74. Harrison SL, Greening NJ, Houchen-Wolloff L, et al. Age-specific normal values for the incremental shuttle walk test in a healthy British population. *J Cardiopulm Rehabil Prev* 2013; 33: 309–313.
75. Elliott D, Denehy L, Berney S, et al. Assessing physical function and activity for survivors of a critical illness: a review of instruments. *Aust Crit Care* 2011; 24: 155–166.
76. Pavy B, Iliou MC, Meurin P, et al. Safety of exercise training for cardiac patients. Results of the French registry of complications during cardiac rehabilitation. *Arch Intern Med* 2006; 166: 2329–2334.
77. Rogers MA, Yamamoto C, Hagberg JM, et al. The effect of 7 years of intense exercise training on patients with coronary artery disease. *J Am Coll Cardiol* 1987; 10: 321–326.
78. Belardinelli R, Georgiou D, Cianci G, et al. 10-year exercise training in chronic heart failure: A randomized controlled trial. *J Am Coll Cardiol* 2012; 60: 1521–1528.