A.C.P.I.C.R.

Association of
Chartered Physiotherapists
in Cardiac Rehabilitation

ACPICR Standards

Standards for Physical Activity and Exercise in the Cardiovascular Population

2015

3rd Edition

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Introduction

Cardiac Rehabilitation (CR) is an expanding speciality within physiotherapy. In 1995 the Association of Chartered Physiotherapists in Cardiac Rehabilitation (ACPICR) was established to develop the interests of all physiotherapists involved in CR.

The group is recognised as a professional network by the Chartered Society of Physiotherapy (CSP) and the British Association for Cardiac Prevention and Rehabilitation (BACPR), the national multi-disciplinary organisation for CR professionals.

These standards have been developed through a review of the evidence for best practice and consensus of expert opinion in the exercise component of CR [1-4], by a working party of the ACPICR. They are updated from the 'ACPICR Standards for Physical Activity and Exercise in the Cardiac Population' which was published in 2009. They have been peer-reviewed by the BACPR Exercise Professionals Group (EPG). The full list of peer reviewers can be found on page [79]. The aim is to standardise the quality and approach taken by exercise professionals when delivering the exercise component of CR, in order to provide service equity to the widest variety of people with cardiovascular disease (CVD).

It is important to recognise that whilst the broad evidence-base for the efficacy of CR is exercise focused, emerging evidence and practice must respect that exercise is but one sub-component of lifestyle risk factor management, and that equal value should be placed on the other main components including psychosocial health, medical risk factor management, cardioprotective therapies, and central to all these, health behaviour change and education [5].

Aim of the booklet

This publication aims to provide a reference guide for current CR exercise professionals to deliver safe and optimally effective exercise to all eligible individuals with, or at high risk of developing CVD and includes:

- presenting the best practices of individualised care, primary prevention, rehabilitation and secondary prevention of all components as applied to the elements of the patient's life which have been, or will be affected by their cardiovascular (CV) status
- a detailed framework for setting up new programmes and benchmarking existing programmes
- a guide for the setting of local and national standards
- evidence for line managers and CR practitioners to secure a quality service
- a guide to health and safety
- guidance for managing the complex and high risk individual
- a tool to compliment and elaborate on the BACPR Standards and core components in particular core component 3.2.1 Physical activity and exercise [5].

Each of the standards within this publication are designed to meet a given core criteria and should be regularly monitored through audit [6]. The content of this publication is not exhaustive and therefore further reading is recommended. These standards should be used in conjunction with the CSP Quality Assurance Standards for Physiotherapy Service Delivery [7]. For those individuals whose practice is not regulated by either the CSP or Health and Care Professions Council (HCPC), they should be applied within the realms of one's own profession's standards, for example The Code of Practice of the Register of Exercise Professionals (REPs) [8] or The Code of Practice of the British Association of Sports & Exercise Sciences (BASES) [9].

Target individual population

In keeping with national frameworks and guidelines [1,4,10,11] it is recommended that the following groups will benefit from receiving CR and should be targeted:

- Coronary heart disease (CHD)
  - Individuals with new onset or worsening exertional angina
  - Acute coronary syndromes (ACS)
- Before and after revascularisation – percutaneous coronary intervention (PCI) or coronary artery bypass surgery (CABG)
- Other cardiac surgery
- Following any step wise alteration in CHD condition
- Other atherosclerotic disease for example peripheral arterial disease (PAD)
- Stable heart failure (HF) and cardiomyopathy
- Congenital heart disease
- Following arrhythmias and implantable device interventions (implantable cardioverter defibrillator (ICD), permanent pacemaker (PPM), cardiac resynchronisation therapy (CRT))
- Other specialised interventions such as cardiac transplantation and ventricular assist devices (VADs)
- Those at high multi-factorial risk of CVD [12,13]
- Metabolic syndrome (hypertension/diabetes/obesity).

Adaptations should be made to the CR programme to allow inclusion of all individuals with, or at high risk of developing, CVD according to their risk stratification (Appendix E), comorbidities and physical ability, thereby providing appropriate education, counseling and supervision.

Equality and diversity in cardiac rehabilitation

The burden of CVD is spread across all groups within the population, however its concentration in some particular groups may pose service planning considerations for exercise practitioners delivering the CR pathway. Various publications have highlighted that there are marked inequalities in the way several groups access CR services: women, minority ethnic groups, elderly, lower socioeconomic groups, people with more severe CHD, and people with mental and physical health comorbidities have all been shown to be under-represented [14-19]. Practitioners must consider active recruitment strategies to incorporate these groups equally within their services.

In order to address inequalities, CR providers must consider the diverse needs of the local population served by their programme [18]. Staff must show socio-cultural competency when assessing and utilising interventions for individuals from minority groups. Strategies should be implemented which remove barriers to individuals receiving adequate care, for example, written information should be considered in appropriate languages for the local population, the exercise component should be offered regardless of age [16] and single sex classes should be offered where appropriate.

An obvious challenge is posed when respecting the style and nature of exercise that may need to be considered with individuals from different cultural backgrounds; however practitioners must be able to demonstrate that they are providing a fair and equal service, having considered unintentional discrimination against specific groups and be able to demonstrate that adaptations are offered where appropriate.

In order to challenge inequalities and mainstream equality in health, individual feedback on the CR services provided should be sought at appropriate intervals [1,4,10,11]. In addition, to meet the individual's psychosocial needs and to create the best possible chances of uptake, long-term adherence and self-management of a physically active lifestyle, the BACPR Standards and Core Components recommend that a choice of CR venue (hospital, community or home) is offered [5].

Key national guidelines associated with cardiac rehabilitation

A number of key publications guide the design and implementation of CR as summarised below:

Group	Guideline/Policy	Website
General (all)	• Scottish Intercollegiate Guidelines Network (SIGN) guidelines for CR (2002)	www.sign.ac.uk
	• American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR) (2006)	www.aacvpr.org
	• American College of Sports Medicine (ACSM) (2009)	www.acsm.org
	• Joint British Societies' (JBS3) Consensus recommendations for the prevention of cardiovascular disease 2014	www.jbs3risk.com
	• BACPR Guidelines for CR (1995)	www.bacpr.com
	• BACPR Standards and Core Components for CR (2012)	www.bacpr.com
	• National Service Framework (NSF) - Coronary Heart Disease (2000)	www.dh.gov.uk
	• Together for Health- a heart disease delivery plan (2013)	www.wales.gov.uk
	• Clinical Resource and Efficiency Support Team (CREST) – Guidelines for Northern Ireland (2006)	www.crestni.org.uk
	• National Health Service (NHS) commissioning (2010)	www.nice.org.uk
	• National Institute for Clinical Excellence (NICE) CR commissioning (2011)	
	• United Kingdom (UK) Physical activity guidelines (2011)	
	• European Society of Cardiology (ESC) 2012	www.escardio.org
	• Cochrane 2011	www.cochrane.org
	• BACPR RCUK resuscitation training and facilities requirements for supervised CR programmes	www.bacpr.com www.resus.org.uk
	• Canadian Association of CR (CACR) (2009)	www.cacr.ca
Myocardial infarction (MI)	• Secondary prevention in primary and secondary care for patients following a myocardial infarction (Clinical Guideline (CG)172) (2013)	www.nice.org.uk
	• Care for Patients following a Myocardial Infarction (CG48) (2007)	

Heart Failure (HF)	• Chronic Heart Failure: management of chronic heart failure in adults in primary and secondary care (CG108) (2010) • European Society of Cardiology (ESC) (2008) • SIGN Heart Failure Guidelines (2007) • NICE Commissioning HF (2011) • NICE Chronic HF guidelines (2010) • Cochrane 2010	www.nice.org.uk www.escardio.org www.sign.ac.uk www.nice.org.uk www.cochrane.org
Arrhythmias and ICD	• NSF CHD - Chapter 8 of NSF (2005) • NICE guidelines for atrial fibrillation (CG36) (2006) • ESC guidelines (2010)	www.dh.gov.uk www.nice.org.uk www.escardio.org
ACHD	• ESC guidelines (2010) • AHA Exercise guidelines (2004) • Bethesda Conference 36 (2005)	www.escardio.org
Hypertension	• NICE guidelines (2011) • ESH/ESC guidelines (2013) • British Hypertension Society (2011) • Guidelines Hypertension (2010)	www.nice.org.uk www.escardio.org www.bhsoc.org
Primary Prevention	• DOH (2011) • Cochrane 2011	www.dh.gov.uk www.cochrane.org

Burden of cardiovascular disease

According to the World Health Organization (WHO), the leading causes of non-communicable disease deaths (NCD) in 2008 were cardiovascular diseases, with the global estimate of deaths by CVD 17.31 million, or 48% of all NCDs, and 7.3 million of these were attributed to heart disease [17,20]. Although mortality from CVD is reducing year on year, it continues to be the most common cause of death in the United Kingdom (UK), accounting for just under almost 180,000 deaths each year. Recent statistics indicate that deaths from CHD were 80,000 [12]. In 2010 in the UK, CVD caused 46,000 premature deaths, of which 68% were in males. There remains however, huge variations in coronary disease mortality across the UK. For example, death rates are higher in Scotland compared to England and higher in lower income regions. Death rates from CHD are highest in the north-west of England and lowest in southern England. The good news is that death rates from myocardial infarctions in England have halved since 2002 and the incidence of CHD has decreased in all areas. Moreover, the number of PCI procedures being performed has trebled over the past 10 years.

Regarding morbidity from CHD and according to national health surveys, there are 1.2 million men and 900,000 women diagnosed with chronic angina – although these figures are lower when taken from the General Practitioners Register Database. There are also currently approximately 800,000 people suffering from HF, with about 25,000 new cases being diagnosed every year – 60% being in the male population. The diagnosis of HF increases with age.

Importantly however, in line with successful government policies, the overall burden of CHD has been reduced over the past four decades and targets laid down in The Health of the Nation (1992) have already been met.

The British Heart Foundation (BHF) and other organisations nonetheless recognise that there is no room for complacency and they remain committed to targeting the inequalities in CVD prevalence, to identifying the main causes of CVD, and continuing to reduce the incidence of CVD within the population.

Prevention of cardiovascular disease (CVD) and the role of physical activity

Prevention can be classified as primary or secondary prevention, although in CVD the distinction between the two is not definitive due to the gradual and long-term nature of the disease process [21]. Prevention of CVD can also be a population based approach such as the Change4Life Campaign [22].

According to the JBS3, primary prevention strategies should be targeted equally at those with

- established atherosclerotic CVD
- individuals diagnosed with diabetes
- those at high risk of developing symptomatic CVD [12].

Individuals can be considered at risk if there is:

- Family history of premature atherosclerotic disease or established hypercholesterolaemia
- Elevated blood pressure > 160 mmHg systolic or > 100 mmHg diastolic, or lesser degrees of blood pressure elevation with target organ damage
- Elevated total cholesterol to high density lipoprotein (HDL) cholesterol ratio [12]
- Asymptomatic individuals who have a combination of risk factors.

Prevention requires a multi-factorial approach to key modifiable risk factors (smoking, hypertension, diabetes or impaired glucose tolerance, dietary patterns, physical activity, alcohol consumption, dyslipidaemias and psychosocial factors) [23,24]. Lack of physical activity is an independent risk factor [25] and contributes to risk reduction in other risk factors.

Physical activity is defined as any human movement above resting state. It is the total volume of physical activity as influenced by the size of muscle mass engaged and the intensity, frequency and duration of such activity. These factors should be considered when participating in structured exercise, recreation or activities of daily living as it is the combined accumulation from all these activities which will determine whether an individual is attaining enough physical activity to be considered healthy [26].

The most contemporary evidence reports that globally >40% of people with CHD are "inactive". More poignant is that from the individual country data within this same survey, >75% of people in the UK with CHD were "inactive" [27].

This same report, along with the Joint Chief Medical Officer's (CMO) Report for England, Wales, Scotland and N. Ireland [28] states similar levels of prevalence in other health conditions related to inactivity and time spent sitting, including: poorer insulin sensitivity, blood glucose and fat metabolism, type II diabetes, obesity, some cancers, and poorer psychosocial well-being and mood.

The greatest benefit in reducing the development or progression of CVD in both primary and secondary prevention is when physical activity is performed at an intensity which leads to an improvement in aerobic fitness (>40% of maximal aerobic capacity) [29-31]. In both primary and secondary prevention of CVD, for every one metabolic equivalent (MET) increase in aerobic

fitness there is a reduction of 8 – 17% in premature mortality [32]. The key target of getting large proportions of national populations to attain physical activity levels greater than 4.3kcal/kg/day has been to recommend individuals accumulating 150 minutes of moderate intensity activity or 75 minutes of vigorous activity per week; along with minimising extended periods of being sedentary [28].

The scientific measurement of physical activity is normally reported as kilocalories (kcal) or kilojoules. The related epidemiological evidence, including that noted above has shown that when individuals expend greater than 4.3 kcal/kilogram (kg) of body mass per day (for example 1000-1500 kcal per week for a 75 kg male) above basal metabolic requirements, there is a decline in the incidence of CVD which is due to either a reduction in risk factors or from an actual improvement in endothelial status, or a halting or regression in the formation of atheromatous plaques [33-35].

- **Limit sedentary time**

AND

- **150 minutes moderate intensity activity a week**

OR

- **75 minutes of vigorous activity spread across week**

OR

- **A combination of moderate and vigorous activity spread across the week**

N.B.

- The activity should be performed in at least 10 minute bouts
- The overall volume of activity is more important than the duration and intensity

UK physical activity guidelines, 2011 [28]

Definition of cardiac rehabilitation

The BACPR define cardiac rehabilitation as:
"The coordinated sum of activities required to influence favourably the underlying cause of CVD, as well as to provide the best possible physical, mental and social conditions, so that the individuals may, by their own efforts, preserve or resume optimal functioning in their community and through improved health behavior, slow or reverse progression of disease" [5].

Physical activity guidelines and their application in cardiac rehabilitation

It must be appreciated that national guidelines for physical activity are aimed at the prevention and not the rehabilitation of chronic diseases and disability. They aim to provide an overall public health message and not necessarily provide guidance for specialised and individualised exercise prescription for those with CVD. In a large majority of the studies included in the Cochrane review on CR [36], aerobic exercise training was performed at moderate to vigorous intensity, two to three times per week, averaging 30 minutes per session of aerobic type activity (with a range of 60 to 100 minutes per week). This is similar for the Cochrane Review on exercise in HF [37]. Much of this data in both CHD and HF individuals has been collected on males under the age of 65 years, and thus for many enrolled in CR the "one size fits all" approach of the CMO's recommendation [28], and in some cases the Cochrane Reviews and the various NICE guidelines may not be appropriate (physiologically and behaviourally). This may be especially true in the early stages of rehabilitation or for the older, low functioning and higher risk individual. Before designing a programme around ideal targets identified in

systematic reviews and national guidelines, appropriate goal setting must consider the following: risk stratification, current functional capacity, psychosocial constraints and comorbidities.

The BACPR [5] has summarised the key evidence for supporting the efficacy of activity and exercise-based CR following an MI or coronary revascularisation, including:

Reductions in
- All cause mortality by 11 – 26% [38-40]
- Cardiac mortality by 26 – 36% [38-40]
- Unplanned hospital admissions by 28 – 56% [41,42].

Improved
- Quality of life [36]
- Functional capacity [36]
- Early return to work [36]
- Development of self-management [36].

Similarly, systematic reviews have highlighted benefits to individuals with chronic heart failure (CHF), demonstrating evidence of decreased mortality, enhancement of quality of life (QOL) and that exercise is safe for these individuals [37,43].

The early commencement of comprehensive rehabilitation is also associated with better uptake and adherence to a CR programme [44,45]. Furthermore, a meta-analysis recommends commencing exercise as soon as possible following an MI (assuming risk stratification and condition stability is determined), where for every week delay in commencing exercise equates to a delay of one further month for beneficial ventricular remodelling to occur [46].

Physical activity and exercise therapy must be included as a core component of any programme that aims to either reduce the incidence of, or prevent further disease progression in "at risk" individuals with and without established CVD. CR exercise performed that follows the recommended standards and guidelines is safe. Supervised CR has demonstrated one fatal event per 752,365 patient-hours, which compared favourably to one death per 565,000 person hours of general population exercise [47].

Provision of cardiac rehabilitation

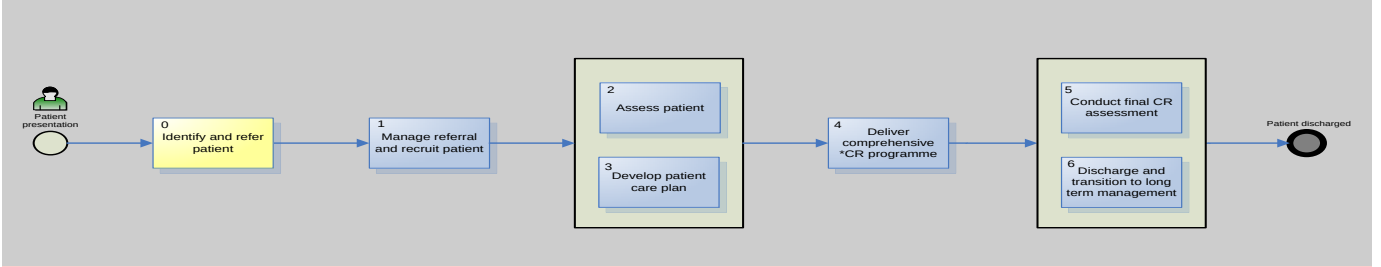
CR is an integral part of the care of the cardiac population. Comprehensive CR, combining the key components of exercise, education, psychological and social support, is endorsed by NICE clinical guidance [16-18]. CR involves a team of professionals working in an integrated way with the individual, his/her partner and family.

Exercise is a key element within the core components for the prevention and rehabilitation of CVD. The seven components are: lifestyle risk factor management (regarding physical activity and exercise, diet, weight management and smoking cessation), psychosocial health, cardio-protective therapies, medical risk factor management, health behaviour change and education, audit and evaluation and long-term management [5].

Commissioning CR is fundamental to the wider strategy for the management of CVD and long-term conditions. Based on recent epidemiological data, reports suggest that 0.4% of the population in England would be suitable for referral to a CR service per year [18]. Commissioners may use a local needs assessment to determine optimum levels for local service provision [15, 18].

Collaboration between primary and secondary care services is vital in order to achieve the best CR outcomes [48]. Mixed models of provision are likely to be appropriate within a local area. There are approximately 400 CR programmes registered in the UK which are delivered in a variety of settings; either group based in a hospital or community setting or home-based [19,49].

The ACPICR strongly recommends that programmes are registered with the National Audit of Cardiac Rehabilitation (NACR) as the data obtained influences national policy. Details can be obtained from: www.cardiacrehabilitation.org.uk



DoH, 2012

With appropriate screening, the exercise component can be effectively delivered within the community, or at home [18,36]. Following a comprehensive assessment, the delivery of the CR service should be tailored to the individual. From the range of options available, the individual should be encouraged to attend the interventions appropriate to his/her clinical needs at the time and in a suitable setting. Home and group based CR appear to be equally as safe and effective in improving the clinical and health-related quality of life outcomes in individuals following acute MI and revascularisation [50].

Emphasis on empowering individuals to manage their own health is a key element in the management of CVD and other long-term conditions. In order to complete the CR pathway, it is vital that the individual takes advantage of the many exercise and physical activity opportunities available in his/her local community with continued support from the primary care team [15].

Cardiac rehabilitation and the physiotherapist's role

Chartered physiotherapists are autonomous practitioners, who work independently to assess, diagnose and identify individual needs. With their extensive clinical experience, knowledge of pathophysiology and exercise prescription, physiotherapists with the appropriate skills and competences are able to assess and interpret clinical status and functional capacity enabling the development and adaptation of safe, effective and individualised exercise [51].

Comprehensive CR requires the combined skills of a multi-disciplinary team (MDT) of professionals. Chartered physiotherapists have the training, clinical knowledge, experience and skills to qualify them to take the lead in the delivery of the activity and exercise components of comprehensive CR [52].

A physiotherapist's autonomous, problem solving approach allows for a flexible management plan for individuals as opposed to a rigid, protocol driven one. An experienced physiotherapist (Band 6 and above) possesses important clinical knowledge in musculoskeletal

(MSK), CV and respiratory, and neurological medicine, as well as in movement analysis. This professional knowledge, combined with assessment and clinical reasoning skills, and an evidence-based approach to treatment, equips them to undertake the rehabilitation management of individuals with complex comorbidities [1,52]. A physiotherapist is able to adapt activity and exercise prescription for a wide range of neuromuscular and MSK co-pathologies. This means that individuals who may have otherwise been excluded from exercise or deemed to be unsuitable participants, may be included in exercise programmes. By contrast, physiotherapists are also able to identify individuals for whom exercise is either contra-indicated or inappropriate at a given moment in time. It is this specialist knowledge and skills together with exercise qualifications that make physiotherapists unique in their contribution to the CR team, allowing them to lead the exercise and activity components for all stages of the CR pathway.
More information can be found on the Role of the Physiotherapist in CR via the ACPICR website www.acpicr.com or by following the link:
http://acpicr.com/sites/default/files/Role%20of%20the%20Physiotherapist%20in%20Cardiac%20Rehabilitation%20Document%20version%204.pdf

Specialist knowledge, skills and competences

Exercise professionals (with a relevant qualification as recognised by the CSP or BACPR), who wish to work/specialise in this area should refer to the following publications:

- BACPR EPG Core Competences for the Physical Activity and Exercise Component of Cardiovascular Rehabilitation Services [5]
- http://acpicr.com/sites/default/files/Role%20of%20the%20Physiotherapist%20in%20Cardiac%20Rehabilitation%20Document%20version%204.pdf
- BACPR Exercise Professionals Position Statement BACPR EPG [51]
- http://www.bacpr.com/resources/51A_EPG_Position_Statement.pdf
- Skills for Health National Workforce Competence Guide for Coronary Heart Disease document [53].

There are specific training courses run by the BACPR in association with the ACPICR – www.bacpr.com/education

The following are areas in which appropriate professional development are required:

- Exercise physiology and prescription in CVD
- Interpreting clinical exercise results and assessing fitness
- Synthesis of assessment results into a safe and effective exercise and physical activity plan, with appropriate goal setting, meeting individuals psychosocial (cognitive and behavioural) capabilities and needs
- Understanding the effects of prescribed medications commonly used for persons with chronic diseases, MSK conditions, neuromuscular conditions, and functional limitations and disabilities associated with aging
- Designing, instructing/coaching appropriate exercise movement techniques and safety
- Managing and monitoring individual or groups of exercising individuals in home, community or hospital-based settings
- Promoting physical activity both in prevention and rehabilitation of CVD, based upon the latest epidemiological and evidence based practice.

There is no substitute for experience and when coupled with guided feedback of results and reflective practice, all possible clinical scenarios can be managed successfully. We encourage

the use of clinical and research networks to share experiences for example iCSP www.csp.org.uk/icsp

STANDARD 1: Service agreement for recruitment and referral

There should be a local recruitment policy/protocol for all individuals to be referred for physical activity advice and the exercise component of CR [4].

Criteria:

1.1 There is an identified medical contact assuming responsibility for clinical issues that arise from CR.

1.2 The written referral policy/protocol should include:

- Source of referral
- Designation of referrer
- Contact details of referrer
- Agreed minimum individual information
- Referral criteria
- Pathway for the individual within the CR service to include management of:
- inappropriate referrals
- individuals who are not ready to commence
- individuals who are unable/unwilling to participate or who fail to attend
- Management of individuals with specialist and complex needs.

STANDARD 2: Initial assessment

Individuals should be assessed and advised on appropriate physical activity and exercise as early as possible within the rehabilitation process. Individuals should undergo thorough screening and an assessment prior to undertaking physical activity and exercise [5]. The referral information should include, as a minimum, baseline data on individual demographics, presenting condition and any relevant investigations and treatments.

Criteria:

2.1 The assessment should encompass the relevant sections identified in the CSP Quality Assurance Standards 7.

2.2 Any contraindications to exercise should be identified (adapted from ACSM 9th edition p 238) [55]

The following are contraindications which preclude an individual from joining or continuing the exercise component (with the exception of allowances as determined in consultation with an appropriate doctor/GP or cardiologist):

- Unstable angina
- Uncontrolled hypertension, that is, resting systolic blood pressure (SBP) >180mmHg, or resting diastolic blood pressure (BP) (DBP) >110mmHg
- Orthostatic blood pressure drop of >20 mmHg with symptoms
- Significant aortic stenosis (aortic valve area <1.0 cm^2)
- Acute systemic illness or fever
- Uncontrolled atrial or ventricular arrhythmias

- Uncontrolled sinus tachycardia (HR>120 bpm)
- Acute pericarditis or myocarditis
- Uncompensated HF
- Third degree (complete) atrioventricular (AV) block without pacemaker
- Recent embolism
- Acute thrombophlebitis
- Resting ST segment displacement (>2 mm)
- Uncontrolled diabetes mellitus
- Severe orthopaedic conditions that would prohibit exercise
- Other metabolic conditions, such as acute thyroiditis, hypokalaemia, hyperkalaemia or hypovolaemia (until adequately treated)
- Severe grade 3 rejection (cardiac transplantation recipients Appendix N).

If individuals present with any of the above contraindications, exercise specialists should use their clinical judgment to give individualised advice regarding physical activity at an appropriate level.

2.3 The results of previous investigations should be taken into consideration and interpreted, including:

- Electrocardiogram (ECG)
- ECG exercise tolerance test (ETT)/cardiopulmonary exercise tolerance test (CPT)
- Echocardiogram (Echo)/ Dobutamine stress echo (DSE)
- Diagnostic angiogram
- Cardiac MRI/CT scan
- Myoview/Thallium scan
- IVUS/FFR
- Biochemistry results including Troponin T/Troponin I/CK/BNP
- Any other medical assessment that highlights limitations in performing physical activity.

2.4 The individual's understanding of his/her diagnosis, investigations and treatment should be ascertained.

2.5 All relevant information regarding the individual's current health status should be considered including outcomes from consultations with GP, consultant, specialist nurses or other health professionals.

2.6 All relevant medication (including dosage and frequency) and supplements should be documented and the individual's understanding and compliance discussed.

2.7 All relevant signs and symptoms should be established:

- Angina
- Shortness of breath (SOB) / dyspnoea
- Palpitations
- Arrhythmias
- Dizziness/lightheadedness
- Orthopnoea
- Ankle swelling
- Fatigue
- Weight gain of >2.3kg in two/three days
- Ascites

- Paroxysmal Nocturnal Dyspnea (PND)
- Cough
- Claudication
- Abnormal auscultatory findings (respiratory and cardiac where indicated).

2.8 All relevant comorbidities should be identified. Any mobility issues, use of aids and adaptations and input from relevant support services should be identified.

2.9 Physical measures should be taken including:

- Heart rate (HR)/rhythm
- Blood Pressure (BP)
- Blood glucose (fasting and 2 hour oral glucose tolerance test (OGTT))
- Weight
- SpO_2 if concurrent lung pathology, ACHD or pulmonary hypertension
- Body Mass Index (BMI)
- Waist circumference.

2.10 Questionnaires used as part of the assessment process should be analysed and discussed with the individual (Appendix A).

2.11 Prior and current physical activity should be established [56,57].

2.12 Readiness to participate in both physical activity and exercise should be established including psychological status, health beliefs and stage of change (Standard 4; Appendix A).

2.13 SMARTER goals in relation to physical activity and exercise should be established for example returning to work, activities of daily living (ADL) and sport.

2.14 Risk stratification should be carried out using recognised criteria (Appendix E) to determine the level of exercise intensity prescribed and supervision required [58,59].

2.15 Training heart rate should be calculated using recommended methods (Appendix C).

2.16 A Functional capacity test (FCT) should be undertaken (Appendix A).

- Choice of test should be dependent on the individual's ability, prior exercise habits, comorbidities and environment/availability of equipment
- The test should be performed following standardised procedures
- The test end point should be established i.e. sub-maximal or symptom limited
- The test should start at a low enough intensity (less than 40% heart rate reserve (HRR)) and include a spread of intensities up to 70% HRR (rating of perceived exertion (RPE) 14, CR10 4)
- The exercise response should be monitored using a combination of HR (Appendix C), RPE (Appendix D) [60], BP, SpO_2 and observation
- All signs and symptoms should be documented.
-

Key message:
Using all relevant information gained from a thorough assessment, the CR professional should use their clinical skills to advise on physical activity and to prescribe a safe and effective exercise programme tailored to the individual's needs.

STANDARD 3: Informed consent

Valid consent must be obtained from the individual prior to carrying out an assessment, functional test or intervention. The CR professional should consult and be aware of guidance on consent issued by their relevant health departments, regulating bodies and local policies and procedures [7, 61-66].

Criteria:

3.1 Consent can either be non-verbal, explicit (written or oral) or implied behaviour.

3.2 All forms of consent must be documented in the individual's records or on a relevant local consent form [67].

3.3 No one may give consent on behalf of another adult over the age of 18 (16 in Scotland) unless with qualified power of attorney (for example the disabled or cognitively impaired).

3.4 16 to 17 year olds can give their own consent. Children under 16 may be 'Gillick competent' to consent to treatment. If not, they must have consent gained from a parent or guardian. However, it is good practice to involve their families in their treatment decisions, if they agree for information to be shared.

3.5 The individual must be fully informed and understand their role in the decision making process.

3.6 All treatment options must be explained, including risks, benefits and side effects. Confirmation of the individual's understanding of the explanation should be established.

3.7 The individual must be given the opportunity to ask questions prior to giving consent.

3.8 Consent must be given voluntarily and freely without pressure.

3.9 The individual must be informed of their right to decline treatment at any stage. If the individual does decline, this must be documented in the individual's record, including the reasons if known.

3.10 If the individual's condition or treatment plan changes significantly, or the individual reports new information, further consent must be given and documented.

3.11 If photographs or other visual or audio recordings are made, written consent must be obtained. Individuals should have the right to withdraw consent at any time. Individuals should be informed that if footage is put on a web-based platform it may be impossible to remove. For more information visit the National Medical Illustration website www.imi.org.uk

3.12 Written consent must be obtained if individuals are involved in educational or study days.

Key message:
Consent should be a continuous process rather than a one-off event and should be focused on the rights of the individual.

STANDARD 4: Health behaviour change to assist individuals to become more physically active

Health behaviour change is essential to facilitate a physically active lifestyle [8].

Criteria:

4.1 Evidence-based health behaviour change interventions should be utilized, for example the Transtheoretical Model [69].

4.2 Communication style should promote an individual-centred approach, for example Motivational Interviewing [70].

4.3 Individual beliefs about exercise should be considered in order to address fears, misconceptions and to solve problems.

4.4 The exercise consultation should include discussing previous activity levels, interests, barriers, self-confidence and social support, thereby developing personal and realistic goals.

4.5 Informed choice regarding all physical activity options available should be given, as this may improve uptake and adherence for example mainstream exercise classes, low level exercise classes, local options of classes of suitable intensity/structure, gym programmes, home exercises, DVDs, walking plans, structured health walks.

4.6 The physical activity should be enjoyable, non-inhibiting, non-competitive and individualised in order to promote confidence and success [26].

4.7 Goals set should be specific, measurable, achievable, realistic, timely, empowering and revisable (SMARTER) [71] with regular follow-up to assess progress and advise on further goal setting [5]. Goals should be re-evaluated following any change from initial assessment i.e. clinical need, response and attitude to exercise.

4.8 Relapse prevention strategies and problem solving should be discussed in order to facilitate long- term physical activity.

4.9 Education and support should be provided to enable individuals to become more physically active. Consideration of referral to other professionals may be appropriate to maximise independence and activity (for example community rehabilitation teams, pulmonary rehabilitation, falls prevention services, elderly rehabilitation centres, stroke rehabilitation services).

4.10 It is essential to encourage activity that is achievable. For low functioning or sedentary

individuals the initial goal may be to achieve enough activity to gain health benefits (Appendix B), improve functional capacity or simply to prevent decline.

4.11 An individual should be educated regarding the benefits of regular physical activity and understand that his/her programme is individualised to his/her needs and their condition.

Key message:
'In meeting the individual's needs, health and behavior change and education are integral to all components of CR. The goals belong to the individual; they have to be meaningful for an individual to have ownership and to want to try to achieve them.' [72p.3.]

STANDARD 5: Safety information for physical activity

All individuals should receive safety information prior to commencing a guided programme of physical activity and this may need to be reinforced as part of an ongoing education programme.

Criteria:

5.1 There is documented evidence that the individual has received and understood information relating to the following:

5.1.1 Preparation for physical activity
- Suitable clothing and footwear
- Pre- and post-exercise eating and drinking
- Exercise environment, circuit and equipment where appropriate
- Benefits and purpose of physical activity
- No smoking for ≥ 1 hour.

5.1.2 How to exercise safely
- Importance of the warm up, cool down and appropriate exercise intensity
- Self-monitoring using HR monitoring (where appropriate) and RPE scales
- Recognition of signs and symptoms of over-exertion, metabolic dysfunction (hypoglycaemia and hyperglycaemia) or circulatory disorders
- Management of chest pain and severe breathlessness
- Adaptations for neuromuscular, MSK, and/or vascular limitations.

5.1.3 Pre-screen
- Relevance of change in medication
- Relevance of progressive symptoms for example suspected angina, arrhythmias or excessive breathlessness despite apparent adherence with the prescribed medication
- Relevance of deteriorating exercise performance/functional capacity despite apparent
- Adherence to the prescribed exercise regimen
- Appropriate monitoring for example blood glucose testing kit if available and

monitoring of weight in HF individuals
- Information regarding when not to exercise for example onset of fever
- Ensuring essential medication is available during physical activity for example GTN.

Any significant change in status may mean that exercise is contraindicated until relevant problems are resolved (Standard 2.7).

Key message:
The individual should receive ongoing education on how to exercise safely and effectively, thereby graduating towards being **a confident and independent exerciser.**

STANDARD 6: Structured exercise programming

The following recommendations are based on providing exercise in typical UK CR settings. These may seem more conservative than the evidence and guidelines from other countries which are based on the assumption that exercise programming and monitoring is determined from more precise maximal cardiopulmonary exercise tests.

In addition to CV training, structured programmes should include exercise that improves strength, flexibility, balance and coordination. It is essential that all programmes include a warm up, conditioning phase and cool down component. The conditioning component should be designed to produce a training effect, achieved by setting and progressing the appropriate frequency, duration, intensity and mode of exercise (Appendix B).

Throughout the structured exercise session, attention should be paid to breathing pattern, posture and positioning and the types of movement that would prevent hypotension, instability and falls.

Although the same principles for exercise training apply for all individuals, special considerations and adaptations for specific groups can be found in the following appendices:

Appendix G – Hypertension
Appendix H – Angina
Appendix I – Heart surgery including heart valve surgery
Appendix J – Atrial fibrillation (AF)
Appendix K – Heart failure (HF)
Appendix L – Implantable cardioverter defibrillator
Appendix M – Cardiac transplantation
Appendix N – Left ventricular assist devices
Appendix O – Adult congenital heart disease (ACHD)
Appendix P – Peripheral arterial disease (PAD) and intermittent claudication (IC)

Criteria:

6.1 Warm up

A low intensity graduated warm up is essential to prevent ischaemia and arrhythmia, by ensuring that the myocardium, coronary arteries and conductive tissues are able to meet the metabolic demands of exertion. This creates sufficient blood flow to ensure the key organs are optimally prepared (metabolically, thermally, neurologically) for the controlled stresses of an effective exercise session.

The aim is to:

- Prevent cardiopulmonary distress due to acute rises in catecholamines
- Increase the ischaemic threshold
- Prevent any unnecessary fatigue or postural instability
- Prevent muscle and joint injuries
- Aid performance of activities within the conditioning phase
- Allow time to assess exercise technique.

A warm up should:

6.1.1 Last for 15 minutes. For lower functioning individuals the period of warm up should be reduced proportionally to the length of the conditioning phase.

6.1.2 Mobilise joints and warm up all large muscle groups that will be engaged in the exercise training session.

6.1.3 Include pulse raising activities which are appropriate in content to the activities being performed in the conditioning phase.

6.1.4 Include static stretching interspersed with pulse raising moves to maintain HR; at present the evidence for preparatory stretching as a part of the above is equivocal. The performance of stretches by individuals often provide periods of active recovery within the warm up and act as a useful guide to assess individuals' proprioceptive/motor control abilities and joint mobility limitations.

6.1.5 Perform a re-warm after preparatory stretching before commencing the conditioning component.

6.1.6 Allow for alternative intensities of aerobic work.

6.1.7 Increase exercise effort gradually, so that by the end of the warm up the following should have been reached:

- A maximum of 40-50% of peak capacity
- HR within 20 beats per min (bpm) of training/target heart rate (THR)
- A maximum of 40% heart rate reserve (HRR)
- A RPE - BORG <11 (RPE scale) or <3 (CR10). (Appendix D).

6.2 Conditioning phase

The recommended dose of weekly CV exercise can be achieved by varying the frequency, intensity and duration which are suitable for the individual (Appendix B).

6.2.1 Frequency

In order to improve functional capacity, exercise should be undertaken at least 2-3 times per week [1,55,59,73].

6.2.2 Intensity

- Moderate intensity aerobic exercise, designed to suit a range of fitness levels, is recommended for most individuals undergoing exercise training [1,55,73-75]
- Individuals should be working at:
  - 40%-70% HRR (VO_2 max)
  - 11 – 14 (BORG RPE scale) (Appendix D)
  - 2 – 4 (CR10 scale) (Appendix D)
- Low functioning, more sedentary or high risk individuals should work towards the lower end of these intensity targets: 40% HRR, or RPE 11 (BORG RPE scale) and 2 (CR10) [55,59]
- Low risk or more active individuals should work towards the higher end of these intensity targets: 70% HRR or RPE 14 (BORG RPE scale) and 4 (CR10)
- Corresponding THR and RPE targets should be set for individuals as per the table below i.e. 40% VO_2 max corresponds to an RPE 11 (BORG RPE scale) and 2 (CR10).

6.2.3 Duration of exercise

- The duration and frequency are interchangeable
- For a structured exercise session a minimum duration of 20 minutes is recommended for the conditioning phase which can be progressed to 60 minutes [55,59,74,78].

6.2.4 Type of exercise

The two types of exercise that should be included are CV and strength training:

- Rhythmic activity of the large muscle groups of the body at a prescribed dosage
- A continuous or interval training approach can be performed
- Common CV exercises include circuit training, walking, cycling or gym based activities
- Muscular, strength and endurance (MSE) exercises which can be performed separately, as a part of the active recovery phases of interval type training or as part of the cool down
- Alternative options should be available for low functioning, high risk individuals or those with comorbidities for example strength training (Standard 6.5) and seated exercise (Standard 6.7)
- All exercise should consider balance, co-ordination and flexibility and opposing muscle groups.
-

6.3 Cool down

The risk of hypotension, ischaemia and arrhythmias within the first 30 minutes after

stopping an exercise session is well documented. A graded cool down has been found to reduce the incidence of these complications. Cool down exercise should be the reverse of the warm up in most respects with the aim to gradually return the cardiorespiratory system to near resting levels within 10 to 15 minutes [55,59,73,75,79.]

6.3.1 The duration should be a minimum of 10 minutes. For low functioning individuals the length of the cool down should be moderated to the length of the conditioning component.

6.3.2 Exercise effort should be gradually decreased relating to the individual's exercise prescription.

6.3.4 Stretching for the purposes of improving flexibility can be incorporated into the cool down [76] (Standard 6.6).

6.3.4 Individuals should be supervised for a minimum of 15 minutes from the end of the cool down.

6.4 Considerations for high intensity interval training (HIIT)

HIIT has been shown to improve CV fitness and health status of cardiac individuals although larger randomised interventional studies are necessary to demonstrate both the safety and efficacy of HIIT in a wider array of cardiac populations (for example older and frailer individuals) [80,81].

The benefits gained from exercise training in general increase proportionally with the intensity of the training programme [81]. HITT (training at 80-90% HRR/$V0_2$max) has been shown to confer greater benefit in selected stable cardiac individuals for a relatively low additional risk, when compared to continuous low-moderate intensity training [55,80-83]. The benefits include greater accumulated CV exercise time achieved and greater CV adaptations - such as improvements in peak oxygen uptake, ventricular function, and endothelial function, as well as improved MSE, and quality of life. HIIT has also been shown to be better tolerated by some individuals compared with moderate-intensity continuous exercise [55].

However programming for the HIIT trials was based on an initial assessment which included a maximal cardiorespiratory analysis (CPET) and closely monitored and supervised exercise sessions using precision measures determined from the CPET.

ACPICR can only recommend HITT when similar protocols for testing, monitoring and supervising to those detailed in the research trials can be provided. Moreover even when HIIT is prescribed as above it remains questionable as to whether such approaches will achieve compliance or adherence in the longer term for independent exercisers.

6.5 Resistance training

Resistance training is associated with enhancement and maintenance of muscle strength and power leading to an improvement in functional ability, stimulation in bone formation and reduction in bone loss. It has also been shown to improve glucose

metabolism, reduce blood pressure and maintain weight [28]. It can be performed safely by many individuals with CVD [55,75].

Resistance training can be used as either an independent session or as part of the active recovery component or cool down of an aerobic circuit; when undertaken after the CV component, a partial cool down is necessary prior to resistance work. Resistance work should be followed by a final cool down.

Moderate (>30% 1 repetition maximum (RM)) to high (70% 1RM) resistance training programmes performed twice a week for 3 - 6 months have shown improvements in muscular strength and endurance of 25-100% [84].

6.5.1 Frequency

Train each major muscle group at least twice a week and no more than 4 times per week (no more than every other day).

6.5.2 Intensity

For initiating strength training and in keeping with the AHA guidelines [84], these intensities are recommended.

- Upper body 30 - 40% 1RM
- Lower body 50 - 60% 1RM
- These intensities should be used initially and progressed, based on clinical and functional needs
- Determination of intensity should be set by appropriate exercise instruction methods in keeping with best practice [85]
- 1RM testing in this group has been shown to be safe but as in HITT aerobic training it may not be tolerable for other reasons such as MSK pain. Estimations of working at the appropriate %1RM can be made by the following options:
  - Working the selected muscle group to fatigue within 10 - 15 reps
  - Choosing a weight which elicits a Borg RPE 14 - 16 or 4 - 6 (CR10) after two repetitions [86].

Training can be progressed up to 50 - 80% 1RM for both upper and lower body once patients demonstrate good technique and have had no adverse responses or symptoms.

6.5.3 Time

Sets:

- A set comprises of the recommended repetitions
- Each set of repetitions for a given muscle group should not be repeated within the circuit
- 2 - 4 sets will improve strength and power [55].

Repitions:

- Perform 8 - 12 repetitions to improve strength and power
- Perform 15 - 20 repetitions to improve muscular endurance [55]
- Older adults or those starting out, perform 10 – 15 repetitions to improve strength [55].

6.5.4 Type

- A circuit should include 8 – 10 different key muscle groups [55,58,88]
- This may not be achievable for low functioning and less able individuals, therefore it is recommended to select a few key muscle groups that would promote function and aid independence.

6.5.5 Resistance training should be performed:

- In a rhythmical manner, though a full range of motion (ROM) that is controlled at a moderate to slow speed (i.e. 3 seconds concentric and 3 seconds of eccentric contraction)
- By alternating between lower and upper body to allow muscles to rest between exercises
- Considering muscle balance
- With a good technique:
  - Good posture
  - Avoiding excessive gripping of weights
  - Avoiding breath hold (Valsalva)
- It is recommended to wait 48 hours between resistance training sessions [55].

6.6 Flexibility recommendations

Considerable evidence suggests that a programme of stretching exercises increases tendon flexibility, improves joint ROM and function, and enhances muscular performance [55,89].

- Flexibility exercises are best performed 2 - 3 times a week when the muscles are warm for example following aerobic exercise
- Hold stretch for 30 seconds to point of tightness or slight discomfort
- Ensure that venous return is maintained whilst stretching
- Repeat stretch 2 – 4 times, accumulating 60 seconds per stretch
- Static, ballistic and proprioceptive neuromuscular facilitation (PNF) stretches are effective.

6.7 **Seated exercise**: (Appendix F)

Seated exercise programmes provide an opportunity to allow low functioning individuals such as the elderly and frail to engage in regular exercise. The evidence suggests that seated exercise improves muscular strength, systolic BP and HR response, balance and everyday living activities in addition to reducing body fat and the risk of falls [90-93].

Seated exercise programmes should follow the same principles as ambulatory exercise and include: CV, resistance and flexibility exercises. It is essential that all programmes comprise of a warm up, conditioning phase and a cool down component.

6.7.1 Seated exercise can be delivered in a variety of ways:

- In separate components i.e. CV exercise followed by resistance training or can be delivered as part of a circuit interval training programme
- With equipment including bikes, rowers and arm ergometers
- Using rhythmic body movements or supported/unsupported bodyweight exercises
- Alongside an ambulatory CR circuit training class or delivered independently as a low functional capacity programme

- An example of a seated exercise class using minimal equipment is described in Appendix F.

6.7.2 Key seated exercise considerations
Seated exercise, through potentially lowering the metabolic demand, can lead to an increase in intrathoracic pressures and activities should be performed appropriately to prevent this, for example correct posture, breathing technique and maintaining venous return.

Once the CV time and movements have been progressed, the patient should be moved onto a mix of supported and unsupported ambulatory exercise, which will provide greater dynamic challenges that will continually improve CV fitness.

6.8 Key exercise considerations

6.8.1 Ensure correct posture is maintained throughout.

6.8.2 Ensure balance of opposing muscle groups.

6.8.3 Avoid overuse of any one muscle group.

6.8.4 Use a variety of different muscle groups throughout sessions to gain global strengthening and to allow individuals to exercise for longer.

6.8.5 Ensure that feet are kept moving during upper body exercise to maintain venous return [93,94].

6.8.6 Avoid sustained breath holding and isometric exercises [37,55,59,73,75,76,96,97].

6.8.7 Avoid rapid changes in position as this can lead to hypotension particularly in the elderly and those on beta-blockers.

6.8.8 Avoid exercises performed in lying during the main conditioning phase [75,94,95]. Floor work when indicated (for example relaxation exercise and stretching) should be carried out after a cool down period when the CV system has returned to near resting state.

6.8.9 Ensure appropriate adaptation and supervision of exercise for individuals with comorbidities.

6.8.10 Ensure music tempo and volume is appropriate to the component of the session.

Key message:

Structured exercise should:

- Include a warm up, condition component and a cool down
- Achieve a training effect via the FITT principle
- Be performed at a moderate intensity
- Be individualised
- Incorporate resistance work.

The overall volume of activity is more important than the duration or intensity to achieve improvement in CV fitness and health benefits.

STANDARD 7: Screening, monitoring and progression

All physical activity and exercise should initially be continuously monitored and evaluated to ensure that it is safe, effective and relevant to changing circumstances. The level of monitoring should be specific to the individual's needs with the aim of progressing towards individual self-monitoring [7].

Criteria:

7.1 Screening

7.1.1 Pre-screening should take place prior to each physical activity/exercise session to ensure that it is safe to continue. This should include: Presence of systemic illness

- Change in signs and symptoms
- Impact of any changes in comorbidities since assessment
- Change in medication or medication dose
- Medication availability, for example GTN
- Details of health status reviews
- Results of further investigations
- Wound healing
- Glucose check for individuals with diabetes (all individuals with diabetes are at risk of hypoglycaemia, particularly those newly diagnosed or those new to exercise)
- Response to recent physical activity – home or recent exercise session.
- Change in psychological status which may affect performance such as anxiety, depression or anger.

7.1.2 Physical activity/exercise should be adapted in light of the pre-screening findings.

7.1.3 Individuals should be educated to self-monitor the above when undertaking physical activity alone.

7.2 Monitoring

7.2.1 Exercise intensity should be monitored using a combination of:

- HR response

- BP response
- Rate Pressure Product (RPP)
- RPE achieved [60]
- Observation
- Pulse oximetry for oxygen saturation levels for example in ACHD individuals.

7.2.2 HR response

- This can be monitored manually, with a HR monitor or by pulse oximetry during CV exercise
- Individuals should work within their pre-determined THR range during CV exercises
- A post-cool down HR should be taken to ensure that the individual has returned to their pre-exercise state
- In certain situations, medication or clinical status may influence the effectiveness of using HR as a monitoring tool for example arrhythmias, HR control medication or with cardiac transplant recipients.

7.2.3 BP response

Resting BP should be taken:

- Using a properly maintained, calibrated and validated device. A manual blood pressure monitor should be used in the presence of arrhythmias
- With tight clothing removed, around arm to be tested
- With the arm supported at heart level and hand relaxed
- Avoiding talking during the measurement procedure
- Using a cuff of the appropriate size
- In sitting and standing for individuals with LV dysfunction and postural hypotension
- Using the same arm for consistency
- Before and after exercise [98]
- Should resting BP be borderline or above the level to contraindicate exercise (Standard 2) the individual should be advised to rest for a further 5 minutes and BP should be rechecked. If BP remains borderline, allow the individual to complete the warm up and recheck their BP response
- BP should be assessed on a case-by-case basis
- Consider the BP reading in relation to the time of anti-hypertensive medication and compliance with medication
- Resting and exercise BP should be taken initially to confirm the appropriate response
- If it is not practical to monitor BP at the time of CV exercise, BP should be taken as soon as the conditioning component is completed
- Should the SBP fall >20mmHg (in the absence of suitable explanation i.e. individual has rushed or is stressed), this may be indicative that the intensity is too high for the individual to maintain the necessary cardiac output to meet the activity demands. In this circumstance, the intensity should be reduced and the individual monitored more closely.

7.2.4 RPE

- RPE can be monitored using either the BORG RPE (6 - 20 scale) or CR10 scale [60] (Appendix D)
- When educating individuals about how to rate their exertion they should

consider 'anchoring to known exertions' and using total body feelings rather than an isolated sensation. To include:
    - Strain and fatigue in the muscles
    - Breathlessness
- To increase the reliability, validity and effectiveness of RPE,
    - Keep the chart in view at all times
    - Rate exertion during a CV activity
    - Focus on the verbal statements rather than a number
    - In order to avoid individuals just giving the rating the practitioner asks for, initially do not tell individuals which level you want them to achieve. Simply guide their intensity of exertion to a level which elicits the appropriate RPE. With practice the individual will then realise the appropriate target levels (this may take up to 3 or 4 sessions) [26,60,99]
- Compare the HR response with the RPE level stated, along with observation, to determine if the individual is competent with self-pacing or whether further education is required.

7.2.5 Observation

It is essential to observe individuals to ensure:

- Safety
- Absence of signs and symptoms of over exertion:
    - Excessive breathlessness/accessory muscle usage
    - Excessive fatigue
    - Chest pain (or other signs of cardiac ischaemia for example jaw tightness)
    - Excessive sweating
    - Dizziness/Lightheadedness
    - Nausea
    - Poor colour
    - Poor quality of movement
- Adherence to exercise prescription
- Correct exercise posture and technique.

7.3 Progression

7.3.1 Individual progression should be based upon the agreed individual goals and evaluation of outcome measures taken at appropriate times.

7.3.2 Progression should consider all aspects of the FITT principle (see Appendix B). The primary aim is to increase the duration and intensity of exercise. Once the recommended duration of 20 min of continuous CV exercise has been achieved then the intensity of exercise should be increased. Intensity can be progressed to 70% of HRR or 14 on the BORG RPE scale or 4 on CR10.

7.3.3 Progression may be achieved by increasing ratios of:

- CV : active recovery time
- Work : active rest
- Standing : seated exercise

7.3.4 Once an appropriate HR and BP response has been established, weaning of these objective measures being performed by a clinician should be considered and self-monitoring and management encouraged. Correlation of HR and RPE levels should be established before objective measures can be weaned to ensure individuals can accurately monitor their exertion levels.

Key message:
CR exercise professionals must be skilled in screening, monitoring, and progression. No method of monitoring should be used in isolation; monitoring should be meaningful to the individual, encouraging them towards safe, effective and independent exercise in the long term.

Standard 8: Home-based programmes and independent exercise

Home-based programmes are a safe and effective form of physical activity and exercise [100]. Evidence demonstrates no significant difference between home and hospital-based rehabilitation in terms of mortality, risk factors, health related quality of life, cardiac events and exercise capacity [101,102]. They are as cost effective as group based sessions [102].

Individuals should be offered a home programme as part of their rehabilitation either alongside or instead of structured group sessions. This may help to overcome some of the barriers to attendance of under-represented groups [103].

Criteria:

8.1 The exercise prescription should be based on a validated functional capacity test (FCT). If unable to carry out a FCT, prescription should be based on assessment of current activity levels in conjunction with clinical evaluation.

8.2 Several options for home-based prescription should be considered:

- An individualised prescribed physical activity plan, for example graduated walking/jogging programme or home-based circuit
- Validated home-based programmes, for example Heart Manual [49], BHF Active Heart, Healthy Heart [104]
- Exercise DVD produced by CR team
- Recreational activities (for example exercise DVDs, golf, dancing).

8.3 In addition to usual considerations when developing a home-based programme, the following should be considered:

- Individuals choice of type of home-based programme
- Home environment including availability of equipment
- Minimising interruptions from telephone, family members and pets.

8.4 To ensure safe unsupervised exercise, individuals will require thorough instructions and the practitioner should ensure that the instructions have been understood. This should include:

- Demonstration and correction of exercise technique

- Instruction on self-monitoring during exercise (Standard 7)
- Education on the normal response to exercise
- Education on the recognition of signs and symptoms of over-exertion
- Education on appropriate warm up and cool down in relation to the activity to be undertaken
- Advice on progression/modification of physical activity/exercise
- Activity advice and safety information.

8.5 Individuals should be issued with:
- Copy of the exercise routine / DVD / manual
- Written safety advice
- RPE monitoring scale
- Home exercise diary
- Any equipment needed i.e. weights/resistance bands if available.

8.6 Adherence and compliance to home physical activity plans should be regularly monitored during supervised exercise sessions or via telephone contact, email or with further home visits. This enables:
- Appropriate progression
- Modification of the exercise programme
- Correction of exercise technique to ensure safety
- Review of SMARTER goals
- Any other issues to be highlighted and addressed.

8.7 Lower functioning, higher risk and more vulnerable individuals should have:
- More regular contact and supervision
- Exercises for balance, posture and coordination
- Exercises incorporated into their daily routine
- Access to other services for aids or adaptations to ensure safety and improve physical activity/exercise levels
- Access to hospital or community based group programmes, once a suitable level of function has been achieved.

8.8 Consider referral to appropriate exercise opportunities in the individuals' local community.

A reliable and valid FCT needs to be developed in order to fully evaluate the efficacy for home-based CR.

Key message:
Home-based programmes are a safe and effective alternative to group sessions. As home programmes are often unsupervised, it is essential that the individuals receive through instructions and the practitioner should ensure that the instructions have been understood.

STANDARD 9: Long-term physical activity planning

It is important that by the end of the individual's clinically supervised rehabilitation, he/she

should be empowered to participate in physical activity for the long term. This can be achieved through an exit interview where long-term physical activity plans are agreed and arrangements are made for transference of care to long-term secondary prevention care [1,3,5]. The aim of this process is to develop the individual's confidence in his/her ability to exercise independently and to take responsibility for his/her health. Continued secondary prevention and support by healthcare and exercise professionals is necessary to assist adherence to physical activity recommendations in the long term.

Criteria:

9.1 The individual should be considered for transference to long-term care when they are medically stable and competent to exercise independently, safely and effectively according to an individual exercise prescription [105].

They should therefore be:

- Able to identify appropriate modes of physical activity to participate in (i.e. via use of METs tables)
- Able to recognise and monitor their optimum level of exercise intensity (i.e. understand prescribed RPE and/or HR training zones)
- Able to recognise the signs and symptoms of over-exertion and take appropriate action (for example stop/reduce activity level, take GTN)
- Competent in self-pacing physical activity and exercise
- Able to progress exercise effectively
- Able to demonstrate compliance with home-based activities
- Able to identify goals for long-term physical activity and exercise.

9.2 Once the individual has been assessed as suitable for independent long-term care a detailed discharge assessment of changes and improvements should be undertaken with the individual.

9.3 In order to support long-term maintenance of physical activity, individuals should be provided with:

- Contact details of the CR team
- Details of medical follow-up
- Advice on long-term exercise prescription and modification
- Information on appropriate local physical activity sessions for example mainstream exercise classes, low level exercise classes, local options of classes of suitable intensity/structure, gym programmes, home exercises, DVDs, walking plans, structured health walks
- Advice on how to deal with relapse
- Advice on the importance of social support
- Information on local support groups
- Onward referral/access to additional support services where appropriate.

9.4 Information is available to carers and families so that they may encourage adherence to long-term physical activity goals.

9.5 There is documented evidence that advice on long-term physical activity has been given to the individual, carer and family [4].

9.6 When transferring an individual to ongoing CR exercise sessions:

- The individual should be transferred to an appropriately qualified exercise professional (REPs level 4 exercise specialist in Cardiovascular Prevention and Rehabilitation)
- The transfer process to the designated exercise professional should involve completing a detailed early phase transfer form (BACPR Exercise Instructor Transfer form should be used as a template). This form gives information on the individual's index cardiac event, previous medical history, medication, risk factors, any pending investigations and exercise prescription achieved during the early phases of CR
- It is the responsibility of the exercise professional to provide a safe and suitable exercise environment
- The exercise professional should know when to refer an individual back to the primary healthcare team or the early phase CR programme for further assessment.

9.7 A rehabilitation summary has been produced and made available to primary care, secondary care and community services involved in the long-term support of individuals.

9.8 For detailed service delivery guidelines for Phase IV see BACPR Exercise Instructor Training (bacpr.com/education).

Key message:
The patient should be medically stable before being referred to CR long-term maintenace. As part of this process, the patient should be educated on the appropriate frequency, intensity, time and type of physical activity and exercise to participate over the long term. In addition, the patient should be referred to a long-term maintenance exercise session, which is led by an appropriate trained exercise professional who holds a REPS level 4 qualification in exercise in CV prevention and rehabilitation.

STANDARD 10: Outcome measures

Consistent measuring of outcomes is an essential component in the evaluation of the effectiveness of CR and is vital for quality improvement.

Outcomes provide meaningful feedback to patients on their progress, encouraging the maintenance of healthy behaviours. Outcomes also provide data to demonstrate the efficacy of a programme and are important to justify the value of services both clinically and financially.
CR outcomes should include:
- Patient-reported health-related quality-of-life
- Clinical outcomes [106]
- Achievement of patient- centred goals
- Patient reported experience.

Criteria:

10.1 Reliable and valid outcome measures should be used (Appendix A). Outcome measures should be:
- Clinically relevant and meaningful

- Patient focused
- Comparable between programmes of varying sizes and resources

10.2 Taking part in the national audit of cardiac rehabilitation (NACR) is one of the minimum standards for CR [5] and programmes should register and submit data in order to standardise outcome measures for benchmarking purposes.

10.3 In order to assess improvement in functional capacity, a repeat FCT should be undertaken to assess for any improvement in exercise capacity. Changes in distance, time, METS, rest stops, HR and heart rate walking speed index, RPE response and change in symptoms should be recorded and interpreted.

10.4 Outcome measures for the older adult may include the achievement of functional independence and prevention of premature disability.

Key message:
The use of standardised validated clinical outcome measures will help to improve the quality and provision of CR programmes nationwide. There is growing emphasis on the use of patient reported outcome measures to assess health outcomes from the patient perspective.

Standard 11: Health and safety

Local protocols for health and safety should be followed at all times. The safety of individuals during the exercise component of CR is paramount. This will be optimised with an accurate risk stratification assessment (Appendix E), an effective induction (Standard 5) and an appropriate exercise prescription (Standard 6) by appropriately trained members of staff. All individuals should be screened prior to each exercise session to ensure they are safe to participate (Standard 7). All staff should be trained and updated regularly in local protocols for life support, moving and handling, infection control and fire.

Criteria:

11.1 Staffing

11.1.1 Each exercise session should be appropriately staffed:

- There should be a minimum of one appropriately qualified exercise professional at all supervised exercise sessions
- In the early rehabilitation process (Phase III) a minimum of two appropriately trained CR professionals who meet the criteria identified by the BACPR-EPG position statement 2012 [54] should be present at all supervised group exercise sessions
- Staff-to-individual ratios for instruction/supervision will depend on the phase of rehabilitation, level of risk stratification, and the extent of any specialist help or supervision for concomitant physical or psychological/cognitive disabilities. The ACPICR currently recommends a minimum staff-to-individual ratio of 1:5 (early rehabilitation)
- This ratio can be reduced as and when individuals progress towards or are deemed as safe independent exercisers.

11.1.2 Irrespective of venue, staff supervising individuals during CR exercise sessions should have maintained their competences in basic life support (BLS), defibrillator training and have access to advanced life support (ALS) services at every supervised exercise session (BACPR RCUK, 2013) [107]. http://www.bacpr.com/pages/page_box_contents.asp?PageID=751

11.2 Emergency protocols

11.2.1 Appropriate resuscitation equipment including a defibrillator should be readily available at every supervised exercise session, irrespective of venue.

11.2.2 There should be evidence of a locally agreed protocol for medical emergencies during an exercise session.

11.2.3 Appropriate incident reporting systems should be used to report any clinical or adverse events which may occur.

11.2.4 There should be a written emergency procedure clearly displayed in the exercise area.

11.2.5 Resuscitation equipment must be maintained in accordance with local protocols.

11.2.6 Access to a telephone.

11.3 Reducing the risk of adverse events when exercising

CR exercise is designed to reduce the incidence of adverse events (Standards 2, 5, 6 and 7). This is achieved by:

- Individualised assessment and prescription
- Risk stratification
- Pre-screening
- Graduated warm up of 15 minutes
- Moderate intensity exercise/physical activity
- Keeping the feet moving during active recovery
- Avoiding breath holding and Valsalva manoeuvre
- Avoiding floor work during the conditioning phase
- Adaptation for comorbidities
- Monitoring and supervision
- Graduated cool down of 10 minutes
- Observation of individuals for 15 min post cessation of exercise.

11.4 Venue and environment

11.4.1 A risk assessment of the environment should be carried out. The size of the exercise area should allow for appropriate space around individuals and equipment, for example floor space required for aerobic exercise per individual of 20 to 25 sq ft (1.8 to 2.3 sq m) and 6 sq ft (0.6 sq m) per space per individual using equipment [105].

11.4.2 The temperature should be maintained between 18-23^{o}C (65-71^{o}F) and humidity of 65% [1,105]. If physical activity does occur in environments outside of these parameters, appropriate precautions and advice must be given which includes considerations for clothing, hydration, exercise intensity and duration (including frequency of monitoring). This will help to maintain the expected physiological responses that would normally occur within the more ideal and recommended environmental parameters.

11.4.3 All exercise equipment must be maintained in accordance with local protocols and in line with manufacturer's guidelines, with risk of use appropriately assessed in keeping with standard health and safety practices.

11.4.4 Infection control procedures should be followed at all times for example cleaning of equipment, hand washing, disposal of sharps.

11.4.5 Drinking water should be available at all times.

11.5 Lone working

11.5.1 Local policies and procedures for working alone should be followed at all times.

11.5.2 Safe systems of work must be put in place and reviewed regularly to eliminate or reduce the risks associated with lone working for example a local tracking procedure to ensure the whereabouts of staff are known.

11.5.3 Staff should receive appropriate training and practical advice which enables them to recognise and reduce risk as far as reasonably practicable.

11.5.4 Personal protective equipment such as lone worker devices, mobile phones and personal alarms may be used to ensure staff safety.

11.5.5 A full risk assessment should take place when visiting an individual's home.

Key message:
Safety of staff and exercising individuals is paramount. National health and safety guidelines and local operational policies should be applied when conducting health and safety assessments.

Standard 12: Documentation

Clear and accurate records must be kept which fully reflect each episode of care. The most appropriate style of record keeping will be determined by the clinical setting. Local security policies and Caldicott guidelines must be followed and records must satisfy legal requirements 7-9,[67].

Criteria:

12.1 Records must be completed by the end of the day or as soon after the session as possible.

12.2 Records must be accurate, concise, legible, timed, dated and signed.

12.3 The individual's name, hospital number and NHS number must be documented on all pages.

12.4 Clinical records must be stored in a secure and confidential manner [7], [67]

12.5 When referrals to other hospitals and/or settings are sent, it must be done in a secure and confidential manner.

Key message:
There is a professional and legal requirement to maintain accurate and up-to-date health records which may be paper based or in an electronic format, or both.

Appendix A: Measurement tools

Physical

- Six minute walk test (6MWT) [108]
- Shuttle walk test (SWT) [109]
- Chester step test (CST) [110]
- Ergometer tests including treadmill and cycle [55, 99, 111]
- Phsical activity questionnaires (PAQs) [56, 122]
- The Duke Activity Status Index [113]

Not validated for cardiac population

- Berg balance scale (CVD – stroke rehab) [114]
- Timed up and go (CVD – stroke rehab) [115]

Psychosocial

- Hospital Anxiety and Depression Sclae (HADS) [116]
- Dartmouth COOP WONCA Charts [117]
- Minnesota www.mlhfq.org [118- 120]
- SF 36 and SF 12 [121,122]
- QLMI questionnaire [123]
- Cardiovascular Limitations and Symptoms Profile (CLASP) [124]
- Macnew [125]
- Global Mood Score [126]
- Illness Perception Questionnaire [127]
- EQ – 5D (formerly the EuroQuol) [128]
- The Kansas City Cardiomyopathy Questionnaire [129]
- CORE-10 [130]

Appendix B: Physical activity guidance and exercise prescription

In general, all exercise practitioners should promote increased daily physical activity and advise a reduction in sedentary time considering the individual's functional status. 'Patients should receive individual guidance and advice on ADLs together with a tailored activity and exercise plan, with the collective aim to increase physical fitness as well as overall daily energy expenditure' [5 p. 14].

The content of the exercise prescription depends on the aim of the exercise. De-conditioned individuals may require an adapted prescription initially until they are able to perform the recommended prescription for health benefits. In some circumstances, the aim may be to maintain their current level of activity and to reduce sedentary time.

The FITT principle for structured exercise

	F **frequency** Number of days per week How often?	**I** **intensity** How much exertion? How hard?	**T** **time** How many min per day? How long?	**T** **type** What specific activity? What sort?
CV Fitness	2 – 3 times per week	Moderate BORG RPE 11 – 14 CR10 2 – 4 40 – 70% HRR	20 – 60 min continuous or interval (plus a 15 minute warm up and 10 minute cool down)	Large muscle groups worked rhythmically.
Muscle strength and endurance	2 – 3 times per week	Upper body 30-40% 1RM Lower body 50-60% 1RM	Minimum one set, ideally 2-4 sets of 10 – 15 reps.	8 – 10 different muscle groups
De-conditioned individual unable to sustain 3 METS	Incorporate into daily routine	Moderate BORG RPE 11 CR10 2 40% HRR *	5 - 10min bouts (gradual increase to accumulate 30 min per day)	Activities to improve function, muscle strength and endurance, posture, balance and coordination for example walking, low step-ups, sit to stand, seated activities.

* For these individuals, a small increase in MET value would lead to a large proportional increase in intensity, for example for a maximal capacity of 5 METS, every 1 MET increase represents a 20% increase in cardiorespiratory effort.

Appendix C: Use of heart rate and determining target heart rates

HR is a reliable means for setting and repeating a given exercise intensity. Independent of the percentage of one's maximum aerobic capacity or HR (true or estimated), if a person exercises at the same HR, he/she will be working at the same oxygen uptake metabolic equivalent (METs). Over the course of an exercise training programme (>4 weeks), a reduction in HR for any given exercise intensity, is a strong indication that maximal aerobic fitness has improved. These fundamental principles, independent of knowing a true maximal capacity or HR, are in themselves a strong rationale for monitoring HR during exercise in CR.

Determining a Target Heart Rate (THR)

Step 1 Measure resting HR (HRrest)
Step 2 Determine a maximum HR (HRmax) (from maximal test or age-estimated formula)
a. account for beta-blockade or
b. use the Keteyian formula [131] for beta-blocked HF individuals (Appendix K)
Step 3 Use the Karvonen method [132] to determine the target % Heart Rate Reserve (HRR) Training zone
THR = [(HRmax – HRrest) x % required] + HRrest

Determining HRmax

The gold standard and only way for determining an individual's true HRmax is by performing a maximal exercise test, otherwise an estimate (based on age) of HRmax may be used.

When estimating HRmax from age, there are three considerations:
1. Whatever method is used, it is likely to be within an average margin of error of +/-10 bpm, with a range of up to +/-20 bpm in some individuals [77]

2. The influence that beta-blockers have on HRmax is up to a reduction of 30 bpm [133-135]

3. Heart failure individuals may have a further sympathetic down regulation, which will lower their HRmax on average by a further 20 bpm, compared to adults of a similar age [131].

HRmax estimation methods

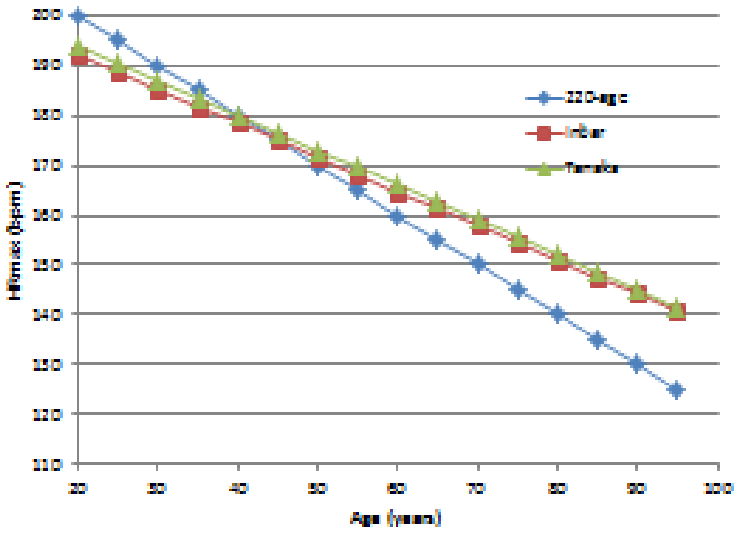
The best recommendation for estimating HRmax from age for participants over the age of 50 is either the Inbar [136] or Tanaka methods [137]. The equations are shown below the graph on page 39. This clearly demonstrates that once a person is over 45 years of age, 220-age increasingly underestimates truer maximum HRs.

Figure A:

Age	220-age	Inbar	Tanaka	Diff to 220-age
20	200	192	194	6 to 8 bpm
25	195	189	191	4 to 6 bpm
30	190	185	187	3 to 5 bpm
35	185	182	184	1 to 3 bpm
40	180	178	180	0 to 2 bpm
45	175	175	177	0 to 2 bpm
50	170	172	173	2 to 3 bpm
55	165	168	170	3 to 5 bpm
60	160	165	166	5 to 6 bpm
65	155	161	163	6 to 8 bpm
70	150	158	159	8 to 9 bpm
75	145	154	156	9 to 11 bpm
80	140	151	152	11 to 12 bpm
85	135	148	149	13 to 14 bpm
90	130	144	145	14 to 15 bpm
95	125	141	142	16 to 17 bpm

Figure B:

Methods for Estimating HRmax



Inbar et al. 1994
205.8 - (0.685 x age)

Tanaka et al. 2001
208 – (0.7 x age)

Adapted from Robergs & Landwehr (May 2002)
J Ex Physiol Online 5: 1-10.

Each individual should have their THR calculated based on thorough assessment (Standard 2) and risk stratification (Appendix E). The training intensities for most individuals range between 40 – 70% HRR. The more complex individual will require lower intensities (30–50% HRR) and hence appropriate adjustments to the calculations overleaf will be required [55,58,59].

HR can remain one of the appropriate intensity markers even when individuals are influenced by chronotropic medication such as beta-blockers, Ivabradine or Diltiazem. In this instance, the resting HRmax is reduced by 20 to 30 bpm and the THR can be re-calculated on this basis. If the individual's medication is held constant, HR will be a reliable measure from which improvement can be determined.

Karvonen formula (Heart Rate Reserve- HRR):

This formula can be used either from a true HR max (examples 1 and 2) or from the age-estimated maximum (example 3), and can be adjusted for beta-blockers as in example 2. This formula is advantageous in that it accounts for the individual's resting HR. A percentage of this is selected, based on the assessment findings, noting that 40 – 70% of HRR is equivalent to 40 – 70% VO_2 max.

Example 1: Training intensity of 40 – 70% HRR from an ETT

Individual X has a HRrest of 60 bpm and achieves a HRmax of 155 during a maximal ECG exercise test.

a. Calculation of HRR = 155 – 60 = 95
b. Selection of % of HRR
   40% of HRR = 0.40 x 95 = 38
   70% of HRR = 0.70 x 95 = 66.5
c. Add resting HR =
   38 + 60 = 98
   66.5 + 60 = 126.5

THR Result: 40 – 70% HRR = 98 to 127 bpm

Example 2: Training intensity 40 – 70% HRR, beta-blocker added after test

Individual X has a HRrest of 50 bpm, achieves a HRmax of 160 during the maximal ECG exercise test. He is subsequently put on a beta-blocker.

a. Calculation of HRR = 160 – 50 – 30 (beta-blocker) = 80
b. Selection of % of HRR
   40% of HRR = 0.4 x 80 = 32
   70% of HRR = 0.7 x 80 = 56
c. Add resting HR =
   32 + 50 = 82
   56 + 50 = 106

THR Result: 40 – 70% HRR = 82 to 106 bpm

Example 3: 40 – 70% HRR on beta-blockers but no maximal exercise test

Individual X (age 60) has a HRrest of 50bpm.

a. Age estimated HRmax from Figure A (Inbar): = 165 – 30 (beta-blocked) = 135 b. Calculation of HRR = 135 - 50 = 85

c. Selection of % of HRR

40% of HRR = 0.40 x 85 = 34

70% of HRR = 0.70 x 85 = 59.5

Add resting HR =

34 + 50 = 84

59.5 + 50= 109.5

THR Result: 40 – 70% HRR = 84 - 110 bpm

Very deconditioned individuals:

For individuals who are very deconditioned, a lower intensity range may be appropriate.

Example 4: 30 – 50% HRR for very deconditioned individual

Individual X (age 75) has a HRrest of 50bpm but no ECG exercise test.

a. Age estimated HRmax from Figure A: = 154 – 30 (beta-blocked) = 124

b. Calculation of HRR = 124 - 50 = 74

c. Selection of % of HRR

30% of HRR = 0.30 x 74 = 22.2

50% of HRR = 0.50 x 74 = 37

Add resting HR =

22.2 + 50 = 72.2

37 + 50= 87

THR Result: 30 – 50% HRR = 72 - 87 bpm

For an example of calculating heart rate targets for individuals in heart failure, please refer to Appendix K.

Appendix D: BORG Scales

BORG RPE Scale [60]

6 No exertion at all
7 Extremely light
8
9 Very light
10
11 Light
12
13 Somewhat hard
14
15 Hard (heavy)
16
17 Very hard
18
19 Extremely hard
20 Maximal exertion

Borg RPE Scale® © Gunnar Borg, 19970, 1985, 1998

Borg's RPE Scale® Instructions [60]

Whilst exercising we want you to rate your perception of exertion, i.e., how heavy and strenuous the exercise feels to you. The perception of exertion depends mainly on the strain and fatigue in your muscles and on your feeling of breathlessness or aches in the chest.

Look at this rating scale; we want you to use this scale from 6 to 20, where 6 means "no exertion at all" and 20 means "maximal exertion."

9 corresponds to "very light" exercise. For a normal, healthy person it is like walking slowly at his or own pace for some minutes.

13 on the scale is "somewhat hard" exercise, but it still feels OK to continue.

17 "very hard" is very strenuous. A healthy person can still go on, but he or she really has to push him or herself. It feels very heavy, and the person is very tired.

19 on the scale is an extremely strenuous level. For most people this is the most strenuous exercise they have ever experienced.

Try to appraise your feeling of exertion and fatigue as honestly as possible, without thinking about what the actual physical load is. Don't underestimate it, but don't overestimate it either. It's your own feeling of effort and exertion that's important, not how it compares with other people's. What other people think is not important either. Look at the scale and the expressions and then give a number.
Any questions?

CR10 scale

0	**Nothing at all**	
0.3		
0.5		
0.7	**Extremely weak**	**Just noticeable**
1		
1.5	**Very weak**	
2		**Light**
2.5	**Weak**	
3		
4	**Moderate**	
5		**Heavy**
6	**Strong**	
7		
8	**Very Strong**	
9		
10		"**Maximal**"
11	**Extremely Strong**	
•	**Absolute maximum**	**Highest Possible**

Borg CR10 scale® [139]
© Gunnar Borg, 1982, 1998, 2003

Borg's CR10 scale instructions [139]

Basic instruction:
10, "Extremely strong", is the main anchor. It is the strongest perception you have ever experienced. It may be possible however, to experience or to imagine something even stronger. Therefore, "Absolute maximum" is placed somewhat further down the scale without a fixed number and marked with a dot "•". If you perceive an intensity stronger than 10, you may use a higher number.

Start with a verbal expression and then choose a number. If your perception is "Very weak", say 1; if "Moderate," say 3; and so on. You are welcome to use half values (such as 1.5, or 3.5). It is very important that you answer what you perceive and not what you believe you ought to answer. Be as honest as possible and try not to overestimate or underestimate the intensities.

Scaling perceived exertion:
We want you to rate your perceived exertion, that is, how heavy and strenuous the exercise feels to you. This depends mainly on the strain and fatigue in your muscles and on your feeling of breathlessness or aches in the chest. But you must only attend to your subjective feelings and not to the physiological cues or what the actual physical load is.

1 is "very light", like walking slowly at your own pace for several minutes.

3 is not especially hard; it feels fine, and it is no problem to continue.
5 you are tired, but you don't have any great difficulties.

7 you can still go on but have to push yourself very much. You are very tired.

10 This is as hard as most people have ever experienced before in their lives.

- This is "Absolute maximum" for example, 11 or 12 or higher.

Borg continues to evaluate the validity of his scales in order that they best represent ratio properties. The latest update has included the development of a CR100 scale to refine the link between the verbal anchors and their congruency with a numerical scale [140.141].

Appendix E: Risk stratification

Risk stratification is a multi-factorial measure used to establish prognosis of future major cardiac events and chances of survival. Mortality risk within the first year for an individual assessed as:

- low risk is 2%
- moderate risk is 10 – 25%
- high risk is >25%

It can also help determine the chances of disease progression in terms of arterial, myocardial or electrophysiological function. This tool helps the exercise professional to identify relevant information for individual management, appropriate level of supervision and monitoring.

AACVPR stratification for risk of cardiac events [58]

LOWEST RISK - C	MODERATE RISK - B	HIGHEST RISK - A
Absence of complex ventricular dysrhythmias during exercise testing and recovery Absence of angina or other significant symptoms (for example unusual SOB, light-headedness or dizziness, during exercise testing and recovery) Presence of normal haemodynamics during exercise testing and recovery (i.e. appropriate increases and decreases in HR and SBP with increasing workloads and recovery) Functional capacity ≥ 7 METS **Non-exercise Testing Findings:** Resting EF ≥50% Uncomplicated MI or revascularisation procedure Absence of complicated ventricular dysrhythmias at rest Absence of CHF Absence of signs or symptoms of post-event/post-procedure ischaemia Absence of clinical depression	Presence of angina or other significant symptoms (for example unusual SOB, lightheadedness or dizziness, occurring only at high levels of exertion ≥ 7 METS) Mild to moderate level of silent ischaemia during exercise testing or recovery (ST-segment depression <2 mm from baseline) Functional capacity <5 METS **Non-exercise Testing Findings:** Resting EF 40 – 49%	Presence of complex ventricular dysrhythmias during exercise testing or recovery Presence of angina or other significant symptoms (for example unusual SOB, lightheadedness or dizziness at low levels of exertion (<5METS) or during recovery) High level of silent ischaemia (ST-segment depression › 2mm from baseline) during exercise testing or recovery Presence of abnormal haemodynamics with exercise testing (i.e. chronotrophic incompetence or flat or decreasing SBP with increasing workloads) or recovery (severe post exercise hypotension) **Non-exercise Testing Findings:** Resting EF <40% History of cardiac arrest or sudden death Complex dysrhythmias at rest Complicated MI or revascularisation procedure Presence of CHF Presence of signs and symptoms of post-event/post-procedure ischaemia Presence of clinical depression
All characteristics listed must be present for patients to remain at lowest risk	**Any one, or combination of these findings places a patient at moderate risk**	**Any one, or combination of these findings places a patient at high risk**

Criteria checklist for use when risk stratifying CHD individuals prior to exercise [105]

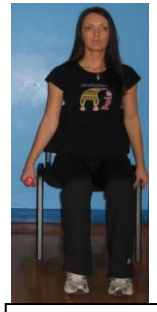
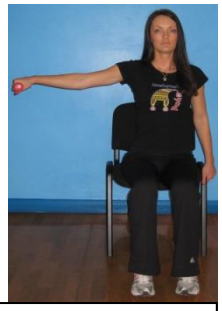
Indicators of severity of event	Indicators of LV function	Indicators of ongoing ischaemia	Other considerations
• An anterior rather than inferior MI • More than one previous infarct • High cardiac enzymes or • troponin levels at time of infarct • Complicated recovery	• LV function – moderate (EF = 40-49%) or poor (EF = <40%) • Presence of HF	• Positive ETT • Ongoing angina/ischaemia • Awaiting further investigations	• Arrhythmias (especially ventricular) • Cardiac arrest secondary to event

Supervision level

This relates to potential difficulties when taking part in the exercise component of CR for example hard of hearing, poor vision, poor balance, MSK/neurological problems which may affect the staff to individual ratio or type of exercises prescribed.

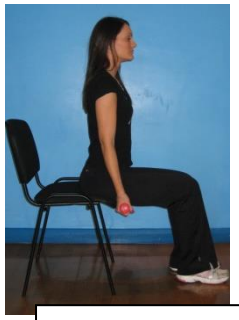
1=High supervision needs 2=Moderate supervision needs 3=Low supervision needs.

Appendix F: Example of seated exercise programme

1. Lateral raises
AR

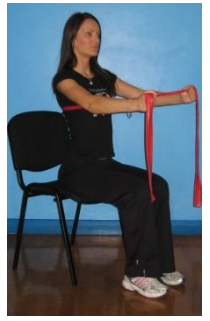
2. Knee lifts
CV




3. Arm curls
AR

4. March
CV

5. Chest press
AR

10. Heel digs
CV

Class Management

Patient spends 1 minute on the CV stations

Patient performs 10-15 repetitions on AR stations

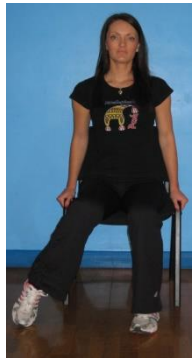
Progressions

The ratio between CV and AR are progressed i.e. 2 CV stations to 1 AR station, 3 CV to 1 AR station etc.


9. Tricep kick backs
AR

8. Toe points
CV


7. Upright row
AR



6. Side toe taps
CV

Adapted from Westminster MyAction Programme Imperial College NHS Healthcare Trust

Appendix G: Extra consideration for individuals with hypertension

Hypertension is one of the most important preventable causes of premature morbidity and mortality in the UK. Hypertension leads to an increased risk of CVD, stroke, HF, PAD and chronic kidney disease (CKD).

The defining criteria for hypertension is a resting SBP ≥140mmHg and/or DBP ≥90mmHg, confirmed by measurements on at least two separate occasions, or when an individual is prescribed antihypertensive medication [55]. Setting blood pressure to recommended levels aims to promote primary and secondary prevention of CVD, and to lower the risk of CV events [12].

ESH/ESC guidelines for the management of arterial hypertension [143] state that 'epidemiological studies suggest that regular aerobic physical activity may be beneficial for both prevention and treatment of hypertension and to lower CV risk and mortality'. A meta-analysis of randomised controlled trials has shown that:

- Aerobic endurance training reduces resting SBP and DBP by 3.0/2.4 mmHg overall and even by 6.9/4.9 mmHg in hypertensive participants. Aerobic interval training has also been shown to reduce BP [144].

- Dynamic resistance training was followed by significant BP reduction, as well as improvements in other metabolic parameters. Isometric exercises are not recommended, since data from only a few studies are available [143].

Clinical practice guidelines identify a substantial therapeutic role for physical activity in hypertension [142,145-147]. The JNC [8] hypertension guidelines recommend lifestyle changes, including the use of the Dietary Approaches to Stop Hypertension (DASH) eating plan and regular physical activity, as an important component in the treatment of high BP [148].

The mechanisms by which exercise lowers BP remain elusive. Possible mechanisms are [149]:

- lower cardiac output and peripheral vascular resistance at rest and submaximal exercise
- decreased HR
- decreased sympathetic and increased parasympathetic tone
- improved endothelial function
- lower blood catecholamines and plasma renin activity
- reduced visceral fat independent of changes in body weight or BMI
- altered renal function to increase elimination of sodium leading to a reduction in fluid volume.

Definitions and classification of office/clinic blood pressure levels (mmHg)*

Category	Systolic	Diastolic
Optimal	<120	<80
Normal	120-129	80-84
High normal	130-139	85-89
Grade 1 hypertension	140-159	90-99
Grade 2 hypertension	160 -179	100-109
Grade 3 hypertension	≥180	≥110
Isolated systolic hypertension	≥140	<90

* The BP category is defined by the highest level of BP, whether systolic or diastolic.

Adapted from ESH/ESC guidelines for the management of arterial hypertension [143]
Primary/essential hypertension (cause unknown in approx. 90% of cases)

Healthcare professionals should ensure that people with treated hypertension have a clinic blood pressure target set to:

- below 140/90 mmHg if aged under 80 years (corresponding ambulatory blood pressure monitoring (ABPM) daytime average or home blood pressure monitoring (HBPM) average blood pressure is 135/85 mmHg) [12]
- below 150/90 mmHg if aged 80 years and over.

Blood pressure targets [143]

- CHD - it is recommended to start drug treatment when SBP is ≥140mmHg with the SBP target of <140mm Hg (lower targets are not supported by valid evidence)
- Diabetes - a SBP goal of <140mmHg and DBP of <85mmHg is recommended. DBP target in patients with diabetes is recommended to be <85mmhg
- Heart Failure - lowering of SBP to around 140mm Hg should be considered in all individuals.

FITT recommendations – aerobic and resistance exercise

When compared to aerobic exercise, resistance training produces the most striking increase in BP and results in less of a HR increase - as a result the RPP pressure product may be less. Individuals with hypertension should participate in more frequent and longer duration activity to compensate for the recommended reduced intensity of 40% up to 60% HRR.

Aerobic exercise should be supplemented by resistance training following the recommendations in appendix B, working towards the 60 - 80% 1RM [55] as appropriate after patients have been taught and able to demonstrate correct techniques and able to avoid any negative behavioural factors linked to delayed onset muscle soreness or joint aches. There is growing evidence that resistance training (when performed safely) may be of value for controlling BP [150].

Exercise at moderate intensity lowers resting BP more effectively than high intensity training [149]. Although vigorous intensity aerobic exercise is not necessarily contraindicated in patients with hypertension, moderate intensity aerobic exercise is generally recommended in preference to vigorous intensity aerobic exercise to optimize the benefit to risk ratio [55].

Special considerations in exercise prescription

The following points should be considered prior to prescribing exercise:

- In reference to blood pressure targets, individuals with uncontrolled or severe (Grade 3) hypertension should first be assessed by their doctor and must be prescribed appropriate antihypertensive medication before they undertake exercise training
- Individuals should not exercise if resting SBP ≥180mmHg and/or DBP ≥110mg Hg (Standard 2.2) [55]
- Check for hypotension or orthostatic hypotension due to anti-hypertensive medication
- Use a manual BP monitor in the presence of Grade 2 or 3 hypertension.

Medication with exercise considerations

- Some beta-blockers may reduce sub-maximal and maximal exercise capacity primarily in patients without myocardial ischaemia. Using RPE to monitor exercise intensity is especially important in these individuals (Standard 7)
- Antihypertensive medications may lead to sudden excessive reductions in post exercise BP. Extend and carefully monitor the cool down period carefully under these circumstances. In order to enhance exercise adherence in these individuals, education about the acute or immediate BP-lowering effects of exercise (known as post-exercise hypotension) is essential
- While antihypertensive medications are being up-titrated and when multiple medications are required to control BP, symptoms should be monitored even more closely
- Beta-blockers and diuretics may adversely affect thermoregulatory function. Beta-blockers may also cause hypoglycaemia. In these situations, individuals should be educated about fluid replacement and precautions when exercising in the heat and the precautions that should be taken to avoid these situations [55,149,151].

Appendix H: Extra considerations for individuals with Angina

Background

- Individuals with angina can become deconditioned as a result of their symptoms and physical activity misconceptions and as a result can be lower functioning (Appendix B for advice on exercise prescription for lower functioning individuals)
- Before commencing exercise classes individuals with stable angina should be on optimal medical therapy
- Individuals should be advised on the importance of a warm up to increase the ischaemic threshold.

Pre-Exercise Training

It is important to:

- Establish baseline angina symptoms for each patient, as these may vary between individuals
- Discuss angina management and medication
- Discuss importance of carrying GTN tablets or sprays at all times
- Refer on if symptoms suggest unstable angina.

Angina during exercise session:
If a patient experiences angina during the exercise session:

- Stop exercise and sit in 'W' position
- Advise to take GTN
- If symptoms not relieved after 5 minutes repeat dose of GTN
- If symptoms not relieved 5 minutes after second dose of GTN local emergency procedures (if in hospital) should be followed or an ambulance should be called
- If symptoms are relieved, wait for 5 minutes following GTN and rewarm before recommencing the exercise session.

General advice

Posture must be considered during exercise:

- Supine positions increase cardiac output and hence myocardial oxygen demand
- Sudden posture changes can increase intrathoracic pressure which is known to increase ischaemia [99]
- Anginal symptoms should be monitored in order to identify increasing frequency, severity or triggers
- It may be advisable to ask the patient to keep a chest pain diary to include: triggers, nature and length of symptoms and how relieved
- Should individuals' symptoms become more severe or frequent, a medical review and period of stabilisation is necessary before continuing structured exercise
- Myocardial ischaemia occurs at a reproducible RPP – once established, exercise can be prescribed below this level to gain benefits without provoking symptoms
- The Angina Plan [152] is a brief cognitive behavioural therapy intervention that can be used with individuals by appropriately trained facilitators
- Angina attacks can be provoked by stress therefore it is important that programmes include relaxation and stress management components [153].

Appendix I: Extra considerations following heart surgery including heart valve surgery

Open heart surgery

Approximately 28,000 coronary artery bypass graft (CABG) operations and almost as many valve replacement/repair operations take place in the UK per year. Preoperative decline in physical activity levels can lead to physical deconditioning of the CV and MSK systems. Improved oxygenation and function of the cardiac muscle will improve symptoms but it is not sufficient to reverse the effects of deconditioning [154]. In particular individuals having valve surgery may have suffered from debilitating symptoms prior to surgery causing restrictions in activity [155].

There is a scientific and clinical evidence basis for providing CR for individuals post CABG. Supervised exercise based CR has been shown to increase functional capacity, favourably modify disease-related risk factors, decrease symptoms, and improve quality of life [18,151,154,156-161]. The population undergoing heart surgery is aging [162] and outcomes are favourable in postsurgical individuals aged greater than 75 years [157, 158]. However persistent fatigue can hamper recovery in the elderly individual group and tailored interventions are needed [158, 159].

After valve surgery in almost all areas of individual management, randomised trials and meta-analyses do not exist [156, 157]. Trials that do exist are very few in number, narrowly focused with small numbers, have limited general applicability, and do not lend themselves to meta-analysis because of widely divergent methodologies and different individual characteristics. Recommendations are therefore almost entirely based on non-randomised studies and relevant basic science.

Assessment

The following common post-operative problems impact on physical recovery and should therefore be considered prior to prescribing exercise:

- Fatigue [158,163,164]

- Persistent sternal pain, heaviness, stiffness – affecting return to ADLs, sleep pattern and mood [163,165]
- Sleep problems [163-165]
- Shortness of breath on exertion (SOBOE) (related to CV and MSK deconditioning, dysfunctional breathing related to pain, pleural effusion post-CABG - more than 85% of individuals develop a pleural effusion although the majority resolve spontaneously) [157,163]
- Neck, shoulder, thoracic spine, lumbar spine discomfort [163]
- Decline in cognitive function (memory, concentration, planning) [157,166] Off-pump surgery may result in less neuro-cognitive problems [161,166-169]
- Anxiety / depression [163,164166-169]
- AF and atrial flutter - especially in elderly individuals [157,163]
- Anaemia - significantly more frequent in elderly individuals [157]
- High resting HR and poor HR recovery. This improves with participation in comprehensive CR.

Special considerations in exercise prescription

1. Sternotomy:
   The sternal wound, surrounding trauma and poor posture (through pain avoidance) can lead to related MSK problems – stiff neck, shoulders, thoracic spine and lumbar spine. ROM and postural exercises should be encouraged 24 hours after surgery. Light hand weights from 1-3lbs (0.5 -1.5kg) should also be encouraged if there is no evidence of sternal instability during the in-patient phase [149].
   Expert opinion and current practice suggest commencing formal exercise sessions from 6 weeks post surgery [18].
   Individuals who experience post-operative sternal movement or sternal wound complications should perform lower extremity exercises only [149].
   Between 5-8 weeks post surgery lifting with the upper extremities should be restricted to 5-8 lbs (2.5 -3.5 kg).
   Post surgical individuals should avoid traditional resistance training exercises (with moderate to heavy weights), until the sternum has healed sufficiently, generally by 3 months [55].

2. Increasingly elderly population with co-existing comorbidities:
   - Reduced muscle strength, energy and stamina. It is important to encourage reducing the length of sedentary episodes, performing daily home exercise and reintroducing daily habitual activity
   - Advise individuals on managing fatigue, pacing daily activity, frequent 5 minute bouts of functional exercise to build stamina
   - Tailor advice with specific goals for progressively increasing daily activity [158,159].

Percutaneous heart valve alternative interventions

- Transcatheter aortic valve implantation (TAVI) is assuming a major role in the routine management of individuals with aortic stenosis. It can now be considered the standard intervention in individuals with critical aortic stenosis with multiple co-existing conditions, with high care and rehabilitation needs, for which conventional surgery is not an option [170,171].
- Percutaneous mitral valve repair for severe mitral regurgitation.
- Percutaneous balloon mitral valvuloplasty for mitral valve stenosis.

Appendix J: Extra considerations for individuals with atrial fibrillation (AF)

AF is the most prevalent sustained cardiac arrhythmia encountered in worldwide clinical practice [172]. It has a profound impact upon an individual's quality of life; sustaining a sinus rhythm is associated with improved quality of life and better exercise performance [173] with specific recommendations for participation in competitive sports and leisure-time physical activity [174].

The incidence of AF is significantly lower in older adults who participate in light to moderate physical activities [175].

AF occurs in 1 – 2% of the general population and its incidence increases with age, from <0.5% at 40 - 50 years, to 5 – 15% at 80 years [172, 174].

The haemodynamic changes that occur in AF particularly the irregularity of the ventricular response, causes reduced cardiac output with consequent risk of thrombo-embolic events, decreased exercise capacity and fatigue in some individuals. Therefore, AF needs to be well managed medically before an exercise assessment is considered [149].

Studies looking at the effects of exercise training on individuals with AF report an increased exercise capacity through 6MWT distance and significantly decreased resting HR [176-178].

Risk stratification

AF often presents in conjunction with a variety of other underlying CV conditions. The exercise considerations for conditions including HF, CHD, diabetes, cardiomyopathy, significant valvular disease and hypertension should take priority over the concurrent AF [149]. Individuals with AF will be classified using the AACVPR stratification by considering the effects of the arrhythmia and other coexistent conditions.

Assessment

Due to the chronically irregular ventricular response in AF and variability in the diastolic filling period the most accurate ways of measuring cardiovascular parameters during a FCT are to use:

- 12 lead ECG /telemetry for accurate analysis of rhythm and HR (6 second rhythm strip)
- Manual blood pressure monitor (SBP is more difficult to determine) [142]

Age-predicted MHR targets are not valid. MHR tends to be considerably higher in individuals with AF. There is however, a marked variability in the maximal HR response 'as evidenced by standard deviations of 30 contractions/min, even among subjects of a similar age' [149] (Standard 2.2). HR response will be affected by the use of AV suppressant medication.

Exercise prescription special considerations

There are two major factors to consider when prescribing exercise for individuals with AF:

- The inherent unreliability of the pulse rate
- Any concurrent or underlying heart disease

Exercise intensity should ideally be prescribed based on METs and perceived exertion levels. The use of HR may be inappropriate as there is often a pulse apex deficit in AF and it may not be possible to accurately record the radial pulse rate especially when the HR is rapid. Manual pulse palpation of the carotid artery for a slightly longer period may be needed for a reliable HR to be

obtained. Alternatively, where appropriate, a stethoscope over the apex heart beat may be used to accurately assess HR. HR monitors are not accurate in AF. The FITT principle applies in the same way as for individuals in normal sinus rhythm.

Appendix K: Extra considerations for individuals with heart failure

HF is characterised by an inability of the heart to adequately deliver oxygenated blood to metabolising tissue. There is no single diagnostic test for HF and diagnosis relies on clinical judgement based on a combination of history, physical examination and appropriate investigations [179]. HF is a syndrome where there is objective evidence of cardiac dysfunction at rest and may include hallmark symptoms of breathlessness (exertional dyspnoea, orthopnoea and paroxysmal nocturnal dyspnoea), fatigue and ankle swelling. The degree of breathlessness can be quantified by use of the New York Heart Association (NYHA I-IV) classification system [180].

Much of the research into the management of HF has concentrated on individuals with reduced contraction of the left ventricle, defined by an ejection fraction (EF) of <40%. The agreed description of this group of individuals is HF with left ventricular systolic dysfunction (LVSD). But recent evidence has shown that almost half the individuals with HF syndrome do not have LVSD but have a preserved ejection fraction; they are referred to as HF with preserved ejection fraction (HFPEF) [181].

Impaired cardiac output and abnormalities in central haemodynamic function can lead to abnormalities in skeletal muscle metabolism and morphology, peripheral blood flow, vascular function, neuro-hormonal responses and pulmonary function, with consequent progression of disease. The prognosis for HF is poor with 30-40% of individuals dying within 1 year of diagnosis [179].

Systematic reviews of exercise-based CR in individuals in stable HF with LVSD have confirmed the safety and effectiveness of exercise as an intervention [37,75,181-183]. Benefits reported are a reduction in hospitalisation rates, decreased symptoms and improved quality of life [37,75,120,182-184]. In particular, the Cochrane reviews [37,183] have reported average improvements in increased exercise capacity:

- VO_2 max by 2.16ml/kg per min
- Exercise duration by 2.38 min
- Work capacity by 15.1 watts (W)
- 6MWT by 40.9 metres.

The bulk of evidence for exercise and HF is for those individuals with LVSD, however there is evidence that exercise training for HF syndrome with HFPEF is also beneficial and safe [185] when prescribed as for HF with LVSD.

Specific guidelines and protocols for exercise training with HF individuals are available [55,73,89,90,186].

Risk stratification

HF individuals are classified amongst those deemed at highest risk of further cardiac events according to the AACVPR stratification criteria (EF of <40%) [58]. Individuals may additionally present with other criteria:

- significant symptoms at low levels of activity of less than 5 METs
- abnormal haemodynamics with exercise testing
- peak VO_2 of <10 ml/kg per min
- 6MWT of <300m which is associated with poorer short-term survival.

Given the pathophysiology of HF and acknowledged increased risk with exercise, rigorous individual assessment and risk profiling need to be coupled with appropriate monitoring and a safe management and delivery system when undertaking exercise training [8,53].

Assessment

During the assessment process (Standard 2), the following should be considered prior to performing exercise in addition to the usual contraindications [88]:

Calculating heart rate targets - Keteyian regression equation for HF

Exercise HRs for HF individuals will be approximately 10 – 20 beats lower than in individuals without heart failure [138]. To account for this Keteyian et al [131] have provided this regression equation:

119 + (0.5 x HRrest) – (0.5 x age) - (0, if test was completed using a treadmill) (5, if using a stationary bike)

This regression equation already assumes that patients are on rate altering medication, hence you do not need to subtract for beta-blocked heart failure patients. They caution, however, that the margin of error can be up to 18 bpm when this prediction equation is utilised.

For a full description of heart rate target calculations please refer to Appendix C.

Example: 40 – 60% HRR for beta-blocked heart failure individual

Individual X (age 70) has a HRrest of 50bpm but no ETT.

a. Age estimated HRmax from Keteyian formula for walking:
   119 + (0.5 x HRrest) – (0.5 x age) – 0 (treadmill) =
   119 + (0.5 x 50) – (0.5 x 70) – 0 = 109
b. Calculation of HRR = 109 - 50 = 59
c. Selection of % of HRR
   40% of HRR = 0.40 x 59 = 23.6
   60% of HRR = 0.60 x 59 = 35.4
   Add resting HR =
   23.6 + 50 = 73.6
   35.4 + 50 = 85.4

THR Result: 40 – 60% HRR = 74 - 85 bpm

Contraindications to both exercise testing and training

- Early phase after ACS (up to 2 days)
- Acute HF (during the initial period of haemodynamic instability)
- Critical aortic stenosis
- Severe hypertrophic obstructive cardiomyopathy
- Intracardiac thrombus.

Contraindications to exercise training

- Progressive worsening of exercise tolerance or dyspnoea at rest over previous 3–5 days
- Significant ischaemia during low-intensity exercise (<2 METs, 50 W)
- New-onset AF/atrial flutter.

Increased risk for exercise training

- >1.8 kg increase in body mass over the previous 1–3 days
- Concurrent, continuous or intermittent dobutamine therapy
- Decrease in SBP with exercise
- NYHA functional class IV
- Complex ventricular arrhythmia at rest, or appearing with exertion
- Supine resting HR >100 bpm
- Pre-existing comorbidities limiting exercise tolerance.

A significant change in status may mean exercise is contra-indicated until relevant problems are resolved.

Exercise prescription

Graduated warm up and cool down are especially important in the HF individual, as without the appropriate graduated transition periods at the beginning and end of exercise, he/she is at particular risk of ischaemia, post exercise hypotension or threatening ventricular dysrhythmias. This should be moderated in length and intensity to match the main conditioning phase (Standard 7).

The evidence-based approach to increasing CV and muscle endurance in HF individuals recommends initially adopting an interval versus a steady state approach, with focus on increasing the peripheral stimulus whilst minimising the CV stress.

Following a comprehensive individual assessment there should be:
- Promotion of increased physical activity i.e. encourage walking, using stairs, housework, gardening and active recreational sports as appropriate
- Prescription of exercise i.e. aerobic training, resistance training and respiratory training.

Aerobic training using an interval approach

- Start low and go slow
- The FITT principle dose should be adapted appropriately (Appendix B)
- Initially short, frequent periods of 5 to 10 minutes of total activity are more effective and better tolerated in very de-conditioned and compromised individuals (<3METs)
- Initially use work phases of 1 to 6 minutes and rest phases of 1 to 2 minutes [187]
- Consider intervals of work: rest ratio (1:2; 1:1), CV:MSE ratio (1:1; 2:1) and alternate seated:standing work ratio (1:1; 1:3)
- Intensity should be low-moderate (40-70% VO_2), RPE 10-14 (6-20 scale), 3-4 (0-10 scale) (Appendix B – initial intensity may be 40% or less of HRR, carefully monitored against RPE).

Some research has looked at HITT using treadmill for 4 minutes at 90-95% VO_2 with 3 minutes of active recovery plus warm up and cool down [89]. However, HIIT is **not** recommended routinely and more research in this area is needed.

Aerobic training using a continuous approach

Interval training is considered more effective than continuous for increasing exercise tolerance

- Continuous CV work using treadmills and static bikes has been used in research trials with beneficial results. Again start low and go slow. Very de-conditioned individuals may start with 5-10 minutes at low intensity x 2 week. Individuals may be progressed up to 10-15 minutes ultimately increasing to 20-60 minutes, 3-5 x a week at low to moderate intensity (40-70% VO_2) as appropriate.

Resistance training

Initiation of a resistance training programme must be individual and supervised by a suitably qualified and competent exercise professional. The progressive steps should be:

- 5-10 reps at < 30% 1RM (RPE <12) x 2-3 week - to learn technique
- 12-25 reps at 30-40% 1RM (RPE 12-13) x 2-3 week - to improve endurance and co-ordination
- 8-15 reps at 40-60% 1RM (RPE <15) x 2-3 week - to increase muscular mass.

Respiratory training

Trials have shown that inspiratory muscle training for appropriate individuals can improve exercise capacity and quality of life [188, 189]

- Start at 30% of maximum inspiratory mouth pressure
- Alter intensity every 7-10 days up to a maximum of 60%
- Training should be 20-30 minutes per day, x 3 – 5 week for 8 weeks.

Other exercise interventions

- Breathing exercises, breathlessness management and recovery strategies
- Emphasis on posture training and core trunk strength
- Promotion of energy conservation techniques and guidance on pacing.

Exercise cautions

- Avoid excessive accessory muscle use and muscle fatigue with arm and upper body exercise in very de-conditioned individuals
- Avoid breath holding and Valsalva manoeuvre
- Avoid abrupt postural changes and stooped activities
- Avoid keeping legs stationary
- Show caution with seated exercise (reduced venous return). If performed, lower the intensity and combine with gentle leg exercise, for example alternate heel raises.

Key points

- Promote benefits of exercise training – "strong legs, spare the heart"
- Encourage leg and calf muscle exercise to increase venous return
- Pace effort/promote "walk and talk"
- Promote exercise philosophy "little and often"
- Promote self-management approach with exercise goal setting.

Appendix L: Extra considerations for individuals with an implantable cardiac device

Implantable devices include:

- Pacemakers
- Pacemakers with cardiac resynchronisation therapy (CRT)
- Implantable cardioverter defibrillators (ICD)

Pacemakers and CRT pacemakers

There are approximately 40,000 pacemakers implanted annually in the UK, to treat a variety of abnormal heart rhythm disturbances for example resting bradycardia, blunted HR response to exercise, tachybradycardia syndrome and AF. There are several types of devices:

- Single chamber device – for example abnormal atrial rhythms (such as AF)
- Dual Chamber device – complete or intermittent heart blocks
- Biventricular device (CRT) – HF.

CRT is a proven treatment for HF induced conduction disturbances and ventricular dysynchrony to reduce symptoms and improve cardiac function, by restoring coordinated contraction between the ventricles. Research findings have shown that CRT can reduce the risk of death from HF by 51% and reduce hospitalisations by 29%. The device deals with rhythm and output, however muscles still require training. It has been demonstrated that exercise training in CRT individuals can almost double their improvement in exercise capacity, as well as improve their haemodynamics and quality of life [190,191].

Exercise considerations with pacemakers

- Exercise prescription should be adapted taking into consideration the individuals underlying cardiac status, for example, when prescribing exercise for an individual with a CRT pacemaker; the HF exercise recommendations should be taken into account (Appendix N)
- Activities which may lead to damage to the device itself or lead displacement should be restricted (see ICD exercise prescription considerations and precautions below).

ICD

NICE recommends ICD implantation to reduce sudden cardiac arrest in individuals who have been identified at risk due to previous presentation of life threatening arrhythmias [192]:

- Cardiac arrest due to ventricular tachycardia (VT) or ventricular fibrillation (VF)
- Spontaneous sustained VT with syncope and haemodymnamic compromise
- Sustained VT without haemodynamic compromise with an ejection fraction (EF) 35% and NYHA III or IV status.

An ICD may also be implanted for prophylaxis [192]:

- Myocardial infarction (MI) with EF <35% and non-sustained VT on Holter monitoring.
- Inducible VT on electrophysiological testing
- MI with EF < 30% and a QRS duration equal to, or more than 120 milliseconds
- Familial conditions with high risk of sudden death for example long QT syndrome, hypertrophic cardiomyopathy, Brugada syndrome.

Evidence for ICD and exercise training

Exercise interventions with those with an ICD have not been extensively studied. The first prospective randomised control trial in ICD individuals with low capacity (EF <35%) demonstrated that exercise-based rehabilitation (including aerobic circuit training) has significant and beneficial outcomes in terms of cardiorespiratory function (CRF) and psychological wellbeing [192], although ICD shocks to terminate arrhythmias are associated with reduced quality of life and increased mortality [193]. Similar findings have been found in larger retrospective studies with a 20% mean improvement in CRF following regular aerobic exercise training [194]. Physical activity and exercise plays a substantial role in enabling individuals with an ICD to take control of his/her condition.

Clinicians are often concerned about exercising an individual with a known arrhythmia as the consequence of poorly performed exercise at a relatively high intensity could be a ventricular arrhythmia, which could be fatal. The important point, in terms of CR, is that clinicians are often exercising patients well below the intensities associated with exercise-induced arrhythmias. Manchester Heart Centre data (2007) shows the average METs associated with exercise-induced arrhythmias was 9.4 which is higher than the level prescribed in most CR programmes. Evidence is emerging to demonstrate that individuals with systolic HF are at no greater risk of shocks when exercise training [183,193].

Appropriate regular physical activity should be encouraged in individuals with an ICD, as this improves parasympathetic tone and HR variability, thereby reducing arrhythmia risk [79,195].

What increases the likelihood of arrhythmia during exercise?

- Reduced vagal tone, circulating catecholamines and myocardial demand particularly at the start and on sudden cessation of exercise [79,196,197]
- Anxiety [198]
- Habitual physical inactivity [193]
- Unaccustomed vigorous physical activity [193,199]
- High relative exercise intensity [199].

Exercise can be performed safely without increasing the risk of cardiac complications provided the exercise is prescribed at the appropriate intensity and the exercise session incorporates an effective warm up and cool down period [193, 200-202].

Risk stratification

The majority of individuals with a CRT pacemaker or an ICD will be classified as high risk via the AACVPR criteria, due to their underlying cardiac status or previous history of arrhythmia [58].

Assessment

In addition to the assessment process (Standard 2), the following points should also be considered prior to prescribing exercise:

- Evaluation of the individuals current cardiac status which may vary from structural disease with a poor LVEF, to individuals with electrical cardiac disease who may have normal cardiac function.
- Knowledge of the following ICD parameters:
  - ICD therapy threshold setting in bpm
  - Whether the device is set for VT or VF

    - Rapid onset setting
    - Sustained VT settings
    - ICD therapy, for example anti-tachycardia pacing or shocks
- Knowledge of contact details and communication links to the electrophysiology referral team for follow up of missing referral information and to discuss any concerns.
- Knowledge of prior shock history – 90% of individuals will have assigned a cause to a shock [203] leading to avoidance behaviour. If a shock has been previously experienced on physical exertion this may be a barrier to exercise [193].
- Knowledge of the relationship between the ICD and exercise training thresholds. To establish this, a sub-maximal FCT is an essential element of the assessment process.

Exercise prescription considerations and cautions

There is the potential for the ICD to interpret an exercise sinus tachycardia as an arrhythmia whilst in the detection zone. Given the physical and psychological implication of dealing with a shock and the long-term issues with inappropriate ICD therapies, a proactive approach to avoid this situation is considered best practice [193,204-206]. To reduce the risk of this occurring, the exercise prescription should follow the recommended standards for structured exercise training (Standard 7) with the following additional considerations:

- Begin exercise training a minimum of 6 weeks post device implantation to ensure lead integrity
- Keep the exercise HR 10 bpm below ICD detection threshold [200] using HR monitoring initially until effective use of RPE has been established
- Avoid excessive end ranges of shoulder movement and/or highly repetitive vigorous shoulder movements to reduce the risk of failure of a lead [96,97,201]
- Horizontal and seated arm exercises should be kept to a minimum [96,97,198]. Seated arm exercise is associated with reduced venous return, reduced end-diastolic volume, a concomitant decrease in cardiac output and increased likelihood of arrhythmia [97,198,201]. If performed, lower the intensity and place emphasis on muscular endurance. Mild leg exercise, for example alternate heel raises, when combined with arm exercise, reduces the haemodynamic response compared with strict arm work [94]
- Avoid breath hold and sustained isometric work which are associated with reduced venous return, reduced end-diastolic volume, a concomitant decrease in cardiac output and increased likelihood of arrhythmia. Isometric work, particularly of the abdominal region, should be avoided especially during arm exercise in individuals with low functional capacity [55,58,73,75,76,96,181]
- Avoid dangerous alone activities i.e. swimming, climbing ladders.

What to do if an individual receives a shock during the exercise session

It is important to have a protocol so that staff are aware of procedures to follow should an individual experience a shock during an exercise session:

- Sit or lie the individual down
- If the individual recovers quickly and feels well after a shock, continue; the individual should inform the follow-up centre as the device will need to be interrogated to check the appropriateness of the shock, following which medication and/or device settings may be altered
- If the individual is feeling unwell after a shock or more than one shock is delivered, local emergency procedures (if in hospital) should be followed, or an ambulance should be called.
- Exercise should be started again swiftly after the device has been interrogated, to avoid the ICD discharge becoming a psychological block on future activity [191].

Sports participation

It has been suggested that individuals with an ICD can only participate in low-moderate dynamic and low static sports, except those with risk of bodily collision, if there is no malignant VT, they have normal cardiac function and are six months post implantation or most recent arrhythmic episode requiring anti-tachycardia pacing/shock [207]. Recent data shows that although shocks during participation in competitive sports are not rare, there are few serious adverse events [208], with the majority of individuals who have received shocks returning to their sport [209]. As there is a scarcity of evidence to support or exclude the participation in sports with an implantable device it is recommended that a blanket veto should not exist [209].

The recommendations for participating in sports should be assessed on an individual basis with consideration of the following factors [96, 97, 200, 202, 207, 208]:
Cardiac status i.e. the underlying reason for device implantation
Type of sport i.e.:

- degree of static work
- CV demand
- degree of burst activity
- external factors – humidity, extreme cold
- competitive demand
- bodily contact – likelihood of damage to the device
- extreme ipsilateral arm movements, which could cause lead dislocation or rupture e.g volleyball/ basketball, racquet sports, swimming
- whether pre-syncope / dizziness expose individual and others to increased risk

To reduce the risk of an inappropriate shock due to sinus tachycardia, it is recommended that ICD settings should be tailored to the anticipated heart rate achieved during the sports activity [207,209].

In the UK, to reduce the risk of lead displacement new internal defibrillators (S-ICD) are being fitted subcutaneously without leads into the heart. The S-ICD is suitable for young people with conditions such as hypertrophic cardiomyopathy, arrhythmogenic right ventricle arrhythmia and other inherited arrhythmias who are very active but who do not require pacing.

Appendix M: Considerations for individuals post cardiac transplantation

Cardiac transplantation is associated with a mêlée of physiological alterations which may influence exercise capacity. These include:

- surgical denervation of the transplanted heart in the recipient [210]
- decreased chronotrophic competence
- altered ventricular function [211]
- altered vascular endothelium [212]
- pulmonary diffusion changes [213]
- accelerated graft vascular disease [214]
- reduced bone mineral density [215]
- changes in skeletal muscle morphology [216, 217].

The aerobic capacity and therefore exercise tolerance in heart transplant recipients can be between 40–60% lower than aged matched controls [218]. Despite this, transplant recipients can benefit from exercise training. An increase in aerobic capacity, muscle mass, muscle strength and bone density has been documented [219-221]. Much of the training effect occurs through

peripheral adaptation [222]. This is limited initially by poor musculature as disuse atrophy and defects of muscle metabolism associated with HF may persist from the pre-operative period [220,223].

Implications of denervation on exercise

- Loss of vagal tone to the sino-atrial (SA) node resulting in an increased resting HR of around 30% [222]
- No increase in HR through sympathetic stimulation on commencing exercise; some increase in cardiac output occurs through the Frank- Starling mechanism
- As steady exercise continues, increasing HR is achieved over 10 to 15 minutes, due to the chronotrophic effect of circulating catecholamines [222,224]
- The peak HR and VO_2 max is significantly lower than in normally innervated subjects [223]
- Breathlessness and fatigue are more likely due to:
  - increased CO_2 production compared with healthy subjects
  - decreased O_2 delivery to peripheral working skeletal muscles
- Loss of sensation of pain in the presence of cardiac ischaemia [225]
- Interference with salt and water retention
- Causes some loss of control of peripheral vasculature.

Effects of denervation on ceasing exercise

Slow decline in HR due to:

- No Vagal brake on the SA node [224]. This is significant, as HR alone will not be reflective of exercise intensity
- slow removal of catecholamines from the circulation, taking 10 to 15 minutes [225]
- an increased risk of hypotension on ceasing exercise abruptly, as venous return from working muscles drops whilst HR remains high.

Risk stratification

The majority of heart transplant recipients will be classified as low risk via the AACVPR criteria [223,226] however the age limit of donors has increased in recent years and therefore, there is a risk of donor CHD being present.

Assessment

- An ETT protocol should allow a warm up and cool down stage to allow circulating catecholamines to become effective and have continuous progressive increments in work rates of 1 to 2 METs per stage, allowing the denervated heart to adapt to the increased workload [227]
- CV endurance training should be set between the anaerobic threshold and 10% below, as established by an incremental ETT [214,228]. If this information is not available, a percentage of the peak HR should be used to guide the training, depending on how the peak exercise capacity compared with predicted measures [228]
- Maximal effort can be assumed from the BORG RPE of 19 to 20 and the ventilatory threshold from a rating of 12 to 14. Having noted the level of energy expenditure on the exercise test where the ventilatory threshold or RPE 12 to 14 is achieved, this can be translated in terms of exercise pace or ergometer power output [223,226]
- If ETT results are not available, a FCT should be carried out to determine exercise intensity and baseline measurements. Test protocols should allow time for an appropriate increase in HR and oxygen consumption at each workload

- Consensus of the UK Transplant Centres demonstrates that the most practical method of prescribing exercise for this group relies on the individual perception of having exercised, until there is some mild muscle fatigue or shortness of breath and then checking their description of these feelings against the BORG RPE scale to maintain a rating of 12 to 14.

Exercise prescription

Although there is evidence that CV and resistance training for heart transplant recipients is beneficial for many reasons [215,229,230], the current literature does not demonstrate consensus regarding what should be included in the exercise programme. There are very few studies which have investigated exercise programmes for individuals in early rehabilitation and to date, there have not been any randomised control trials in this area.

The exercise regimens that have been shown to make significant improvements in physical parameters include those described below:

- A resistance training programme of 10 to 15 repetitions at 50% of 1RM has been shown to cause significant improvements in bone mineral density; including lumbar resistance which should be increased by 5 – 10% [231]
- To include aerobic and resistance exercises: 30 to 40 min of treadmill or exercise cycle, five days a week for 12 weeks at an intensity of 12 to 14 on the BORG RPE scale and a lower limb resistance training regimen of between 3 to 5 sets of 10 repetitions of 50% of 1 RM [215,229,231]
- Walking at 60% – 70% peak VO_2 for 15 to 20 minutes (confirmed by a BORG RPE of 12 to 14) after a 5 minute warm up and light limb strengthening exercises [230]
- Magnitude of improvement is related to the duration of training (12 to 16 weeks, 3 to
- 5 x week) and intensity (work at levels 11 to 14 BORG RPE scale for sessions 30 minutes long excluding warm up and cool down) [222,225,232].

Exercise considerations

- Resting HR is 30% higher, therefore exercise prescription as a percentage of HR maximum (as calculated by the [220] – age method) is not appropriate for these individuals
- RPE has been investigated with this population of individuals [231] and has been found to be effective to guide exercise intensity. However, caution should be taken as it has not been validated in cardiac transplant individuals
- Careful prolonged warm up necessary (10 to 15 minutes) to allow catecholamine levels to increase HR
- Prolonged cool down and muscle stretches (10 to 15 minutes) to allow a decrease in circulating catecholamines and therefore HR, to avoid a rapid drop in BP [226].
- The duration of the CR programme may need to be extended to take account of episodes of rejection or infection, which may prevent exercise for several days/weeks at a time.
- If an individual has received significant doses of steroids to treat rejection episodes, there is a possibility that the individual may suffer from steroid-induced myopathy. If this is the case, exercise intensity may need to be kept lower (RPE 11-13) initially to allow for muscle adaptations.

Exercise cautions

- An accelerated form of coronary atherosclerosis may develop post transplant so that at 5 years post surgery around 45% of individuals have angiographic evidence of disease and at 9.5 years post surgery this increases to 53% [220]. Pain from cardiac ischaemia will be absent

as a result of denervation, therefore other symptoms such as breathlessness should be considered.

- Recent biopsy score:
  - If cellular rejection is present it is graded on a scale from 1 to 4 (mild to severe).
  - If rejection is severe, the individual should discontinue CV and resistance exercises until the biopsy result is clear. During moderate rejection, exercise should be maintained at current levels without progression; in mild rejection the exercise regimen should be progressed slowly [224,226]
  - Rejection increases the risk of arrhythmia and reduced cardiac output
  - With rejection, high dose corticosteroids are given for three days followed by a tapering down regimen, increasing the risk of skeletal fractures on high impact exercises after a rejection episode, the exercise programme should be tailored to reduce impact/stress on the skeletal system initially with a gradual progression back to pre-rejection exercise levels.
- Individual reported temperature – the transplant individual should take their temperature daily to monitor the first signs of an infection. If immunosupression is low, an individual can become unwell very quickly in the presence of an infection. Exercise should not be continued in the presence of pyrexia.
  - It is recommended to wait 6-12 months post transplantation before resuming swimming to ensure that immunosupression and infection / rejection episodes are stable. The transplant team should advise when an individual may begin swimming.

Appendix N: Considerations for individuals with left ventricular assist devices

Background

The rapidly expanding technology in this field has now enabled individuals with left ventricular assist devices (LVAD), bi-ventricular assist devices (BiVAD) or a total artificial heart device (TAH) to be discharged home from the hospital setting. An LVAD is the most common device implanted in the UK at the present time.

Currently there is a lack of evidence regarding exercise training protocols for people who have an LVAD implanted for end-stage HF. To date, there has not been any studies published investigating the effects of different exercise training protocols (including frequency, intensity and type) with this patient group.

Of the papers that have described rehabilitation post - LVAD implantation many of them are single case studies, have less than 10 subjects; or are retrospective analysis [233-235].

There are currently many versions of LVAD available and the capacity of exercise will depend on the ability of the device to deliver an output that matches the intensity of exercise required. There are two basic forms of blood pump that are in current use:

- pulsatile or positive displacement pumps
- non-pulsatile, continuous flow pumps.

The newer generation of continuous-flow pumps have been shown to have the same effects as pulsatile pumps in regards to left ventricular unloading and cardiac haemodynamics [236].

Individuals are discharged home once they can mobilise independently, perform ADLs, climb stairs and have achieved a set level of knowledge regarding the device, so that they can care for themselves independently. Some individuals will require a carer with them 24 hours a day, depending on their underlying cardiac function. Other individuals are able to be alone in the

day but may be required to have an adult in the house with them during the night. Each individual will learn how to change the power source so that they can mobilise independently away from the main unit and will be able to perform emergency procedures in case of device alarms and pump failure.

Exercise considerations

Staff who will be involved with the individual during the programme will require basic training surrounding the device and have an understanding of the device alarms. If the individual needs to have a carer with them 24 hours a day a fully trained person must be present in the vicinity of the CR assessment or exercise session so that they are able to deal with any device alarms/emergencies should they occur. The individual will need to have all the emergency equipment should it be required near to hand. This will include emergency procedure information, spare batteries, a spare controller, spare battery clips and any other equipment that may be required for the device in order for the external components of the device to be changed over, should they fail. Each VAD centre will have access to an on-call VAD co-ordinator 24 hours a day for advice via telephone, or in case of emergency.

Many individuals with end-stage HF who require an LVAD may already have been fitted with an ICD +/- bi-ventricular CRT (Appendix M).

HR and BP assessment can be challenging and variable with the continuous flow pumps, as the continuous nature of the pump eliminates the arterial pulse. The use of a Doppler BP monitor or stethoscope and sphygmomanometer, may assist in gaining more accurate readings. Maximal exercising HR and maximal exercise intensity may have been established by the referring hospital by means of a cardiopulmonary exercise test prior to attendance at a CR programme and this information can be used to prescribe exercise intensity effectively.

For the continuous flow pumps the speed of the device is set at the same rate, whether the patient is asleep or exercising.

The individual's ability to perform at a prescribed intensity of exercise may be limited by the rate of the pump and the patient's underlying myocardial function. Subjective measures may be necessary to monitor exercise intensity i.e. use of RPE scale, changes in work of breathing and fatigue.

Hypotension in low pump flows is one of the most common problems encountered, hence the patient must be well educated regarding the normal flow values so that he/she is able to take appropriate action when required. Individuals may need encouragement to drink water before and during the exercise session to maintain pump flows.

The position of the drive-line (the line that is tunnelled from the device implanted in the heart to the external controller system and power source) may affect the type of exercise that the person is able to perform. If the drive-line is tunnelled through the abdominal wall the individuals are not able to perform any specific abdominal exercises, or movements causing excessive abdominal stretch/torsion. The drive line insertion site will limit core muscle strength exercises and trunk range of movement. These restrictions are necessary to prevent excess movement and potential trauma of the drive line which increases the risk of infection. Bilateral arm exercise above the head (i.e. bilateral latissimus dorsi pull-down) should also be avoided due to increased stress on the abdominal musculature which can cause trauma to the drive-line.

Individuals must be asked about any problems with drive-line infection prior to the session, as

it is not advisable to exercise when an active infection is present.

Fast movements (jumping or jogging) and ballistic type (for example bouncing on a trampette) exercise should be avoided to reduce any micro-trauma at the drive-line site or damage to the drive-line itself.

Whole body resisted exercises should also be avoided, due to the potential trauma caused to the drive-line. These include use of a cross-trainer, ski-machine, rowing machine, star-jumps or swimming/swinging motions with the arms (use of kettlebells).

Individuals may have had a sternotomy to implant their device. Depending on how soon they are referred to CR, it may be necessary to limit arm exercise in accordance to healing time scales.

Individuals with a LVAD should also be encouraged to slow down gently after CV exercise in order to avoid large haemodynamic shifts which may reduce LVAD flows causing the individual to feel light-headed/faint.

The underlying condition requiring LVAD insertion and post-operative effects will affect the degree of exercise tolerance at any time. Each individual with a LVAD will require an individual assessment and exercise programme depending on their physical limitations and the ability of the device to affect exercise capacity.

Some individuals may have suffered a neurological event, due to thrombus formation, a frequently documented complication of LVAD implantation, or have a peripheral neuropathy that may influence choice of the modes of exercise prescribed.

Exercise Prescription

LVAD insertion has been shown to improve oxygen deficiency and exercise capacity measured by peak VO_2 during maximal exercise [237]. It has also been shown that after 5 months of LVAD insertion peak VO_2 was significantly better than that of NYHA class III patients, (15.4 ± 1.0 ml/kg/min) and that the pulsatile pump itself was the limiting factor to further improvements in exercise capacity [238]

- Treadmill exercise testing using modified Bruce, Naughton or modified Naughton protocol and a supine bicycle protocol beginning at 50-Watts, increasing by 25-Watts every 3 minutes until fatigue have been used safely with this patient group [237,239]. The modified Wassermann ramp protocol for a cycle ergometer has also been used safely to assess maximal exercise capacity [238]
- Treadmill exercise with a workload of 3-5 METs (2.1mph, 2% gradient) for 20-30 minutes has been shown to be safe and effective, as has the use of the supine bicycle [233,239].

Contraindications to exercise

Currently only one study has published any contraindications to exercise but these are only stated as contraindications to exercise 4 to 6 weeks post surgery [240]. These contraindications are included in the list below:

- Onset of angina or significant pains around the chest
- A drop in SBP below resting or an increase in SBP exceeding 200mmhg
- Oxygen desaturation <85%

- Drop in LVAD flow <3 l/min
- Borg RPE rating of >13 at sub-maximal workloads
- LVAD flow rate that is different from the individual's "normal" flow (either higher or lower. A higher flow rate may be an indication of a systemic infection and a lower flow rate may indicate hypovolaemia or thrombus)
- A power value (for example Watts) that is different from the individual's "normal" value, either higher or lower. This can be an indication of a thrombus in the pump or a malfunction of the pump
- An increase in the number of suction events (the LV being sucked onto the inflow tract of the device). Suction events can only be noted if the device main display unit is being utilised. Suction events can cause damage to the LV if they continue for long periods. Suction events may be prevented by increasing oral fluid intake
- Any device alarms. The alarms should not be silenced and the individual should not continue to exercise until the alarm has been fully investigated with the individual seated and appropriate action taken
- A recent ICD shock
- An increase in shortness of breath at rest above normal for that patient
- An increase in weight of more than 2kg over 2 days
- New onset of neurological changes
- Pain, oozing or bleeding around the drive-line.

The only investigation to report any incidents during exercise training, states that the events were all minor, resulting in no increased morbidity or mortality and included venous pooling, hypovolemia and decreased drive line air volume in the pulsatile pump [233].

Appendix O: Exercise considerations for adults with congenital heart disease

The European Society of Cardiology (ESC) [241] states regular exercise at the recommended levels should be encouraged in all adults with congenital heart disease (ACHD). In reality, people with ACHD have relatively low levels of physical activity compared to their age-matched peers, with few achieving the UK recommendations for physical activity for health [242].

Current situation

Due to improvements in interventions and treatments, the number of adults living with congenital heart disease now outnumbers the number of children diagnosed with CHD. In 2010 there were approximately 20,000 adults living with ACHD in the UK. Whereas 40 years ago 80% of people with ACHD died before the age of 16, 80% are now surviving over the age of 16. Increasing number of individuals have survived with complex surgical modified disease.

Bethesda Classification of ACHD

Congenital Heart Disease is a collective term to describe a large number and wide spectrum of malformations of the heart and great blood vessels that are present at birth. Using the Bethesda Classification [243], individuals with ACHD may be satisfactorily classified according to the complexity of the lesion as simple, moderate, or complex.

Bethesda classification of adult congenital heart disease	
Simple	• Mild pulmonary stenosis • Mild congenital valvular stenosis • Atrial Septal Defects (ASD) closed or not requiring closure/ with sequelae • Repaired Ventricular septal defects (VSDs) • Repaired ASDs and VSDs • Mild pulmonary regurgitation • Congenital aortic stenosis • Repaired total or partial anomalous pulmonary venous drainage
Moderate	• Unrepaired VSDs unless complicated haemodynamics • Repaired ASDs with good haemodynamic result • Moderate pulmonary stenosis/regurgitation • Repaired tetralogy of Fallot with good haemodynamic result • Aortic stenosis • Repaired coarctation without aortic obstruction or aneurysm formation • Discrete subaortic stenosis • Mild Ebsteins anomaly • Unrepaired ASDs with right heart dilation for consideration of closure
Complex	• Single ventricle physiology • Fontan physiology • Pulmonary atresia with major aortopulmonary collaterals or conduit • Tetralogy of Fallot with electrical or significant valvar sequelae • Systemic right ventricles: Mustards / Sennings / congenitally corrected transposition of the great arteries (ccTGA) • VSD (repaired or unrepaired) with significant AR or complicated haemodynamics • Unrepaired AVSDs (without Eisenmengers physiology) for consideration of repair • Individuals with conduits (repaired truncus arteriosus, Rastelli operations, Pulmonary atresia) • Complex left ventricular outflow tract obstruction in women of child bearing age • Unrepaired coarctation • Repaired coarctation with significant sequelae • Ebsteins anomaly • Eisenmenger individuals • Double chambered right ventricle • Post Ross operation • Metal valve replacements in women contemplating pregnancy • Individuals for assessment for surgical or percutaneous intervention

Exercise problems in ACHD

Poor exercise capacity is common in ACHD. VO_2 max may be half that of age matched peers. This may be related to the cardiac condition itself, but may be due to other factors such as becoming deconditioned due to long term inactivity.

Factors which contribute to reduced function

- Abnormal cardiac anatomy and/or physiology
- Pressure or volume overload leading to ventricular dysfunction
- Poor chronotrophic response to exercise
- Arrhythmias – onset may be due to haemodynamic decompensation [241]
- Sudden cardiac death (SCD) – the greatest known risk of late SCD are:

- Tetralogy of Fallots, transposition of the great arteries (TGA), ccTGA, and aortic stenosis
- Abnormal respiratory anatomy/physiology
- Pulmonary hypertension/insufficiency
- Reduced vital capacity.

Other factors:

- Exercise capacity may be greatly diminished even in asymptomatic individuals [244] due to:
  - Habitual low levels of exercise
  - Discouragement of exercise in childhood by parents, carers, teachers, and health professionals [245]
  - Fears and misconceptions creating barriers to activity.

Evidence for exercise training with ACHD

Evidence is emerging that regular exercise at recommended levels can be performed and should be encouraged in all individuals with ACHD [246] and that ACHD is an appropriate group of individuals to introduce to formal exercise training [242].

Assessment

In addition to the usual assessment considerations, for the ACHD individual it is essential to know the following:

- Has previous surgery been **corrective** i.e. there is now a normal functioning heart, or **palliative** i.e. the heart / circulation are missing an important essential feature (single ventricle), or the circulation is organised in an unnatural way
- How the circulation works
- What affect exercise will have on the circulation
- For cyanotic individuals, it is important to know the resting SpO_2 and the level to which it falls on exercise
- An appropriate FCT should be chosen which matches the functional capacity of the individual.

Exercise guidelines for ACHD

- Most patients with ACHD can safely participate in most forms of recreational activity of low to moderate intensity (4 – 6 METS) [241,247]
- Some simple classifications and corrected conditions may participate in competitive sports [241,248]
- Specific recommendations for exercise and sports should be based on the individual's ability, the impact on underlying haemodynamics and the risk of acute decompensation and arrhythmias [241]
- As a general recommendation, dynamic exercise is more suitable than static exercise [241]
- Individuals should be educated to identify symptoms when exercise should be terminated.
  - Dizziness, palpitation, fatigue, excessive dyspnoea, chest pain [247]
- Some lesions are not compatible with competitive sports, due to the morphological severity/complexity and tendency to serious arrhythmias [242, 248] – including Eisenmenger syndrome, Pulmonary Arterial Hypertension and Univentricular Heart, coronary artery anomalies, Ebstein's anomaly, and ccTGA and TGA repaired by atrial swich or Rastelli procedure.

It is generally recommended to avoid the following

- Burst activities – sudden acceleration or deceleration over short distance [247]
- Activity in extreme adverse environmental conditions due to alterations in blood volume, electrolytes and hydration [247]
- Adrenergic activities for some conditions i.e. long QT syndrome – diving (LQT1), loud noises (LQT2) [247]
- Intense static activities with Valsalva manoeuvre [247]
- Extreme sports – hang gliding, bungee jumping (especially if on anticoagulants) [247]
- Cyanotic individuals – avoid dehydration and temperature extremes.

Precautions

As ACHD individuals have always lived with their condition and are 'used to poor exercise tolerance' they may deny or ignore symptoms which can be potentially dangerous and thus increase the risk for SCD on exercise

Condition	Category 1 **Sports** Endurance training, athletic competition, contact sports	**Category 2 Sports** Low intensity competitive sports	**Category 3** **Recreational Activity** Moderate exercise	**Category 4** **Recreational Activity** Light exercise	**Additional considerations**
VSD	Defect / repair with normal pulmonary pressure 3months post repair			Defects with pulmonary hypertension	
ASD	Defects / repairs with normal pulmonary pressure 3months post repair	Defects with mild pulmonary pressure (Class 1A)		Defects with right-to–left shunt and cyanosis	Avoid scuba diving with remaining shunt
PDA	Small PDA normal LV 3m post-surgical repair			Moderate / large PDA with pulmonary hypertension	
Pulmonary stenosis / RVOTO	Normal RV and peak systolic gradient <40mmHg 2-4 weeks post valvuloplasty	Peak systolic gradient >40mmHg (Class 1A &1B)		Severe pulmonary stenosis	Mild avoid competitive static sports
Aortic stenosis / LVOTO / coarctation aorta	Mild AS with normal ECG Mild coarctation without root dilatation 3 months post angioplasty	Moderate AS without LV Hypertrophy (Class 1A) 1B, IIA if ETT to level of sport without symptoms Coarctation with systolic arm/ leg gradient > 20mmHg (Class 1A) Aortic root dilatation (Class 1A & 1B)		Severe AS	Severe AS – avoid isometric activity Mild AS excessive static sports at competition level No competitive sport if LV dysfunction or symptoms

Tetralogy of Fallot	Normal R heart pressure Mild RV volume overload No residual shunt	Marked pulmonary regurgitation, RV hypertension (Class 1A)			Avoid isometric exercise
Transposition of Great Vessels post Mustard/ Senning repair		If mild chamber enlargement with no arrhythmias or syncope (Class 1A & IIA)	Encourage regular moderate to low intensity activity		
Transposition of Great Vessels post arterial switch	Normal LV	Mild haemodynamic abnormalities / ventricular dysfunction (Class 1A, 1B, 1C, IIA)			Avoid extreme exercise
Ebsteins Anomaly	No cyanosis, normal RV, no arrhythmias	Moderate tricuspid regurgitation		Severe Ebsteins anomaly without surgical repair	Avoid extensive static sports to competition level Avoid heavy isometric exercise if mild TR or RV dysfunction
Fontans Circulation		Class 1A Class 1B if normal LV and SpO2			Mostly advised to limit ambitions to recreational sports
Pulmonary atresia			Excellent haemodynamics	Without excellent haemodynamics	Avoid isometric exercise
Hypertrophic Cardiomyopathy		Selected individuals (Class 1A)	Encourage low to moderate intensity activity		Avoid competitive sports Avoid extreme sports
Dilated Cardiomyopathy		Selected individuals			Avoid competitive sports Avoid extreme sports
Long QT Syndrome				Encourage light activity	Avoid swimming or diving (LQT1) Avoid sudden noise (LQT2) Avoid competitive sports Avoid extreme sports
Brugada Syndrome				Encourage light activity	Avoid competitive sports Avoid extreme sports

Arrhythmogenic RV Cardiomyopathy		Selected individuals (Class 1A)		Encourage light activity	
Pulmonary hypertension / Eisenmengers' Syndrome	Peak systolic pressure <30mmHg	If SaO2>80%, no arrhythmia or <moderate RV dysfunction	Encourage light to moderate exercise with pacing		Avoid strenuous exercise

Table adapted from, ESC Guidelines, AHA scientific statement and Bethesda 36 Conference Task Force recommendations [241, 247, 248]

All individuals in Category Sports 1 and 2 should be encouraged to participate in regular moderate intensity physical activity if not engaging in sports participation.

Bethesda Conference 36, Task Force 8: classificaiton of Sports [248]

	A. Low dynamic < 40% VO_2max	**B. Moderate dynamic 40-70% VO_2max**	**C. High dynamic >70% VO_2max**
III. High static > 50% MVC	Bob sledding / luge Gymnastics Martial arts Sports climbing Water skiing Weight lifting Windsurfing	Body building Downhill Skiing Skatebarding Snowboarding Wrestling	Boxing Canoeing/kayaking Cycling Decathlon Speed Skating Triathlon
II. Moderate static 20-50% MVC	Archery Diving Equestrian Motorcycling	Jumping field events Figure skating Rugby Sprinting Surfing Synchronized swimming	Basketball Ice Hockey Cross country skiing Lacrosse Middle distance running Swimming Handball
I Low static < 20% MVC	Billiards Bowling Cricket Golf Rifle shooting	Baseball Fencing Table tennis Volleyball	Badminton Hockey Race walking Orienteering Squash Long distance running Tennis

Appendix P: Considerations for people with peripheral arterial disease (PAD) and symptoms of intermittent claudification (IC)

Peripheral arterial disease (PAD) with its main symptom being leg pain that causes limping and the inability to sustain walking (intermittent claudication; IC), shares the same CVD risk factors and atherogenic processes as CHD and stroke [249]. The need to provide CR programme adaptations to accommodate people with PAD is high, where it can be expected that 41% of this population will develop CHD, 38% an MI, 31% angina and 14% HF [250]. Prevalence in the general population is >20% in those aged over 65 years [249]. The high risk of developing CHD and HF from PAD, coupled with an ageing population in the UK, means that the total numbers of people with PAD entering CR programmes, who have suffered an MI or have HF, is set to increase.

The ankle brachial pressure index (ABPI) is used to objectively classify the severity of PAD [251]. It is determined by simultaneous measurement of ankle and brachial BP, where the ABPI score is closely linked to mortality risk and the severity of IC symptoms (Table 1). Physiotherapists and exercise professionals must note in their documentation both the ABPI score if available and symptom severity along with walking exercise capacity (discussed below) as a means of providing exercise and risk factor guidance.

Table 1
* Clinical status, claudication symptoms and mortality risk related to Ankle Brachial Pressure Index (ABPI) (adapted from Fowkes [252]).

Clinical status	ABPI (relative mortality risk compared to norm ABPI of 1.1)
Symptom free	1 or more
Intermittent claudication symptoms	0.95 (1.5x greater risk) down to 0.50 (>4x risk)
Pain at rest	0.5 - 0.3
Gangrene and ulceration	<0.2

*The values of ABPI in Table 1 relate in most cases to the severity of symptoms experienced by patients. However, in individualised cases, as with most clinical conditions, there will be patients with symptoms but with a high ABPI and others with a low ABPI and no symptoms.

Assessment of walking and exercise capacity

Functional capacity in PAD requires three elements during walking or stepping type assessments:

- Time to the onset of IC muscle pain
- Length of time before ceasing walking due to walking pain becoming unbearable (for example Borg CR-10 score > 7)
- Overall aerobic exercise capacity (estimated or actual) expressed in METs [253].

For those whose pain limits them from being able to sustain exercise up to an intensity of 70% HRR during a walking or stepping-based assessment, a non-weight-bearing exercise assessment (cycle ergometry, arm ergometry, rowing ergometry – see comments on practicality below) may be preferable [254].

Promotion of walking

Observational data from Garg et al. demonstrated that those with PAD who walked more regularly were at a decreased risk of early mortality [255]; walking less than 1 mile per week showed 3.5 times greater risk of mortality compared to those who walked more than 2.5 miles per week. For the latter group this is an average of walking distance of 0.5 miles most days of the week.

Walking that pushes people to continue walking in spite of pain is shown to be of benefit to improving walking distance and performance [253]. Within this evidence there was little change to ABPI scores. Tan et al. provide some explanation for this by showing that improved performance from regular walking and exercise training led to improved walking economy and metabolism, lower oxygen uptake and blood lactic acid levels, respectively, for any given walking speed [256].

Achieving exercise training benefits within CR sessions

For those with low ABPI and/or more severe IC, attaining the target intensity of 40-70 %HRR or $\%VO_2$ max performed for >20 minutes during weight-bearing (standing) aerobic exercises – walking, circuit exercise – may be unachievable. In these cases, not only does an interval approach need to be taken, but this needs to include either non-weight-bearing such as rowing, cycling, swimming, or upper limb activities like arm ergometry to attain a beneficial volume of aerobic/cardiorespiratory activity.

A progression of walking and/or weight-bearing activity must be set as a goal, so that corresponding improvements in overall aerobic functional capacity and longer (time and distance) walking capabilities are achieved. There is some evidence, that supervised exercise sessions lead to better outcomes than home-based/self-managed exercise in PAD however more data is required to confirm longer term and quality of life benefits [257]. It is known, that although angioplasty can improve function up to 12 months, the benefits of regular walking in the longer term is likely to be the best therapy compared with most medical interventions [253]. Regular upper limb exercises have been shown to improve walking performance [254].

Practical exercise monitoring, grading and guidance considerations

When using RPE and pain ratings in PAD, it is important to differentiate between overall exercise effort (normal muscle and respiratory responses to exertion) and the localised sensations of muscle aches/pain [60,258]. Patients should be instructed to rate their exercise for the rest of their body, separate to the localised leg muscle IC pain. Individualised pain ratings, using Borg's CR-10 scale should be recorded independently and reviewed in relation to walking speed, distance, heart rate and whole body RPE to evaluate improvements due to training. As with the exercise assessment, a balance of activities between upper and lower body, weight-bearing and non-weight-bearing activity should be performed so the patient can achieve exercise intensities that will improve both cardiorespiratory fitness and muscle pain responses.

When using cycle or rowing ergometers, progressions can be adapted, starting with having individuals perform most of the work with the "good leg" and then gradually increasing effort over days and weeks with the PAD-affected leg. Other adaptations include; using adjustable cycle cranks, placing the heel of the affected leg on the pedal to reduce calf muscle use, and not using the toe straps on the pedals of the cycle and rowing ergometer. With time, "graded exposure" techniques of engaging the affected calf muscle to similar levels as to the non-affected leg can be achieved.

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Abbreviations

AACVPR	American Association of Cardiovascular & Pulmonary Rehabilitation
ACHD	Adult Congenital Heart Disease
ACPICR	Association of Chartered Physiotherapists in CR
ACS	Acute Coronary Syndrome
ACSM	American College of Sports Medicine
ADL	Activities of Daily Living
AED	Automated External Defibrillator
ALS	Advanced Life Support
AR	Active Recovery
BACPR	British Association for Cardiac Prevention and Rehabilitation
BLS	Basic Life Support
BASES	British Association of Sports & Exercise Sciences
BMI	Body Mass Index
BNP	B-type Natriuretic Peptide
BP	Blood Pressure
bpm	Beats Per Minute
CABG	Coronary Artery Bypass Surgery
CCF	Congestive Cardiac Failure
CHD	Coronary Heart Disease
CHF	Chronic Heart Failure
CK	Creatine Kinase
CKD	Chronic Kidney Disease
CPR	Cardiopulmonary Resuscitation
CPD	Continuing Professional Development
CR	Cardiac Rehabilitation
CRF	Cardiorespiratory Function
CRT	Cardiac Resynchronisation Therapy
CSP	Chartered Society of Physiotherapy
CST	Chester Step Test
CT	Computed Tomography
CV	Cardiovascular
CVD	Cardiovascular Disease
DSE	Dobutamine Stress Echocardiogram
ECG	Electrocardiogram
Echo	Echocardiogram
EF	Ejection Fraction
ESC	European Society of Cardiology
FCT	Functional Capacity Test
ETT	Exercise Tolerance Test
FITT	Frequency, Intensity, Time, Type
FFR	Fractional Flow Reserve
GTN	Glycerine Trinitrate
HADS	Hospital Anxiety and Depression Scale
HCPC	Health and Care Professions Council
HFPEF	Heart Failure with Preserved Ejection Fraction
HR	Heart Rate
HF	Heart Failure
HRR	Heart Rate Reserve
ICD	Implantable Cardioverter Defibrillator
ILS	Immediate Life Support
IVUS	Intravascular Ultrasound
kcal	Kilocalories
kg	Kilogram

KSF	Knowledge and Skills Framework
LVAD	Left Ventricular Assist Device
LVSD	Left Ventricular Systolic Dysfunction
MDT	Multidisciplinary Team
MET/METS	Metabolic Equivalent
MHR	Maximal Heart Rate
Min	Minute
MI	Myocardial Infarction
mph	Miles Per Hour
MRI	Magnetic Resonance Imaging
MSE	Muscular Strength & Endurance
MSK	Musculoskeletal
NACR	National Audit Cardiac Rehabilitation
NHS	National Health Service
NICE	National Institute for Health and Clinical Excellence
NSF	National Service Framework
NSTEMI	Non ST Elevation Myocardial Infarction
NYHA	New York Heart Association
OGTT	Oral Glucose Tolerance Test
PAQ	Physical Activity Questionnaire
PCI	Percutaneous Coronary Intervention
PCT	Primary Care Team
PND	Paroxysmal Nocturnal Dyspnoea
PPM	Permanent Pacemaker
PAD	Peripheral Arterial Disease
QOL	Quality of Life
RCT	Randomised Control Trial
REPs	Register for Exercise Professionals
RM	Repetition Maximum
RPE	Rating of Perceived Exertion
RPP	Rate Pressure Product
SA	Sino-atrial
SBP	Systolic Blood Pressure
SCD	Sudden Cardiac Death
SIGN	Scottish Intercollegiate Guidelines Network
SMARTER	Specific, Measurable, Achievable, Realistic, Timely, Empowering and Revisable (goals)
SOB	Shortness of Breath
SOBOE	Shortness of Breath on Exertion
STEMI	ST Elevation Myocardial Infarction
SWT	Shuttle Walking Test
THR	Training/Target Heart Rate
UK	United Kingdom
VF	Ventricular Fibrillation
VO_2max	Aerobic Power
VT	Ventricular Tachycardia
W	Watts
WC	Waist Circumference
WHO	World Health Organisation
6MWT	Six Minute Walk Test

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