ACPICR

Association of Chartered Physiotherapists In Cardiovascular Rehabilitation

2023
4th Edition

ACPICR Standards

Standards for Physical Activity and Exercise in the Cardiovascular Population

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The Association of Chartered Physiotherapists in Cardiovascular Rehabilitation is a professional network of the Chartered Society of Physiotherapy.

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Introduction

Cardiovascular Rehabilitation (CR) is a continually evolving specialty 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. In 2019 the name was changed to the Association of Chartered Physiotherapists in Cardiovascular Rehabilitation.

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

This 4th edition of the standards has been developed through a review of the evidence for best practice and consensus of expert opinion in the exercise component of CR, by a working party of the ACPICR. They have been peer-reviewed by the BACPR Exercise Professionals Group (BACPR-EPG) and other individuals. A full list of the peer reviewers can be found on page 93.

Aims of the Publication

This document complements and elaborates on the BACPR Standards and Core Components for Cardiovascular Disease Prevention and Rehabilitation, particularly its section on physical activity and exercise training [1]. This publication aims to provide a reference guide for current CR exercise professionals to deliver safe and effective exercise to all eligible individuals with, or at high risk of developing cardiovascular disease (CVD), ultimately supporting these individuals to become more active in line with the United Kingdom (UK) physical activity guideline most appropriate for them [2] *(see Appendix A)*. Whilst these standards focus mainly upon early (core) rehabilitation, they provide useful information to support exercise professionals working across the CR pathway.

This publication provides:

- a detailed framework of best practice to support development of new programmes and benchmarking of existing programmes
- guidance for managing the complex and high-risk individual
- guidance for health and safety
- guidance for the setting of local and national standards
- evidence to support line managers and CR practitioners in securing a quality service

The content of this publication is not exhaustive and therefore further reading is recommended. Guidance on competitive and recreational sport and individuals is not provided across all of the diagnostic groups; instead please refer to European Society of Cardiology (ESC) guidelines on sports cardiology and exercise in individuals with CVD [3].

In addition, this publication should be used in conjunction with the CSP Quality Assurance Standards for Physiotherapy Service Delivery [4] and the CSP Code of Members' Professional Values and Behaviour [5]. Clinical Exercise Physiologists should consult The Scope of Practice for a UK Clinical Exercise Physiologist (CEP-UK) [6].

For those individuals whose practice is not regulated by the CSP, CEP-UK or Health and Care Professions Council (HCPC), the standards should be applied within the realms of one's own profession's standards, e.g. The Membership Code of Conduct of the The Chartered Institute for the Management of Sport and Physical Activity (CIMSPA) [7], or The Code of Practice of the British Association of Sports & Exercise Sciences (BASES) [8].

Provision of CR

The BACPR defines CR 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 patients may, by their own efforts, preserve or resume optimal functioning in their community and through improved health behaviour, slow or reverse progression of disease" [1].

It is important to recognise therefore 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 health behavioural change and education, psychosocial health, medical risk management and long-term strategies [1]. For further detail, please refer to the BACPR Standards and Core Components for Cardiovascular Disease Prevention and Rehabilitation [1].

New to this Update

- All 12 standards have been reviewed and updated in line with current guidelines and evidence
- The appendices have been expanded to include detail on remotely-delivered cardiovascular rehabilitation and on individuals with left ventricular (LV) thrombus, abdominal aortic aneurysm (AAA), diabetes mellitus, spontaneous coronary artery dissection (SCAD), and non-obstructive coronary artery disease (NOCAD)
- The ACPICR Peer Review [9] document has been updated to allow for ongoing monitoring through an audit process

For all 12 standards and for the appendices providing considerations for individuals with specific diagnoses/conditions, key messages have been used to highlight the main points.

STANDARD 1: Recruitment and referral

The BACPR Standards and Core Components document [1] outlines that comprehensive CR, inclusive of the physical activity and exercise component, should be offered to priority groups irrespective of age, sex, ethnic group or other clinical conditions. These groups are:

- acute coronary syndrome (ACS)
- coronary revascularisation
- heart failure
- stable angina
- pre-/post-implantation of cardiac defibrillators and resynchronisation devices
- post-heart valve repair/replacement
- post-heart transplantation and ventricular assist devices
- adult congenital heart disease (ACHD)

The document [1] also acknowledges that there are other populations known to benefit from CR:

- atrial fibrillation
- non-obstructive coronary artery disease (NOCAD)
- peripheral arterial disease (PAD)
- SCAD

and notes that individuals at high risk of developing CVD may benefit from the comprehensive lifestyle interventions and risk factor management that CR provides.

Whilst recognising that resource limitations may prohibit CR services from widening their rehabilitation offer beyond the priority groups, the BACPR highlights that an overlap in risk factors across the cardiovascular and chronic disease spectrums ideally places CR teams to provide high quality, cost-effective interventions to those with and without established CVD [1].

Regardless of the referring cardiac diagnoses, there should be an agreed and co-ordinated local recruitment policy/protocol for the physical activity advice and the exercise component of CR [1].

Criteria:

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

1.2 The referral should include:
- Source of referral
- Designation of referrer
- Contact details of referrer
- Agreed minimum individual information:
  - demographics
  - sufficient detail of presenting condition (including results of any recent, relevant investigations and treatments)

1.3 The protocol should have clear referral criteria and include mechanisms to manage:
- Inappropriate referrals
- Individuals who are not ready to commence
- Individuals who are unable/unwilling to participate or continue with the programme
- Re-offer of and re-entry to CR

Key Message

The physical activity and exercise component, as part of comprehensive CR:

- should be offered to all priority groups irrespective of demographics or other clinical conditions
- may be accessed by a wider population with/without established CVD where resources allow
- should have an agreed and co-ordinated local recruitment policy

STANDARD 2: Initial assessment

All individuals should be assessed and advised on appropriate physical activity and exercise as early as possible within the rehabilitation process. There should be thorough screening, and an assessment prior to undertaking physical activity and exercise [10]. Assessment should be in person, wherever possible, even when a home-based programme is to be undertaken *(see Appendix B)*. However, individuals should not be disadvantaged if they cannot attend an in-person appointment. It is acknowledged that prescribing structured exercise training may not be appropriate when a face-to-face assessment has not been conducted, and an incremental approach to physical activity advice and exercise prescription may be more suitable.

Criteria:

2.1 The assessment should encompass the relevant sections identified in the CSP Quality Assurance Standards [4]

2.2 Any contraindications to exercise testing and training should be identified in line with American College of Sports Medicine (ACSM) guidelines [10]:

- **Absolute Contraindications [10]**
  - Acute myocardial infarction (MI) within two days
  - Ongoing unstable angina
  - Uncontrolled cardiac arrhythmia with haemodynamic compromise
  - Active endocarditis
  - Symptomatic severe aortic stenosis
  - Decompensated heart failure
  - Acute pulmonary embolism, pulmonary infarction, or deep venous thrombosis
  - Acute myocarditis or pericarditis
  - Acute aortic dissection
  - Physical disability that precludes safe and adequate testing
- **Relative Contraindications [10]**
  - Known obstructive left main coronary artery stenosis
  - Moderate-to-severe aortic stenosis with uncertain relationship to symptoms
  - Acquired, advanced or complete heart block
  - Recent stroke or transient ischaemic attack
  - Mental impairment with limited ability to co-operate
  - Resting hypertension with systolic blood pressure >200mmHg or diastolic >110mmHg
  - Uncorrected medical conditions (e.g. significant anaemia, electrolyte imbalance or hyperthyroidism)

In the presence of any of these relative contraindications, exercise professionals should use their clinical judgement to give individualised advice about 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 test (CPET)
- Echocardiogram (echo)/Dobutamine stress echo
- Diagnostic angiogram
- Cardiac Magnetic Resonance Imaging (MRI)/Computed Tomography (CT)
- Myoview/Thallium scan
- Intravascular Ultrasound (IVUS)/Fractional Flow Reserve (FFR)
- Biochemistry results including Troponin/Creatine Kinase (CK)/B-type Natriuretic Peptide (BNP)
- Any other medical assessment that highlights physical activity limitations

2.4 The individual's understanding of their 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 specialist and generalist primary and acute care consultations.

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/dyspnoea
- Palpitations
- Arrhythmias
- Dizziness/lightheadedness
- Orthopnoea
- Ankle swelling
- Fatigue
- Weight gain of >1.8kg in 2-3 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)
- Weight
- Oxygen saturation level (SpO_2) if concurrent lung pathology, adult congenital heart disease (ACHD) or pulmonary hypertension
- Body Mass Index (BMI)
- Waist circumference
- Blood glucose if relevant

2.10 Questionnaires used as part of the assessment process to assess physical and psychosocial health and well-being should be analysed and discussed with the individual *(Appendix C)*

2.11 Prior and current participation in physical activity should be established *(Appendix C)*

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 C)*

2.13 **S**pecific, **M**easurable, **A**chievable, **R**elevant, **T**imely goals that can be **E**valuated and **R**evised (SMARTER goals) in relation to physical activity and exercise and vocation should be agreed (e.g. returning to work, activities of daily living (ADL) or sport).

2.14 Risk stratification should be carried out using recognised criteria *(Appendix D)* to determine the level of exercise intensity prescribed and supervision required [11].

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

2.16 A functional capacity test (FCT) should be undertaken *(Appendix C).*

The choice of test should be dependent on the individual's ability, prior exercise habits, co-existing morbidities and environment/availability of equipment. The test should:

- be performed following standardised procedures
- have an established endpoint i.e. sub-maximal or symptom-limited
- start at a low enough intensity (<40% heart rate reserve [HRR])
- include a range of intensities up to 70-75% HRR / Borg Rating of Perceived Exertion [RPE] Scale® 14 / Borg 10-point Category Ratio [CR10] Scale® 4.5 (See *Appendices E* and *F)*
- allow monitoring of the exercise response using a combination of HR, RPE, BP, SpO_2 and observation

All signs and symptoms should be documented during the test, and following the test until the individual has fully recovered.

Key Message

There should be a thorough initial assessment which comprehensively encompasses all available and relevant subjective and objective information relating to the individual's physical and psychosocial health and well-being. This should include a functional capacity test.

This assessment should enable establishment of the individual's risk stratification, and should incorporate goal setting.

STANDARD 3: Informed consent

Valid consent must be obtained from the individual prior to carrying out an assessment, functional capacity 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 [4,5,12-16].

Criteria:

3.1 Consent may be 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 [17]

3.3 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.

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

Key Message

Consent must be obtained and documented, and reviewed regularly, ensuring that any changes in the individual's condition(s) and treatment plan are taken into account.

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

Health behaviour change is integral to enabling adoption of any healthy behaviour, including becoming more physically active [1].

Criteria:

4.1 Evidence-based health behaviour change theories and techniques should be used, e.g. motivation theory [18] and techniques included in the taxonomy of behaviour change techniques [19].

4.2 Communication style should promote an individual-centred approach, e.g. motivational interviewing [20]

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, e.g. mainstream exercise classes, low level exercise classes, local options of classes of suitable intensity/structure, gym programmes, home exercises, videos, 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 [21].

4.7 Goals set should be SMARTER with regular follow-up to assess progress and advise on further goal setting [22,23]. 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 (e.g. community rehabilitation teams, pulmonary rehabilitation, falls prevention services, elderly rehabilitation centres, stroke rehabilitation services, or social prescribers).

4.10 It is essential to encourage activity that is achievable. For low functioning or sedentary individuals the initial goal may be to form physically active habits or behaviour, reduce sedentary time and 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 their programme is individualised to their needs and their condition.

Key Message

In meeting the individual's needs, health and behaviour change and education are integral to all components of rehabilitation.

The goals belong to the individual; they have to be meaningful for an individual to have ownership and to want to strive to achieve them.

STANDARD 5: Safety information for physical activity

All individuals should receive safety information prior to commencing a structured exercise training programme or independent physical activity [10].

Criteria:

5.1 There should be documented evidence [4,17] that the individual has received and understood information relating to the following:

Preparation for physical activity
- Benefits and purpose of physical activity
- Suitable clothing and footwear
- Pre- and post-exercise eating and drinking
- Exercise environment, circuit and equipment where appropriate
- No smoking for ≥1 hour prior to exercise
- Ensuring essential medication is available (e.g. glyceryl trinitrate [GTN])

Pre-screening information
- When not to exercise (e.g. fever, concerning symptoms)
- Relevance of change in medication i.e. titration or ceasing medications
- Relevance of progressive symptoms despite apparent adherence with the prescribed medication
- Relevance of deteriorating exercise performance/functional capacity despite apparent adherence to the exercise programme
- Self-monitoring or additional relevant measures (e.g. blood glucose testing)

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 any relevant abnormal exercise response
- Management of chest pain and severe breathlessness
- Adaptations for co-existing morbidities

Any significant change in status may mean that exercise is contraindicated until relevant problems are resolved *(Standard 2)*.

5.2 The individual should be supported to self-monitor and self-manage, using this information, to help them become a confident and safe independent exerciser. The information may need to be reinforced as part of ongoing education.

Key Message

The individual should receive ongoing education on how to exercise safely, thereby graduating towards being a confident and safe independent exerciser.

STANDARD 6: Structured exercise programming

The following recommendations are based on providing exercise in typical UK cardiovascular rehabilitation 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 which provide details on an individual's maximal physiological values (including e.g. ECG changes) and high intensity exercise tolerance.

Exercise training should be prescribed according to the FITT (**F**requency, **I**ntensity, **T**ime and **T**ype) model [3,24,25]. The primary focus of the exercise programme should be to elicit a training effect and optimise total energy expenditure over the week [3,24,25]. The frequency, intensity and duration of exercise can be varied to suit the individual, and should be progressed as appropriate [24,26].

Although typically described as being either aerobic (cardiovascular – CV) or resistance (RT) training, the types of exercise included in programmes should comprehensively address all aspects of physical fitness (cardiovascular endurance, muscle strength and endurance, body composition and flexibility) taking into account the specific goals and capabilities of each individual [24,25]. Every exercise session should include a warm up, conditioning phase and cool down.

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 appendices. Whilst these appendices provide guidance across a range of cardiovascular conditions, as the population ages, CR participants show an increasing prevalence of a wider range of chronic conditions, and around 50-80% present with multimorbidity (two or more co-existing conditions) [27]. In this group, outcomes are often reduced [27,28]. Programmes should provide flexibility in their delivery to meet the complex needs of these individuals [28], in line with relevant condition-specific guidance documents. Collaboration with other specialist health and social care services may be required to provide the comprehensive support required.

Criteria:

6.1 Warm-up

A low intensity, graduated warm-up provides an essential transition to the conditioning component of a structured exercise session, allowing the body to adapt to the physiological, biomechanical and bioenergetic demands that accompany the onset of exercise [10]. This occurs via an increase in myocardial tissue metabolism, endothelial-induced relaxation of the smooth muscle within coronary artery walls, and to a lesser extent, an increase in sympathetic drive [29]. The resultant vasodilation may increase the individual ischaemic threshold and prevent angina at the onset of exercise [30]. Gradual increases in coronary and systemic blood flow also enable the key organs to prepare for the exercise metabolically, thermally and neurologically – optimizing capability and performance within the exercise session [31].

By increasing skeletal muscle temperature, the warm-up increases muscle metabolism, intramuscular neural conduction, muscle fibre performance and oxygen uptake kinetics [31-33]. Subsequently, there is reduced muscle and joint stiffness, and enhanced postural control, balance, muscle power and exercise tolerance [31-35]. Enabling individuals to practice the activities contained within the conditioning component allows feedback and correction to ensure safe and effective technique.

A warm up should:

- Mobilise joints and warm up all large muscle groups that will be engaged in the exercise training session
- Include pulse raising activities which are appropriate in content to the activities being performed in the conditioning phase
- Include stretching interspersed with pulse raising moves to maintain HR
- Perform a re-warm after preparatory stretching before commencing the conditioning component
- Allow for alternative intensities of aerobic work
- Increase exercise effort gradually, so that by the end of the warm up the following should have been reached:
    - HR within 20 beats per minutes (bpm) of training/target heart rate (THR)
    - RPE - BORG <11 (RPE scale) or <3 (CR10)

Whilst evidence and guidelines on warm-up duration specify that this component should last for a minimum of 10 minutes [25,35], it is widely accepted that sufficient incorporation of graduated mobilising, pulse raising and stretching activities requires a total duration of 15 minutes. For lower functioning individuals the period of warm-up should be reduced proportionally to the length of the conditioning phase (e.g. for an individual who can only manage a 10-minute conditioning component, a 5-minute warm-up will be more appropriate).

6.2 Conditioning Phase – Aerobic or Cardiovascular (CV) Training

6.2.1 Frequency

In order to improve functional capacity, exercise should be undertaken at least three times per week [3,24,25].

6.2.2 Intensity

There is a delicate balance in achieving an exercise intensity which optimises CV fitness gains, whilst being safe for, and acceptable to the individual [36]. In the absence of maximal data from a baseline cardiopulmonary exercise test, for the majority of individuals, moderate intensity aerobic exercise training within these corresponding ranges will be most suitable [25]:

- 40-70% HRR (VO_2 max) *(Appendix E)*
- 11-14 (BORG RPE scale) *(Appendix F)*
- 2-4 (CR10 scale) *(Appendix F)*

For low functioning, more sedentary or high risk individuals it will be more appropriate to start training at the lower end of these intensity targets: 40% HRR, which corresponds with RPE 11 (BORG RPE scale) and 2 (CR10) [25,26].

More active individuals or lower risk individuals should work towards the higher end of these intensity targets: 70% HRR which corresponds with RPE 14 (BORG RPE scale) and 4 (CR10) [25,26].

When an individual demonstrates improved aerobic endurance (achieving increased or desired exercise duration), intensity should be progressed, as appropriate at regular intervals, to ensure that the programme continues to induce improvements [26].

6.2.3 Time (Duration)

Whilst duration and frequency of training are interchangeable, within a structured exercise session a minimum duration of 20 minutes is recommended for the conditioning phase - which can be progressed to 60 minutes as appropriate [25].

6.2.4 Type

Aerobic training recommended to improve CV fitness involves large muscle groups, performing dynamic activities resulting in increases in heart rate and energy expenditure [3,25].

Aerobic training can be continuous or interval-based, and is often delivered via cycling, walking or circuit training exercises. Interval training is useful for those unable to sustain a continuous workload at the desired intensity. By providing a greater challenge to the cardiopulmonary, peripheral and metabolic systems, interval training can elicit a more efficient training effect [3].

While muscle strengthening exercises can be performed as a part of the active recovery phases within interval type training, when an individual progresses towards continuous aerobic training and active recovery duration subsequently reduces, consideration should be given to how to maintain and progress the muscle strengthening training dose within the session.

6.3 Conditioning Phase – Resistance Training (RT)

RT is most effective when delivered in combination with CV exercise as observed during a conventional CR exercise session [38]. It should be performed following the main warm-up and CV activities, and following a partial cool down. However, RT can also be delivered as an independent session focusing on the specific muscular requirements of the individual.

There are a multitude of ways in which RT can be delivered to develop muscular strength, power or endurance. A whole-body approach targeting the major muscle groups (aiming to work the larger muscle groups prior to the smaller muscle groups) delivered in circuit training classes can ensure muscle balance.

6.3.1 RT Assessment

For optimal design and prescription of an RT programme, determining an individual's strength using a one-repetition maximum (1RM) test for each particular muscle group is advocated [39], however although generally safe if performed without Valsalva manoevre, this test may not be tolerable in some individuals (e.g. due to musculoskeletal [MSK] pain). If not determined from assessment, a 1RM can be estimated from a higher number of repetitions (reps) up to a maximum of 10 reps, using a recognised formula [40].

Alternative methods of predicting the 1RM include the use of the Borg CR10 Scale *(Appendix F)* (a 4-5 rating after two reps providing an estimated 40-60% of 1RM) or, upon completion of one training set, use of the Repetitions in Reserve [41] scale (the less reps an individual feels they can perform during a movement, the higher they would score on the CR10).

6.3.2 Frequency

RT sessions should deliver enough stimulus to ensure that a progressive overload occurs in the targeted muscles. Following this overload, a subsequent recovery period is required, allowing for muscular adaptation. Individual differences must be considered to ensure sufficient recovery from the RT session. Recommendations suggest a minimum time period of 48 hours between bouts of RT [10]. Therefore, 2-3 RT sessions per week will allow for these recovery times to be met.

6.3.3 Intensity

Determining initial weight load to be lifted by individuals can be estimated as being 30-40% of 1RM for the upper body movements and 50-60% of 1RM for lower body movements [39].

Those new to RT should commence training at the lower ends of these ranges, whilst those with more RT experience could commence towards the higher ends.

6.3.4 Time

- *Set(s)*
  A set comprises of the number of consecutive reps performed. Depending on an individual's aims and their existing training level, RT programmes may start with 1 set, progressing up to 3 sets for each muscle group.

- *Repetitions*
  Individuals should aim to achieve 8-10 reps in each set [10]. Typically, when an individual can perform >10 reps the weight load should be increased. If the concentric and eccentric phases of the movement are performed for 3 seconds each, the working muscle group will have a total time under tension of 6 seconds per rep. If 10 reps are performed the duration of the set will be 1 minute. Consideration is required to ensure that the total volume of work performed [42] by the individual within a RT session is known (e.g. one exercise consisting of one set performed for 10 reps with a weight load of 10kg would result in a volume of 100kg).

- *Recovery*
  A minimum period of 1 minute between sets should be taken to ensure that the individual has recovered from their previous efforts. Longer periods may be required depending on individual differences, muscle group worked and/or amount of weight lifted [43].

6.3.5 Type

RT can be performed utilising bodyweight, pulley systems, portable equipment (e.g. cuffs, kettlebells, resistance bands, and ankle weights), free weights and specialised weight training machines. Specific RT approaches (i.e. supersets, giant sets, drop sets, pyramid sets) are best delivered in a traditional gym-based setting. Consideration is required to ensure that all individuals receive specific and effective RT guidance based on their distinct needs and capabilities.

6.4 Cool Down

A graduated cool down (a 'reverse of the warm up') has been found to aid faster restoration of vagal and sympathetic tone, whilst maintaining venous return and preventing blood pooling in the extremities – reducing the risk of complications such as hypotension, ischaemia and arrhythmias which can occur within the first 30 minutes after stopping an exercise session [35,44-46]. Performing a partial cool down prior to RT will reduce the likelihood of these complications during the RT component of training.

Cool down exercise should gradually return the cardiorespiratory system to near-resting levels within 10 to 15 minutes. The duration should be a minimum of 10 minutes, however as with the warm-up, for low functioning individuals the length of the cool down should be moderated to the length of the conditioning component (e.g. for the individual who can only manage a 10-minute conditioning component, a 3-minute cool down will be more appropriate).

Exercise effort should be gradually decreased relating to the individual's exercise prescription. Stretching to improve flexibility can be incorporated into the cool down. Individuals should be supervised for a minimum of 15 minutes from the end of the cool down.

6.5 Considerations for High Intensity Interval Training (HIIT)

The benefits of an exercise training programme generally increases, albeit incrementally, with its intensity [47]. HIIT is a mode of exercise training that allows individuals to tolerate higher intensities of exercise by alternating between short bouts of high and low intensity exercise. There is some disagreement on what constitutes 'high intensity' exercise, but it is often considered to be >85% peak power output or VO_2max [48].

A recent, large-scale randomised controlled trial, involving UK CR programmes, investigated effects of HIIT and moderate intensity steady-state (MISS) exercise in individuals with stable coronary heart disease (CHD) [49]. The trial found that low-volume HIIT improved cardiorespiratory fitness more than MISS training, by a clinically meaningful margin [49]. 'Low-volume HIIT' was a twice-weekly protocol (10 x 1-minute HIIT work phases @ 85-90% peak CPET workload, interspersed with 10 x 1-minute AR phases @ 20-25% peak, with progressive increases in intensity). Importantly, this trial demonstrates positive outcomes from HIIT in typical UK healthcare settings.

In accordance with these findings, systematic reviews and meta-analysis have shown that in those with stable CHD or heart failure, HIIT can improve peak aerobic fitness to a greater extent than MISS training [50,51]. Conversely, a randomised controlled trial involving those with heart failure [52] failed to show that HIIT improved peak aerobic fitness more than MISS training. However, the intensity of exercise conducted by those in the HIIT group was only ~10% higher than that performed by the moderate intensity continuous training group. Thus, the differences in intensity may not have been sufficient to lead to differential changes in aerobic fitness in the two exercise groups.

The UK HIIT or MISS trial [49] concluded that HIIT is both safe and well tolerated in those with stable CHD. Though the evidence base confirms that HIIT is safe method of exercising for those with stable CHD or heart failure [49,53], there is still a higher volume of information relating to the safety of MISS training in individuals with cardiac disease, and the safety of HIIT performed by those with other types of cardiac disease is under-reported. In clinical trials, the attrition and adherence rates of exercise training using HIIT appear to be similar to those involving MISS training [53]. Using HIIT is therefore unlikely to have a negative effect on programme completion, if it is used in populations similar to those recruited in clinical trials.

Although it is acknowledged that existing trials investigating HIIT have prescribed exercise training using data from maximal CPET, which is not routinely available for many UK CR exercise professionals; HIIT (and in particular low-volume HIIT) does appear to be emerging as a safe and effective option of exercise training for appropriately screened individuals as part of an individualised exercise prescription. As such, and in line with a number of published international guidelines, it is envisaged that UK guidelines will in future follow a similar approach, recommending the progression of appropriate individuals from moderate to higher exercise intensities, over the course of an early (core) CR programme.

6.6 Balance and Flexibility Recommendations

Although balance and flexibility decrease with increasing age, across all age groups both of these aspects of fitness can be improved [25], and it may be pertinent to include both types of work within a CR exercise session tailoring their emphasis to suit the needs of those attending.

Evidence suggests that a programme of stretching exercises increases tendon flexibility, improves joint range of motion and function, and enhances muscular performance [25,54]. Typically static stretches (slow stretch of a muscle/tendon group and holding the position) are most commonly performed within a CR exercise session, usually as part of the warm-up and cool down. Performance of stretches helps regulate warm-up and cool down intensity, and should pose no harm to any individual if taught correctly, and appropriately modified where required. Warm-up stretches also act as a useful guide to assess individuals' proprioceptive/motor control abilities and joint mobility limitations before commencing the conditioning component. When stretching, ensure that venous return is maintained.

To improve flexibility, stretches should be [25,37]:

- performed 2-3 times per week
- held for approximately 30 seconds to point of tightness or slight discomfort
- repeated 2-4 times, accumulating 60 seconds per stretch

A further benefit of flexibility exercise is enhanced postural stability and balance, particularly when combined with RT [25]. Although improving balance is not generally recognised as an overarching goal of CR, it may be an individual's goal, particularly where a balance deficit and fear of falling is limiting their ability to fully engage in any exercise session, reducing their outcomes from the programme [54]. Notably, in older adults, a few studies have demonstrated that incorporating balance work within CR elicits enhanced improvements in exercise capacity [55,56]. The 'Super Six' [57] is an example of a set of simple balance exercises which could be incorporated within an exercise session, or taught for the individual to do at home.

6.7 Considerations for Lower Functioning Individuals

Lower functioning individuals unable to sustain a workload of 3 METS (metabolic equivalents) – e.g. walking at 2mph - should be advised to incorporate short frequent bouts of physical activity into their daily routine, gradually increasing the duration and reducing the frequency of these bouts as their exercise endurance improves. Activities should be varied and functional, encompassing CV work, muscle strengthening, balance and flexibility.

6.8 Seated Exercise Considerations

Seated exercise programmes provide an opportunity to allow low functioning individuals (e.g. elderly and/or frail) to engage in regular exercise. The evidence suggests that seated exercise improves muscular strength, systolic blood pressure and heart rate response, balance and everyday living activities, whilst reducing body fat and falls risk [58,59]. Seated exercise programmes should follow the same principles as ambulatory exercise and include a warm up, conditioning phase and a cool down component.

Seated exercise can be delivered in a variety of ways:

- in separate components i.e. aerobic exercise followed by RT, or 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

Seated exercise, though potentially lowering the metabolic demand, can lead to an increase in intrathoracic pressures and activities should be performed appropriately to prevent this (e.g. with correct posture and breathing technique whilst maintaining venous return) [60]. As the individual progresses (i.e. an increase in aerobic endurance is evident) they should be moved onto a mix of supported and unsupported ambulatory exercise, which will provide greater dynamic challenges to continue to improve fitness.

6.9 General Exercise Session Considerations

Ensure that:

- correct posture is maintained throughout
- there is balance of opposing muscle groups, and use of a variety of different muscle groups throughout sessions to gain global strengthening and to allow individuals to exercise for longer
- feet are kept moving to maintain venous return [60]
- adaptations and supervision of exercise are appropriate for those with comorbidities
- music tempo and volume are appropriate to the session component
- when indicated, floor work (e.g. relaxation exercise and stretching) is done after a cool down period when the cardiovascular system has returned to near-resting state [61,62]

Avoid:

- overuse of any one muscle group
- sustained breath holding and isometric exercises [25]
- rapid changes in position (this can lead to hypotension particularly in elderly individuals and those on blood pressure lowering medications)
- exercises performed in lying during the main conditioning phase

6.10 Summary of Recommendations (FITT)

	Frequency *Days per week* *How often?*	**I**ntensity *How much exertion?* *How hard?*	**T**ime *Minutes per day?* *How long?*	**T**ype *What specific activity?* *What sort?*
CV fitness	3 times per week	Moderate BORG RPE 11-14 CR10 2-4 40-70% HRR	20-60 minutes [plus 15-minute warm up and 10-minute cool down]	Can be continuous or interval training; Large muscle groups worked rhythmically
Resistance training	2-3 times per week	Upper body: 30-40% 1RM Lower body: 50-60% 1RM	Minimum 1-3 sets of 8-10 reps	Main muscle groups
Flexibility and balance	2-3 times per week	To mild discomfort	Each stretch held for 30 seconds, performed 2-4 times	Main joint/muscle groups
De-conditioned individual unable to sustain 3 METS	Incorporate into daily routine	Moderate BORG RPE 11 CR10 2 40% HRR	5-10minute bouts (gradual increase to accumulate 30 minutes per day)	Activities to improve function, muscle strength and endurance, posture, balance and coordination *(e.g. walking, low step-ups, sit to stand, seated activities)*

Key Message

Structured exercise should:

- be tailored to the individual's goals and capabilities
- provide an effective dose of training to improve fitness
- include aerobic, muscle strengthening, and balance and flexibility exercise
- include a warm-up and cool down

STANDARD 7: Screening, monitoring and progression

Previously, the ACPICR recommended that the initiation of physical activity and exercise should be continuously monitored and evaluated. This helps to ensure safety, intervention efficacy, and that the intervention remains relevant to the individual's changing circumstances. Where possible, this is still recommended. However, the increased emphasis on providing home-based programmes to widen CR access may make continuous monitoring impractical in some individuals. Regular monitoring for those participating in home-based CR is still essential but may e.g. take the form of regular phone calls, e-mails, or video conferences. Individuals who choose to participate in home-based programme should not be disadvantaged, and should be contacted regularly. The level of monitoring should be specific to the individual's needs with the aim of progressing towards individual self-monitoring.

Criteria:

7.1 Screening

This should take place prior to each physical activity/exercise session to ensure that it is safe to participate and 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 e.g. anxiety, depression or anger

Physical activity/exercise should be adapted in light of the pre-screening findings. Individuals should be educated to self-monitor when exercising independently and should be able to contact a qualified and competent healthcare professional in the event that they are uncertain about whether to undertake the activity or abstain.

7.2 Monitoring

Exercise intensity should be monitored using a combination of:

- HR and BP response
- Rate Pressure Product (RPP)
- RPE achieved *(Appendix F)*
- Observation/discussion
- Pulse oximetry for SpO_2 levels where indicated (e.g. in ACHD)
- METs at a given HR or RPE, as linked with a given pace or speed or physiological effort required of a given daily activity [63]

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 and a post-cool down HR should be obtained, to ensure that the individual has returned to their near-resting level. In certain situations, medication or clinical status may influence the effectiveness of using HR as a monitoring tool (e.g. where there are arrhythmias, HR control medication, or following cardiac transplant).

7.2.3 BP response

Resting BP should be taken:

- Using a properly maintained, calibrated, validated device and appropriately sized cuff
- With tight clothing removed around arm to be tested and the arm supported at heart level and hand relaxed (use the same arm for consistency)
- With no talking during the measurement procedure
- In sitting and standing (those with LV dysfunction and postural hypotension)

A manual blood pressure monitor should be used in the presence of arrhythmias. 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, and the reading considered in relation to the timing of and compliance with antihypertensive medication.

Initially an exercise BP should be taken to monitor and confirm an appropriate exercise 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 [10].

7.2.4 RPE

RPE can be monitored using either the BORG RPE (6-20 scale) or CR10 scale. When educating individuals about how to rate their exertion a number of key points should be considered [64]:

Keep the chart in view at all times. Ensure the participant understands the concept of sensing the different physical responses to exercise (such as breathlessness and strain/fatigue in the muscles) prior to using the rating scale.

Anchor to known exertions (e.g. 'no exertion' is sitting still, 'maximal exertion' is the concept of pushing the body to the absolute physical limit). Consider exposing the individual to several levels of exercise intensity to demonstrate different levels on the scale. Focus on the verbal descriptors prior to linking this with a corresponding numerical value.

Encourage the individual to focus on all the different sensations elicited from the exercise being performed (i.e. breathlessness and muscular sensations) and pool to give an overall rating. If there is an over-riding sensation, differentiated ratings can be used.

Explain that there is no right or wrong rating, the rating needs to be what the individual perceives. To achieve this, avoid advising a target RPE initially and instead set exercise intensity to a level which elicits the appropriate rating. With time and ongoing use the individual will then realise the appropriate target levels (this may take up to 3 or 4 sessions) [21,65,66]. It is also important to ensure the rating is taken during exercise, rather than asking the individual to recall the rating after the exercise has ended.

When using RPE it is useful to 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.

Recent evidence suggests that when using RPE to guide exercise intensity for training adaptation, baseline cardiorespiratory fitness should also be taken into account. Exercise conducted at an intensity corresponding to the ventilatory anaerobic threshold (VAT) has been suggested as the minimum training intensity required to elicit training adaptations [67]. On average, individuals with a lower functional capacity (~5 METs) who are exercising at an RPE of 10 (range 9-12) may be working at an intensity corresponding to the VAT. This is likely to rise to 12 (range 11-13) in individuals who have a functional capacity of ~6.5 METs. Those who have a higher functional capacity (~8.5 METs) may need to exercise at an RPE of at least 14 (range 13-15) for them to be working at an intensity corresponding to the VAT [68].

7.2.5 Observation & Discussion

It is essential to observe and talk to individuals, to ensure their safety by monitoring the absence of signs and symptoms of over exertion:

- Excessive breathlessness/accessory muscle usage
- Excessive fatigue
- Chest pain (or other signs of cardiac ischaemia, e.g. jaw tightness)
- Excessive sweating
- Dizziness/Lightheadedness
- Nausea
- Poor colour (e.g. cyanosis, pallor)
- Poor quality of movement

This also allows monitoring of their adherence to the exercise prescription, 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 *(Standard 6).* The primary aim is to increase the duration and intensity of exercise. Once the recommended duration of 20 minutes 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 4.5 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, and the individual relationship between HR and RPE has been established, a gradual reduction in the use of these objective measures should be considered, and self-monitoring and management encouraged.

Key Message

The individual must be screened before each exercise session, to ensure safety.

A comprehensive approach to monitoring, encompassing a variety of subjective and objective measures, should be used.

The exercise prescription should reviewed regularly and progressed in line with this review and the individual's goals.

STANDARD 8: Home-based programmes and independent exercise

Home-based programmes are a safe and effective form of physical activity and exercise [69]. 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 [70-72]. They are as cost effective and sometimes more than, group based sessions [70,72].

Individuals should be offered a home programme as part of their rehabilitation either alongside or instead of structured group sessions. This may enhance engagement by overcoming barriers (e.g. physical, psychosocial, economic, demographic or geographic) to participation [73-75].

Criteria:

8.1 The exercise prescription should be based on a validated FCT. If unable to carry out a FCT, prescription should be based on assessment of current activity levels in conjunction with clinical evaluation or using validated tools. This could be achieved via the use of physical activity questionnaires [76,77], e.g. Duke Activity Status Index or previous levels of activity to current capacity. The reliability and validity of delivering FCTs through remote methods has yet to be established.

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 [78] BHF Active Heart, Healthy Heart [79], REACH-HF [74,75]
- Digital exercise option produced by CR team (e.g. DVD or online)
- Recreational activities (e.g. golf, dancing)

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

- Individual's choice of type of home-based programme
- Home environment including availability of equipment
- The option of completing at a convenient time of day e.g. consider work pattern/hours
- 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 as comprehensively outlined in *Standards 5* and *7.*

8.5 Individuals should be issued with:

- Exercise resources (e.g. 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, video call systems or with further home visits. The video call system should be agreed with the local information governance team.

Monitoring 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
- If required, the ability to allow family members to be part of the rehabilitation session to support in between contacts
- Exercises incorporated into their daily routine (including exercises for flexibility, balance and posture *(Standard 6)*
- 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 individual's local community.

Key Message

Home-based programmes are a safe and effective alternative to group/centre-based sessions. As home programmes are often unsupervised, it is essential that the individual receives thorough instructions and appropriate support and monitoring.

STANDARD 9: Long-term physical activity planning

Strategies to help individuals sustain physical activity and exercise in the long term should be employed [1]. After completing the early or core CR programme a final assessment should take place to empower the individual to engage and adhere to a long-term physical activity programme; the aim being that they are confident independent exercisers taking responsibility for their own health in the long-term.

Opportunities for such physical activity programmes are dependent on local provision and individual preferences (e.g. the individual may choose a supervised maintenance class or a walking group, or a new or previous recreational activity or sport).

Criteria:

9.1 Before being considered for transference to a long-term programme the individual should be clinically stable and competent to exercise independently, safely and effectively according to an individual exercise prescription [80].

They should therefore be able to:

- Identify appropriate modes of physical activity to participate in (i.e. via use of METs tables)
- Recognise and monitor their optimum level of exercise intensity (i.e. understand prescribed RPE and/or HR training zones)
- Recognise the signs and symptoms of over exertion and take appropriate action (e.g. stop/reduce activity level, take GTN)
- Self-pacing during physical activity and exercise
- Progress exercise and physical activity effectively
- Demonstrate adherence to home-based physical activities
- Identify goals for long-term physical activity and exercise programmes

9.2 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 and exercise, individuals should be provided with:

- Contact details of their early CR team and details of medical follow-up
- Advice on long-term physical activity and exercise prescription and modification
- Information on appropriate local community physical activity and exercise opportunities
- Advice on how to deal with relapse and overcoming barriers
- Advice on the importance of social support and information on local support groups (with onward referral as appropriate)

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

9.5 There should be documented evidence that advice on long-term physical activity has been given to the individual, carer and family.

9.6 When transferring an individual to long-term structured supervised exercise sessions [80,81]:

- The individual should be transferred to an appropriately qualified exercise professional with a specialist exercise instructor qualification in line with the CIMSPA
- The transfer process to the designated exercise professional should involve completing a detailed early phase transfer form [81]. This form gives information on the individual's index cardiac event, previous medical history, medication, risk factors, any pending investigations, symptoms during exercise and exercise prescription (total CV time achieved, training heart rate ranges and RPE) achieved during early CR
- It is the responsibility of the exercise professional to provide safe and suitable exercise environments (e.g. community centres, church halls, local authority leisure facilities or private health clubs). Some may also offer remote/virtual and hybrid exercises sessions.
- The exercise professional should know when to refer an individual back to the primary healthcare team or the early CR programme

9.7 A CR summary should be produced and made available to primary and acute care and community services involved in the long-term support of the individual.

Key Message

After completing the early CR programme a final assessment should take place to empower the individual to engage and adhere to a long-term physical activity programme. They should be made aware of all physical activity opportunities available to them.

There should be a detailed transfer process and clear communication to all relevant care/support providers.

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 individuals on their progress, and can encourage the maintenance of healthy behaviours. Outcomes also provide data to determine the efficacy of, and refine the content of, a programme. They can also help justify the value of services both clinically and financially.

CR outcomes should include:

- Self-reported health-related quality of life
- Clinical outcomes
- Achievement of individual-centered goals
- The individual's care experience
- The individual's level of engagement

Criteria:

10.1 Reliable and valid outcome measures should be used *(Appendix C).* Outcome measures should be:

- Clinically relevant and meaningful
- Comparable between programmes of varying sizes and resources

10.2 Programmes should work in partnership with national data systems to establish a robust audit system, measure uptake and evaluate adoption of the BACPR standards and core components [1].

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

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

Outcomes should be valid and reliable, clinically relevant and meaningful to the service and to the individual.

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 D)* which includes an FCT, thorough induction to the programme *(Standard 5)* and an appropriate exercise prescription *(Standard 6)* by competent 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

Each exercise session should be appropriately staffed with a minimum of one appropriately qualified exercise professional at all supervised exercise sessions. In early CR a minimum of one appropriately trained CR professional who meets the criteria identified by the BACPR-EPG [82] should be present at all supervised group exercise sessions. Staff supporting the delivery of the supervised exercise component should refer to the BACPR-EPG document [83] detailing core competences for the physical activity and exercise component of CR.

Staff-to-individual ratios for instruction/supervision will depend on how early in the individual's rehabilitation process the exercise is being delivered, their level of risk stratification, and the extent of any specialist help or supervision they require for co-existing physical or psychological/cognitive disabilities. The ACPICR currently recommends a minimum staff-to-individual ratio of 1:5 in the early CR programme. This can be reduced as and when individuals progress towards or are deemed as safe independent exercisers.

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 [84].

11.2 Emergency protocols

Appropriate resuscitation equipment including a defibrillator should be readily available at every supervised exercise session, irrespective of venue. There should be evidence of a locally agreed protocol for medical emergencies during an exercise session, and access to a telephone. Appropriate incident reporting systems should be used to report any clinical or adverse events which may occur and there should be a written emergency procedure clearly displayed in the exercise area. Resuscitation equipment must be maintained in accordance with local protocols.

11.3 Venue and environment

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 (e.g. the floor space required for aerobic exercise per individual is 1.8-2.3m^2 and 0.6m^2 per space per individual using exercise equipment) [85].

The temperature should be maintained between 18-23^{o}c and humidity below 65% [85]. 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 recommended environmental parameters. Drinking water should be available at all times.

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. Local infection control procedures should be followed at all times (e.g. cleaning of equipment, hand washing, disposal of sharps).

11.4 Risk of exercise-induced adverse events

The risk of exercise-induced adverse events will be minimised with incorporation of:

- Individualised assessment and prescription
- Risk stratification, pre-screening, monitoring and supervision
- Graduated warm-up of 15 minutes and cool down of 10 minutes
- Moderate to vigorous 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 co-existing morbidities
- Observation of individuals for 15 minutes post cessation of exercise

11.5 Lone working

Local policies and procedures for working alone should be followed at all times. Safe systems of work (e.g. a local tracking procedure) must be put in place and reviewed regularly to eliminate or reduce the risks associated with lone working. Staff should receive appropriate training and practical advice which enables them to recognise and reduce risk as far as reasonably practicable. Personal protective equipment such as lone worker devices, mobile phones and personal alarms may be used to ensure staff safety.

A full risk assessment should take place when visiting an individual's home. This should be completed in line with local policies and additional staff should be available if there are concerns around lone working risk.

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, concise 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 and may include paper or electronic formats (or a mixture of both), shared records, uni-professional records and records held by the individual. Local policies relating to information governance must be followed, and legal requirements adhered to, including Caldicott principles and requirements relating to General Data Protection Regulation (GDPR) [86]. Records must also satisfy the requirements set out in profession-specific codes of conduct [4,5]. Detailed guidance on record keeping is available from The Chartered Society of Physiotherapy [17] and National Health Service (NHS) Professionals [87].

Criteria:

12.1 Records must be completed as soon as possible after an event has occurred.

12.2 Written records should be legible and written in permanent black ink to enable legible photocopying or scanning of documents if required.

12.3 All entries in a record must be dated (to include date/month/year), timed accurately and signed. Amendments should be dated, timed and signed, and the original entry still clearly visible. The individual's full name must be documented on all pages, along with their date of birth, hospital number or NHS number. Every page must be numbered.

12.4 Where used, electronic recording systems should be able to show who has made the record, show any revisions or amendments, and should have a means of locking the notes.

12.5 The information contained within the record must be accurate and written in such a way that the meaning is clear. Short forms or abbreviations should only be used if there is an agreed list developed locally that is accessible to anyone entering information into or viewing the health record.

12.6 Clinical records must be stored in a secure and confidential manner, adhering to local protocols in place.

12.7 Onward referral to other services/agencies must be done in a secure and confidential manner, adhering to local policies that are in place.

Key Message

There is a professional and legal requirement to maintain accurate and up-to-date health records. Records should adhere to local and government information governance and data protection policy, and can be in the most suitable format for the clinical setting.

Appendix A – Physical activity and sedentary behaviour

The evidence supporting the health benefits of regular physical activity is compelling, demonstrating the protective effect of physical activity on a range of long-term health conditions alongside CVD, including obesity and type 2 diabetes, mental health problems and social isolation. Additionally, promoting regular physical activity can deliver cost savings for the health and care system and has wider social benefits including increased workplace productivity, and the potential for active travel to impact favourably on congestion and air pollution [2].

The 2019 update of the UK Chief Medical Officers' Physical Activity Guidelines [2] are broadly consistent with previously published guidance, but present separate guidance for different age groups, emphasising the importance of lifetime engagement in regular physical activity and a range of activities. The importance of strengthening activities for all age groups is reinforced, and the additional benefits of balance and flexibility activities for older adults are highlighted. The previous recommendation for activities to be of a minimum duration (10 minutes) to confer health benefits is no longer included, and the emerging evidence base for the health benefits of performing high intensity interval exercise is recognised.

Physical activity for adults and older adults [2]:

- ✓ **Be active**

  150 minutes moderate intensity activity per week (at least)
  OR
  75 minutes vigorous intensity activity per week (at least)
  OR
  A combination of both

- ✓ **Build strength on at least two days a week**
- ✓ **Minimise sedentary time and break up periods of inactivity**
- ✓ ***For older adults*, include activities to improve balance on two days a week (to reduce the chance of frailty and falls)**

N.B.

- For good physical and mental health, aim to be physically active every day
- Any activity is better than none, more is better still

These national guidelines aim to provide an overall public health message, rather than specialised exercise guidance for those with CVD, and therefore physical activity advice and exercise prescription for those attending a CR programme should adhere to recommendations outlined in *Standard 6*.

In supporting individuals to be more physically active in line with national and disease-specific guidelines, appropriate goal setting must consider the following: risk stratification, current functional capacity, psychosocial constraints and comorbidities.

Notably, the 2019 UK Chief Medical Officers' Physical Activity Guidelines [2] outline developments in the evidence base surrounding the risks of inactivity and increased sedentary behaviour on health. Increased sedentary time is associated with increased mortality; regular breaks in sedentary time is thought to increase overall energy expenditure, directly influencing cardio-metabolic risk factors; and for older adults there may also be an association with enhanced ability to manage activities of daily living [88]. For those attending CR, targeting sedentary behaviour can be an attractive strategy to employ for those who are high risk, very deconditioned, and/or those with limited mobility. Furthermore, even for those able to tolerate moderate to vigorous physical activity, interrupting sedentary time with light physical activity is a lifestyle change that may be easier to sustain in the long-term, and should be encouraged alongside moderate to vigorous physical activity. Wearable technology may offer useful cues and prompts to reduce sedentary time [89].

For all individuals attending CR, exercise professionals should promote increased daily physical activity and advise a reduction in sedentary behaviour, taking into account the individual's current functional status. Additionally, there should be individualised guidance and advice on daily activities, alongside a tailored activity and exercise plan, with the collective aim to increase physical fitness as well as overall daily energy expenditure [1]. The content of the exercise plan will depend on the individual's goals. Deconditioned individuals may require an adapted plan initially until they are able to perform the recommended dose of exercise for health benefits. In some circumstances, the goal may simply be to maintain the current level of activity and to reduce sedentary time.

Appendix B: Remotely-delivered cardiovascular rehabilitation

Background and definition of remotely-delivered cardiovascular rehabilitation
In 2020, the onset of national lockdowns in the UK as a result of the coronavirus (COVID-19) pandemic had a significant impact on the delivery of CR in the UK. During that time, national and international statements were published supporting the retention of CR services [76,90-93] and advocating delivery by virtual means.

Remotely-delivered CR (sometimes referred to as virtual CR) can be defined as 'home-based cardiac rehabilitation delivered by virtual mechanisms' [94] and this could include telephone, video consultation, e-mail, postal mail and smartphone applications. Reassuringly, prior to the pandemic, home-based delivery options demonstrated comparable outcomes to centre-based delivery [69] *(Standard 8).* In the post-pandemic era, continuing to offer the option of entirely remotely-delivered CR as an alternative to in-person models of CR holds promise, providing a potential viable solution to overcoming patient-reported barriers to attending in person such as inconvenient time, distance from CR centre [95] and reluctance to take part in group-based sessions, all of which can negatively impact on uptake of CR services [73,96].

It is important to note the distinction between a home-based programme of CR *(Standard 8)* for which a robust evidence base exists and where an initial FCT is performed (to direct the exercise component and for risk stratification purposes), and an entirely remotely-delivered programme of CR without initial FCT [94]. For entirely remotely-delivered CR, it is noted that empirical evidence regarding outcomes, clinical effectiveness and long-term adherence is still needed. UK guidance for delivering the physical activity and exercise component of an entirely remotely-delivered CR programme (in the context of the COVID-19 pandemic) is available [72,97], and in the absence of exercise testing increased emphasis should be placed on clinical assessment and alternative methods of obtaining functional capacity measures, such as Duke Activity Status Index [104] or self-administered 6-minute walk tests (6MWT) [94]. These recommendations are based on expert opinion and current practice.

Implementing remotely-delivered CR
Guidance exists for implementing a virtual or remotely-delivered programme of CR [94], and for CR centres with no previously established pathway for remote CR delivery, initial efforts should focus on use of existing resources, equipment and technology (e.g. telephone and paper resources including information leaflets and manuals). Once established, focus should then shift to optimising and standardising the remote pathway, ensuring national CR standards are being met, national audits are contributed to, and developing local protocols to standardise the pathway of care and optimise workflow. Following this, attention should turn towards enhancing the pathway, seeking appropriate resources and technologies to develop a robust and sustainable long-term pathway of remotely-delivered CR.

One benefit of remotely-delivered CR is that an increasing range of options exist to facilitate its delivery, including direct contact approaches such as telephone, email, or a 1:1 video consultation; group-based synchronous approaches such as a real-time group exercise sessions via video consultation or a social media discussion forum; and asynchronous approaches such as directing patients to pre-recorded material or internet-based information. The latter minimises privacy issues but should be combined with moments of interaction to increase patients' motivation [98].

An increasing number of mobile technology adjuncts are available that can be used to supplement a remotely-delivered pathway of CR, including activity trackers, smartwatches and smartphones, enabling some objective measures of physical activity to be recorded. The addition of such adjuncts to home-based CR has been demonstrated to achieve comparable effects on exercise capacity as CR without such adjuncts [99], however the additional benefit offered by the mobile technology adjuncts is unclear. In addition, higher dropout rates were noted in those using the adjuncts, suggesting a need to determine which devices are most popular with patients to optimise adherence.

Eligibility, risk stratification and exercise training

All those eligible for conventional centre-based CR could be considered for participation in remotely-delivered CR if they choose, and this should incorporate a component of exercise training [94]. This includes individuals stratified as 'high risk' for adverse exercise-induced CV events. However, for more complex individuals (e.g. with co-existing morbidities affecting balance or mobility, those with sensory impairments, and those stratified as high risk) wherever possible an FCT should be used to ensure safe and effective exercise training [94].

In the absence of exercise testing for more complex individuals, extra caution is needed with exercise prescription, and it may be more appropriate to start with advice around functional activity and reducing sedentary time, lower intensity aerobic exercise training and resistance training. Educating individuals regarding symptom recognition during exertion, and appropriate use of an RPE scale is important for all undertaking the exercise component of a remotely-delivered CR programme, and where possible, presence of a household member during exercise training is advisable to provide assistance rapidly if needed [98].

Aside from risk stratification, other factors to consider in determining eligibility criteria for an entirely remotely-delivered CR programme include access to required technology and self-motivation. Efforts should be made to ensure implementation of remote delivery does not impact on individuals' preference for CR access - whether entirely remotely-delivered, traditional centre-based, or a hybrid approach.

Those with limited access to technology, due to geography or socio-demographics, must be considered (e.g. a service could purchase equipment to provide on loan, or encourage family members to assist in use of the appropriate technology). It is also important that in implementing and developing remote delivery pathways, the quality of other CR service delivery pathways are not compromised. Appropriate staffing and resources need to be considered to be able to offer individual choice in CR engagement, all delivery methods need to be of comparable quality, and effective audit and evaluation needs to be ongoing to ensure all routes of CR delivery meet existing national CR standards.

Appendix C: Physical activity and exercise measurement tools

The following measurement tools can be used to evaluate the physical activity and exercise component of CR. Some examples of tools that can be used to evaluate other components of a comprehensive CR programme are given, but for further guidance please refer to the BACPR Standards and Core Components [1].

Functional capacity measures:

- Six-minute walk test (6MWT) [100]
- Incremental shuttle walk test (ISWT) [101]
- Chester step test (CST) [102]
- Ergometer tests including treadmill and cycle [10,66,103]
- The Duke Activity Status Index (DASI) [104]

Other functional tests:

- Short Physical Performance Battery (SPPB) – to assess lower limb function and mobility [105]
- Handgrip strength - an indicator of overall muscular strength and functional status [10]
- Sit-to-stand (STS) tests – for testing lower limb strength [106-108]
- Berg balance scale – to assess balance and falls risk [109]
- Timed up and go – to examine mobility and falls risk [110]

Physical Activity Questionnaires

- Total Activity Measure/Total Activity Measure 2 [111]
- International Physical Activity Questionnaire (IPAQ) [112]

Health and quality of life measures

- The 36-item Short-Form Health Survey (SF 36) and 12-item (SF 12) [113,114]
- EQ-5D (European Quality of Life Five Dimension) [115]
- Dartmouth COOP/WONCA Functional Health Status Charts [116]
- Minnesota Living with Heart Failure Questionnaire (MLHFQ) [117-119]
- Quality of Life after Myocardial Infarction (QLMI) questionnaire [120]
- MacNew Heart Disease Health-Related Quality of Life Questionnaire (modification of the QLMI) [121]
- Cardiovascular Limitations and Symptoms Profile (CLASP) [122]
- The Kansas City Cardiomyopathy Questionnaire (KCCQ) [123]
- Patient-Reported Outcome Measure - Cardiac Rehabilitation (PROM-CR) [124]

Appendix D: Risk stratification

Risk stratification is a multi-factorial measure used to establish prognosis of future major cardiac events and chances of survival. The AACVPR risk stratification tool uses both exercise test and non-exercise test findings in order to stratify individuals as high, moderate or low risk [11,125].

Alongside the individual's exercise capacity, other parameters including echo and ECG results are required to accurately risk stratify in most of the risk stratification protocols [126,127]. Not all of this information is always available so if information is missing, one option is to go up a risk classification to err on the side of caution.

Risk stratification can also help determine the chances of disease progression in terms of arterial, myocardial or electrophysiological function. This helps the exercise professional to identify relevant information for individual management, appropriate level of supervision and monitoring [128].

The BACPR also provides a useful criteria checklist for risk stratifying individuals with CVD prior to exercise [129].

Supervision level

In addition to cardiovascular risk, any potential difficulties that the individual may have when taking part in the exercise component of CR (e.g. impaired hearing, poor vision, poor balance, musculoskeletal/neurological problems) must be taken into consideration as this may affect the staffing required *(see Standard 11)* or the exercise prescription *(Standard 6*).

Stratification of Risk for Cardiac Events during Exercise Participation [11]:

Characteristics of those at highest risk for exercise participation (any one or combination of these findings places an individual at high risk):

Exercise testing findings:

- Presence of complex ventricular dysrhythmias during exercise testing or recovery
- Presence of angina or other significant symptoms (shortness of breath, light-headedness, or dizziness at low levels of exertion (<5 METS) or during recovery)
- High level of silent ischaemia (ST-segment depression ≥2mm from baseline) during exercise testing or recovery
- Abnormal haemodynamics with increasing workloads (i.e. chronotropic incompetence or flat/decreasing systolic blood pressure) or in recovery (i.e. severe post-exercise hypotension)
- Functional capacity ≤3 METs

Non-exercise testing findings:

- Left ventricular dysfunction with resting ejection fraction <35%
- History of cardiac arrest
- Complex dysrhythmias at rest
- Complicated MI or incomplete revascularisation procedure
- Presence of heart failure
- Presence of signs or symptoms of post-event or post-procedure ischaemia
- Presence of clinical depression
- Implanted cardiac defibrillator

Characteristics of those at moderate risk for exercise participation (any one or combination of these findings places an individual at moderate risk):

Exercise testing findings:

- Presence of stable angina or other significant symptoms (e.g., unusual dyspnoea, light-headedness, 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 <2mm from baseline)
- Functional capacity <5 METs

Non-exercise testing findings:

- Rest EF 35-49%

Characteristics of those at lowest risk for exercise participation (all characteristics listed must be present for individuals to remain at lowest risk):

Exercise testing findings:

- Absence of complex ventricular dysrhythmias during exercise testing and recovery
- Absence of angina or other significant symptoms (e.g. unusual dyspnoea, light-headedness or dizziness, during exercise testing and recovery)
- Presence of normal haemodynamics during exercise testing and recovery (i.e. appropriate heart rate and systolic blood pressure responses with increasing workloads and recovery)
- Functional capacity ≥7 METs

Non-exercise testing findings:

- Resting EF ≥50%
- Uncomplicated MI and/or revascularisation procedure
- Absence of complicated ventricular dysrhythmias at rest
- Absence of heart failure
- Absence of signs or symptoms of post-event or post-procedure ischaemia
- Absence of clinical depression

Criteria checklist for use when risk stratifying individuals with CVD prior to exercise (BACPR Risk Stratification Tool [129]):

Criteria that increase risk when exercising	Y or N If all are N: = Low risk	If any Y but NO high risk apply: = Moderate	If any ONE applies tick Y against it: = High Risk
Complicated Event:			
Heart failure	N	N	**Y**
Post event/procedure ischaemia/angina	N	N	**Y**
Reduced Left Ventricular Function:			
LVEF <35% (poor LVF; severely impaired)	N	N	**Y**
LVEF 35-49% (moderate LVF)	N	Y	N
Residual Ischaemia Symptoms:			
Angina or other significant symptoms (light-headedness and dyspnoea) at low workloads	N	**Angina at ≥7 METs**	**Angina at <5 METs**
Silent ischaemia during exercise testing or in recovery (ST segment depression)	N	**<2mm ST↓**	**≥2mm ST↓**
Serious Arrhythmias:			
History of complex ventricular arrhythmias at rest or exercise	N	N	**Y**
Implanted ICD	N	N	**Y**
History of cardiac arrest	N	N	**Y**
Other:			
Maximal Functional Capacity <7 METs	N	**<5 METS**	**<3 METS**
Clinically significant depression treated	N	N	**Y**
Risk Stratification	**Low**	**Moderate**	**High**

(LVEF, left ventricular ejection fraction; LVF, left ventricular function; ICD, implantable cardioverter defibrillator)

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

Heart rate (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, they 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.

Even in the presence of chronotropic medication (e.g. beta-blockers, ivabradine or diltiazem), HR remains an appropriate intensity marker. In this instance, estimated maximum HR is reduced by 20-30 bpm and target HR (THR) re-calculated on this basis. As long as the individual's medication is held constant, HR will remain a reliable measure from which improvement can be determined.

Determining a Target Heart Rate (THR) (adapted from [63]):

Step 1
Measure resting HR (HRrest)

Step 2
Determine a maximum HR (HRmax) from one of the following methods:

a. From maximal exercise test (rare but the only way to truly determine)
b. If over 45 years use 206 – (0.7 x age), the Inbar method [130,131] *(subtract 30 bpm if beta-blocked* [132-134])
c. Under 45 years use 220 – age; *subtract 30 bpm if beta-blocked*
d. Use of 'Ready Reckoner' Table 3 from BACPR Reference Tables [63]
e. For individuals with heart failure, use Keteyian method [135]: 119 + (0.5 x HRrest) – (0.5 x age) – (5, if using a stationary cycle test) **Further guidance for heart failure can be found in Appendix K**

Step 3
Use the Karvonen formula [136,137] to determine desired percentage of heart rate reserve (%HRR):

- %HRR = [(HRmax – HRrest) x % required] + HRrest

Tables 4a-k from the BACPR Reference Tables document [63] can also be used to simplify this process

Additional Information
Each individual should have their THR calculated based on thorough assessment *(Standard 2)* and risk stratification *(Appendix C)*. The training intensities for most individuals will range between 40-70% HRR. A significantly deconditioned individual may require lower intensities e.g. 30-50% HRR [10,11], whilst those with higher levels of fitness may require a training intensity at the upper limit of 70% HRR. Notably, there is emerging evidence to support consideration of intensities greater than 70% HRR for these individuals [67]. In the UK,

the upper intensity limit (70% HRR) is lower than that quoted in US guidelines because UK CR programmes do not typically use continuous ECG monitoring during exercise training sessions.

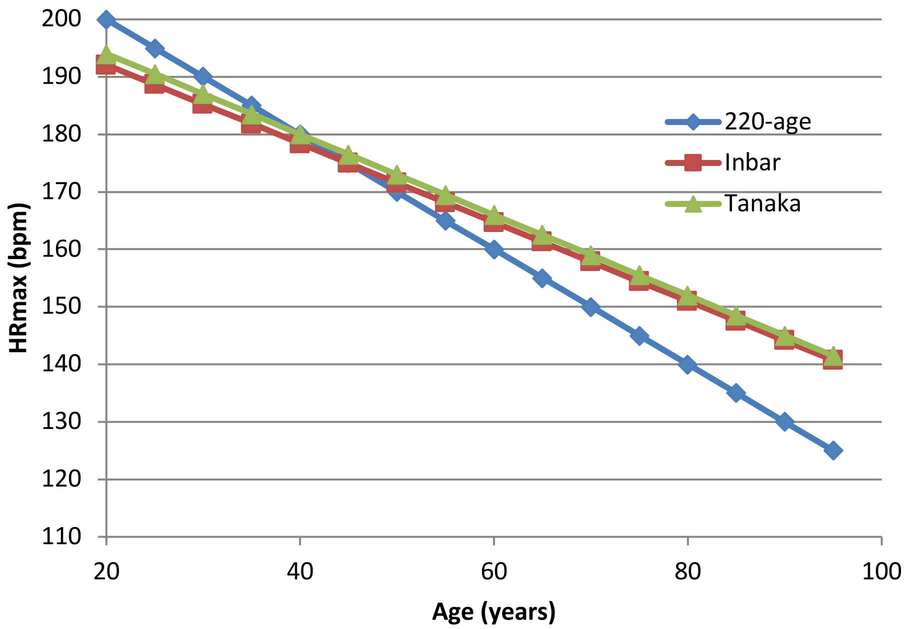
The gold standard and only way for determining an individual's true HRmax is by performing a maximal exercise test, otherwise an estimate (based on age) of HRmax may be used as described above. Even when using an estimated HRmax, HR still remains an appropriate intensity marker. However, when using such equations, it is important for exercise professionals to understand the limitations of the different equations, and the importance of good anchoring of perceived exertion scales as well as identifying how such scales correspond with the prescribed THR *(Appendix F).* When using an estimated HRmax, the following are important considerations:

- Whichever 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 [131].
- Beta-blockers can reduce HRmax by up to 30 bpm [132-134].
- Individuals with heart failure 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 [135]. This is accounted for when using the Keteyian formula.
- Although the '220-age' formula suggested above for individuals under 45 years is simple and commonly used to predict HRmax in healthy individuals of all ages, it can underestimate measured HRmax [10] and specialised equations for estimating HRmax, including the Inbar method [130] and also the Tanaka method [138] may be superior in some individuals. Comparisons between the three methods are shown in *Figures A* and *B*. These suggest that once a person is over 45 years of age, '220-age' may increasingly underestimate HRmax and could risk sub-optimal exercise training for the individual.

Figure A: Methods for Estimating HRmax [131]

Age (years)	220-age	Inbar	Tanaka	Discrepancy with 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 [131]



Note:
Inbar et al [130]: 205.8 - (0.685 x age)
Tanaka et al [138]: 208 – (0.7 x age)

Examples

The Karvonen formula [136] can be used either from a true HRmax *(examples 1 and 2)* or from an 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% HRR is equivalent to 40-70% VO_2 max.

Appendix K shows an example of calculating THR for an individual with heart failure.

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 bpm during a maximal ECG exercise test.

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

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

Example 2: training intensity 40-70% HRR, on beta-blockers
Individual X has a HRrest of 50 bpm, achieves a HRmax of 160 bpm during the maximal ECG exercise test.

a. Calculation of HRR = 160 – 50 = 110
(effect of beta-blocker accounted for because true HRmax available)
b. Selection of % of HRR:
40% of HRR = 0.4 x 110 = 44
70% of HRR = 0.7 x 110 = 77
c. Add HRrest:
44 + 50 = 94
77 + 50 = 127

THR Result: 40-70% HRR = 94 to 127 bpm

Example 3: 40-70% HRR on beta-blockers but no maximal exercise test
Individual X (aged 60 years) has a HRrest of 50 bpm.

a. Age estimated HRmax (Inbar) = 206 – (0.7 x 60) = 164 -30 (beta-blocked) = 134
b. Calculation of HRR = 134 – 50 = 84
c. Selection of % of HRR:
40% of HRR = 0.4 x 84 = 33.6
70% of HRR = 0.7 x 84 = 58.8
d. Add HRrest:
33.6 + 50 = 83.6
58.8 + 50 = 108.8

THR Result: 40 – 70% HRR = 84 - 109 bpm

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

Example 4: 30-50% HRR for very deconditioned individual on beta-blockers
Individual X (aged 75 years) has a HRrest of 50 bpm but no ECG exercise test.

a. Age estimated HRmax (Inbar) = 206 – (0.7 x 75) =153.5 –30 (beta-blocked) =123.5
b. Calculation of HRR = 123.5 – 50 = 73.5
c. Selection of % of HRR:
30% HRR = 0.3 x 73.5 = 22
50% HRR = 0.5 x 73.5 = 36.75
d. Add HRrest:
22 + 50 = 72
36.75 + 50= 86.75

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

Appendix F: Ratings of perceived exertion

BORG Rating of Perceived Exertion (RPE) Scale [65]

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's RPE Scale® Instructions [65]:

"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 okay to continue

17 'very hard' is very strenuous; a healthy person can still go on, but they really have to push themselves; 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. What other people think is not important either. Look at the scale and the expressions and then give a number. Do you have any questions?"

Borg 10-point Category Ratio (CR10) Scale [139]

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®

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' e.g. 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 (centiMax®) scale to refine the link between the verbal anchors and their congruency with a numerical scale [140,141].

Appendix G: Exercise considerations for individuals with hypertension

Background

A common CVD risk factor, hypertension (HTN) causes approximately 25% of myocardial infarctions (MIs) [142]. Regular aerobic training has been recognized as a first-line therapy in treatment and management of HTN, eliciting reductions in CVD mortality, stroke, MI and new onset diabetes mellitus [143-145].

Definitions and classification

'Office' or 'conventional' blood pressure (BP) measurement (in an office/screening setting, using a sphygmomanometer) is considered the gold standard. The defining criteria for HTN are a resting office systolic blood pressure (SBP) ≥140mmHg and/or diastolic (DBP) ≥90mmHg, confirmed by repeated measurements. These are equivalent to a 24-hr ambulatory blood pressure monitoring (ABPM) average of ≥130/80mmHg or home blood pressure monitoring (HBPM) average of ≥135/85mmHg [145-147]. *Table 1* defines the classifications of blood pressure and HTN.

Table 1: Classification of office BP, ABPM and HBPM and definitions of hypertension grade [145-147]:

Optimal	**SBP <120mmHg and DBP <80mmHg**
Normal	- SBP 120-129mmHg and/or DBP 80-84mmHg
High Normal	- SBP 130-139mmHg and/or DBP 85-89mmHg
Grade 1 HTN	- Office SBP 140-159mmHg and/or DBP 90-99mmHg - ABPM daytime average 130/80mmHg or HBPM average of ≥135/85mmHg or higher
Grade 2 HTN	- Office SBP 160-179 mmHg and/or DBP 100/109 mmHg - ABPM daytime average or HBPM average of 150/95mmHg or higher
Grade 3 Severe HTN	- Office SBP ≥180mmHg and/or DBP ≥110mmHg
Isolated Systemic HTN	- Office SBP ≥140mmHg and DBP <90mmHg

Thresholds and treatment

CVD mortality risk increases in linear fashion from BP levels as low as 90mmHg systolic and 75mmHg diastolic upwards [147] and management strategies are determined by the category of hypertension outlined in *table 1*. Lifestyle interventions are indicated for all individuals with high normal office BP to delay the need for drug treatment or complement the BP-lowering effect of drug treatment [147]. Pharmacological management is based on absolute CVD risk, risk modifiers, co-existing morbidities, estimated benefit of treatment, frailty, and individual preferences and is provided as a step-wise approach to those with upwards of grade 1 HTN to reduce the risk of CVD and/or hypertension mediated organ damage [147].

Benefits of physical activity and exercise

It has been well established that regular aerobic and strength training activities are as effective in reducing SBP as ACE inhibitor, beta-blocker and/or diuretic medication in individuals with HTN (exercise reduces SBP by 8.9mmHg versus an 8.7mmHg reduction with medication) [148]. The following provides a summary of two key statements from the ESC [143] and ACSM [149]:

- There is a dose response relationship between physical activity and incident hypertension. Notably, the physical activity dose advocated to optimally reduce BP is higher than that required for general health benefits *(Appendix A*); moderate intensity aerobic training for at least 100 minutes on most days of the week has been found to impact most positively on BP.

- Regular physical activity (aerobic, dynamic or isometric strength training) reduces resting SBP by 5-17mmHg and DBP from 2-10mmHg in those with HTN.

- The mean expected BP reduction for aerobic training ranges from 4.9-12mmHg for SBP and 3.4-5.8mmHg for DBP.

- RT is a second-line exercise therapy in those with HTN. Low-moderate intensity resistance with equal priority for isometric RT reduces resting SBP by up to 6.6mmHg and DBP by up to 5.5mmHg. Low-moderate intensity dynamic RT reduces resting SBP by up to 6.9mmHg and DBP by up to 5.1mmHg.

- A combination of aerobic and RT can be recommended to those who may derive additional metabolic adaptations from RT. However, limited evidence has shown that combined exercise is not equal or superior to aerobic training alone.

Exercise prescription for hypertension

Aerobic training:

Frequency: The frequency should be ≥ 3 days per week, preferably every day, as the positive impact of aerobic exercise on BP is short-lived (up to 12-24 hours) [10,150].

Intensity: For aerobic training this can be set at a low, moderate or vigorous level with an emphasis on moderate intensity (40-59% of HRR, Borg RPE 12-13 on 6-20 scale) [10].

Duration: The duration of aerobic training should be 20-45 minutes per session totaling 150-300 minutes per week [10]. However, in those who are unaccustomed to physical activity or have a low functional capacity, aerobic exercise can be started with several short sessions daily of, for example 5 to 10 minutes.

Type: The type of activity should be prolonged, rhythmic activities using large muscle groups for example walking, cycling, swimming, circuit interval training (e.g. knee lifts, step ups, half-jacks) etc.

Resistance training (RT)*:

Where possible, dynamic RT should be set at 60-70% 1RM initially, progressing to 80% 1RM. For older individuals and novice exercisers, begin with 40-50% 1RM [40]. The larger muscle groups should be worked using 2-4 sets of 8-12 reps [10]. The type of resistance should be resistance machines, free weights, and/or body weight.

Isometric (static) RT has recently been recommended by the ESC [143] - advocating intermittent handgrip contractions lasting 2 minutes for a total of 12-15 minutes per session at low intensity (40% of one maximal volitional contraction). Whilst these benefits of isometric RT on lowering blood pressure must be acknowledged, functional dynamic RT exercises (e.g. sit-to-stand, wall press) are likely to be more appropriate and safe in CR settings, gym and during home programmes.

*[*this is the optimal exercise prescription to impact upon primary hypertension; for those attending CR, they needs to be considered in conjunction with the recommendations outlined in Standard 6]*

Special considerations

Considerations should be given to the level of BP controlling medication, type and/or ongoing changes in medications/medication-related side effects, target organ disease and co-existing morbidities. It is important that individuals with HTN are optimised on their antihypertensive drug therapies early in the CR process. Exercise training should generally be avoided if resting SBP is ≥200mmHg and/or DBP ≥110mmHg (see *7.2.3* for further guidance). Those who are exercising beyond early/core rehabilitation should not exercise if resting SBP ≥200mmHg and/or DBP ≥100mmHg.

Many CVD secondary prevention cardiac medications have antihypertensive properties and can lead to symptoms of orthostatic (postural) hypotension. Orthostatic hypotension can be assessed by measuring the differences in the BP response between sitting and standing. An orthostatic blood pressure drop of >20mmHg with symptoms is a contraindication to exercise training [10].

Antihypertensive medications may lead to sudden excessive reductions in post exercise BP. An extended cool down of 10 minutes is recommended with careful monitoring until BP and heart rate have returned to near-resting levels [10]. The Valsalva manoevre can result in extremely high BP responses, dizziness and fainting. Therefore, such practice should be avoided during lifting and RT [10].

Key Message

There is well established evidence that aerobic training is recognised as a first-line therapy in treatment of hypertension. Moderate intensity aerobic training for at least 100 minutes on most days of the week impacts most positively on blood pressure.

Resistance training is considered a second-line therapy. Though there is evidence for isometric resistance exercise, dynamic work is likely to be more appropriate and safe in the rehabilitation setting.

Appendix H: Exercise considerations for individuals with angina

Background

Individuals with angina can become deconditioned as a result of their symptoms and misconceptions about physical activity, resulting in a reduced functional capacity (see *Standard 6* for guidance on exercise prescription for lower functioning individuals). A 2018 Cochrane Review [151] reported that CR can improve exercise capacity in those with angina. However, the strength of evidence is weaker than that for other forms of coronary artery disease and there are insufficient data to conclude that exercise-based CR can improve quality of life in those with angina. Further research is needed.

Before commencing an exercise training programme

Medications should be optimised before commencing training. It is also important to discuss with the individual:

- the importance of an extended warm-up to increase coronary blood flow, and ischaemic threshold
- their angina symptoms (these can vary widely)
- the importance of effective angina management, adherence to medication, and medication side effects.
- the importance of carrying GTN tablets or sprays at all times
- onward referral for review if symptoms suggest unstable angina

Angina during an exercise session

If an individual experiences angina during an exercise session:

- Stop exercise and ask them to sit down
- Advise them to take their GTN, and monitor them for signs of post-GTN syncope
- Recommend a second dose of GTN if angina symptoms are not relieved after 5 minutes
- Local emergency procedures (if in hospital) should be followed or an ambulance should be called if angina symptoms are not relieved within 5 minutes of receiving a second dose of GTN
- If symptoms are relieved, wait for 5 minutes following GTN and re-warm 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 [66]

Angina symptoms should be monitored in order to identify increasing frequency, severity or triggers. It may be advisable to ask the individual to keep a chest pain diary to include: triggers, nature and length of symptoms and how relieved. Should the individual's 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 rate pressure product (RPP). Once established, exercise can be prescribed below this level to gain benefits without provoking symptoms.

Angina attacks can be provoked by stress. Self-management strategies, including anxiety and stress-management, can help to reduce angina frequency, reduced dependence on GTN, and increase quality of life [152]. The Angina Plan [153] is a brief cognitive behavioural therapy intervention that can be used with individuals by appropriately trained facilitators.

Key Message

Though evidence for exercise-based rehabilitation in angina is limited, physical activity and exercise may help reverse physical deconditioning that can occur with symptom avoidance. Individuals with angina should be provided with advice to exercise safely and self-manage their symptoms.

Appendix I: Extra considerations following heart surgery

Open heart surgery
Individuals undergoing coronary artery bypass graft (CABG) or valve replacement/repair often present with physical deconditioning due to pre-operative decline in their physical activity levels due to symptoms [154]. Whilst surgery improves symptoms through improved oxygenation function of the myocardium, this will not reverse the effects of deconditioning [154,155].

Following CABG, supervised exercise-based CR has been shown to increase functional capacity and quality of life, and reduce disease-related risk factors, symptoms and hospitalisations [156,157]. The population undergoing heart surgery is ageing and comparable outcomes have been found in those 75 years or older [158]. Notably, there is little evidence for CR following valve surgery [159] and 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 [160,161]
- Persistent sternal pain, heaviness, stiffness – affecting return to ADLs, sleep pattern and mood [160,162]
- Sleep problems [160-162]
- Dyspnoea on exertion due to CV and MSK deconditioning, dysfunctional breathing related to pain, and pleural effusion post-CABG (more than 85% of individuals develop a pleural effusion although the majority resolve spontaneously) [160]
- Neck, shoulder, thoracic spine, lumbar spine discomfort [160]
- Decline in cognitive function – e.g. memory and concentration (off-pump surgery may result in less neuro-cognitive problems) [163,164]
- Anxiety/depression [160,161,163,164]
- Atrial fibrillation and atrial flutter - especially in elderly individuals [160]
- Anaemia (especially in elderly individuals)
- High resting HR and poor HR recovery (this improves with participation in exercise training as part of comprehensive CR)

Sternotomy considerations
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. Range of movement (ROM) and postural exercises should be encouraged 24 hours after surgery.

Traditional sternal precautions were intended to prevent sternal complications, and consisted of arbitrary load restrictions. These were based on anecdotal rather than direct evidence and varied widely between surgical centres. It is now thought these restrictive precautions were overly cautious and may actually impede recovery due to muscle atrophy. New evidence [165] suggests that load and time restrictions should be disregarded in lieu of focusing upon asking individuals to keep their upper arms close to their bodies (or 'keep your elbows into your sides') when lifting which then avoids excessive stress on the sternum. Individuals should resume ADLs, including those that are load-bearing, within pain-free limits as long as they keep within these recommendations.

Long-standing expert opinion and practice suggested commencing formal exercise sessions from six weeks post-surgery. However, recent evidence has found that starting exercise training from two weeks after sternotomy is as effective in improving functional capacity, and should be considered with appropriate precautions [166].

Considerations for an increasingly elderly multimorbid population

For these individuals there is likely to be reduced muscle strength, energy and stamina, plus the potential for a more prolonged sternal healing time. It is important to encourage reducing the length of sedentary episodes, performing daily home exercise and reintroducing daily habitual activity and progressing in line with their goals. Advise individuals on managing fatigue, pacing daily activity, frequent 5 minute bouts of functional exercise to build stamina *(see Standard 6)*.

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 [167]. Other interventions include percutaneous mitral valve repair for severe mitral regurgitation and percutaneous balloon mitral valvuloplasty for mitral valve stenosis.

These individuals often demonstrate a degree of frailty and an increased number of comorbidities pre procedure. Research shows that independent of pre-operative status, up to 30% present with a new or increasing decline in physical status during their hospitalisation so this cohort need tailored interventions to improve physical status post procedure. Research is in it's infancy in this cohort however studies have shown benefits with individuals commencing CR from as early as 2-3 weeks post procedure [168,169].

A systematic review has shown CR to be safe after TAVI and furthermore demonstrated improvement in functional capacity, psychological outcomes and frailty scores [167] and a reduction in mortality [169,170].

Key Message

Regardless of age or co-existing morbidities, there is a wealth of evidence supporting the benefits of rehabilitation following coronary artery bypass surgery. Though evidence is limited following valve surgical interventions, all of these individuals are likely to benefit from reversing the physically deconditioning that commonly occurs pre-operatively.

Recent research supports exercising with the upper arms close to the body to protect the sternotomy wound, and indicates that exercise training can begin earlier than the traditional six weeks.

Appendix J: Extra considerations for individuals with atrial fibrillation

The most prevalent sustained cardiac arrhythmia worldwide, atrial fibrillation (AF) 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 [171-173]. The incidence of AF is significantly lower in older adults who participate in light to moderate physical activities [174] and the ESC provides specific recommendations for those with AF regarding participation in competitive sports and leisure-time physical activity [175].

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 [176,177]. Studies examining effects of exercise training on individuals with AF report significant increases in exercise capacity and LVEF, and significantly decreased resting HR [177-181].

Risk stratification
AF often presents in conjunction with a variety of other underlying CV conditions. The exercise considerations for conditions including heart failure, CHD, diabetes, cardiomyopathy, significant valvular disease and hypertension should take priority over the concurrent AF [176,177,181]. Individuals with AF will be classified using the AACVPR stratification [11] 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 BP monitor (SBP is more difficult to determine) [146]

Age-predicted maximum HR targets are not valid. Maximum HR 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 per minute, even among subjects of a similar age [176]. HR response will be affected by the use of AV suppressant (anti-arrhythmic) medication.

Exercise prescription special considerations
There are three major factors to consider when prescribing exercise for individuals with AF:

- The inherent unreliability of the pulse rate
- Any concurrent or underlying heart disease
- Ensuring that the individual is on the appropriate medication to support rate control and prevent potential embolism

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.

Key Message

Research has found that exercise training can improve exercise capacity, ejection fraction and resting heart rate in those with atrial fibrillation. When prescribing exercise for these individuals, consider the inherent unreliability of the pulse rate and concurrent or underlying heart disease. The individual must be on the appropriate rate control and anticoagulant medication before commencing training.

Appendix K: Extra considerations for individuals with heart failure

The complex clinical syndrome of heart failure (HF) brings a variety of symptoms and signs which reflect an impairment of the heart's ability to deliver oxygenated blood to the tissues [182]. The symptoms most commonly encountered are breathlessness (exertional dyspnoea, orthopnoea and paroxysmal nocturnal dyspnoea), fatigue, and oedema [182,183]. The degree of dyspnoea can be quantified by use of the New York Heart Association (NYHA) I-IV classification system [184].

Impaired cardiac output and abnormalities in central haemodynamic function caused by HF can lead to abnormalities in skeletal muscle structure and metabolism, peripheral blood flow, vascular function, neuro-hormonal responses and pulmonary function [185]. The resultant decline in functional capacity combined with the HF symptom burden, can cause a vicious cycle of physical activity avoidance, disability and restriction to daily activities, reduced quality of life, and further decline in functional capacity with worsening symptoms [182]. With an ageing population the co-morbidity burden of HF is increasing [182].

The main terminology used to describe the severity of HF is based on measurement of left ventricular ejection fraction (LVEF) – the proportion of blood ejected from the heart during systole (normal LVEF: ~70%). Most recently, three classifications for HF have been identified: HFrEF (LVEF ≤40%), HFpEF (LVEF ≥50%) and HFmrEF (termed 'HF with mildly reduced EF; EF 41-49%) [182]. Early research suggests potential overlap of characteristics and outcomes across the EF spectrum [182]. However, clinicians should not focus upon LVEF alone when making clinical decisions; the individual's whole clinical 'picture' should be considered. This also applies to exercise training, particularly as there is little correlation between LVEF and functional capacity.

There is robust evidence confirming that exercise-based CR is both safe and effective for HF, improving exercise capacity and quality of life and reducing hospitalisation [186] in this group. These effects of exercise training appear consistent across different models of delivery (including format, mode, dose and location) [186]. For home-based training, the REACH-HF programme is a cost-effective self-management CR package which has demonstrated the same efficacy as centre-based CR [74,75].

Risk stratification and assessment

In the HF population an EF <35% and/or clinical presence of HF deems this group high risk for exercise [11]. They may also present with other criteria deeming them higher risk:

- significant symptoms at low levels of activity of < 5 METs
- abnormal haemodynamics with exercise testing

and an exercise capacity which indicates poorer prognosis [11,187]:

- peak VO_2 of <10ml/kg per minute or 3 METs
- 6MWT of <300m

For this group, the following factors specific to/common in HF [3,188] must be taken into consideration, in addition to those outlined in *Standard 2*:

Contraindications to Exercise Testing and Training:

- Acute HF (during initial period of haemodynamic instability)
- Severe hypertrophic obstructive cardiomyopathy

Contraindications to Exercise Training:

- Progressive worsening of exercise tolerance or resting dyspnoea over previous 3-5 days

Increased Risk for Exercise Training:

- >1.8kg increase in body mass over previous 1-3 days
- NYHA class IV
- Decrease in systolic blood pressure of ≥20mmHg with exercise
- Supine resting heart rate >100 bpm

Assessment for exercise must be rigorous. The increased risk associated with HF, along with its pathophysiology and variable clinical presentation, plus the presence of any co-existing morbidities, all need to be acknowledged to enable safe and appropriate exercise prescription, delivery and monitoring [1,82]. A significant change in status may mean exercise is contraindicated until resolved.

It is important to note that, in those free from contraindications, the benefits associated with being physically active and undertaking safe and appropriate exercise training outweigh the detrimental physical and psychological impact of progressively worsening physical de-conditioning, and/or inappropriate independent exercise undertaken without guidance.

Exercise prescription considerations

Warm-up and cool down

Graduated warm-up and cool down are especially important to reduce the risk of ischaemia, post-exercise hypotension or ventricular dysrhythmias. These should be moderated in length and intensity to match the main conditioning component *(Standard 6*).

Aerobic training – interval or continuous

For both continuous and interval training, the following key principles apply:

- Always start low and go slow
- Use information from baseline exercise test to ascertain suitable total exercise time (adapt FIIT principle *[Standard 6]* as appropriate) and warm-up and cool down phases
- Short, frequent periods of 5-10 minutes of total activity are more effective and better tolerated in those who are very de-conditioned (<3 METs)

Interval training provides the advantage of allowing increased focus upon stimulating the periphery whilst minimising central CV stress [188]. Additional key principles, specific to aerobic interval training are:

- Use information from baseline FCT to ascertain suitable work: active recovery ratios
- Muscle strengthening can be used within active recovery
- Exercise can be performed in sitting if required

- Consider intervals of:
    - work: active recovery (1:2 →1:1)
    - CV: muscle strengthening (1:1 → 2:1)
    - seated: standing (1:1 → 1:3)
- Intensity:
    - should be low-moderate (40-70% VO_2, Borg RPE 10-14, CR10 3-4)
    - may not reach 40% HRR initially (carefully monitor against RPE)

Although several trials have examined HIIT in HF (with work phases ≤90-95% HRmax), results have been inconsistent [189,190], and there is currently insufficient evidence to recommend this in UK clinical practice, although ESC Sports Cardiology guidelines suggest that HIIT may be recommended to prepare lower risk individuals with stable HF for return to high intensity aerobic and mixed endurance sports [3].

Calculating heart rate targets - Keteyian regression equation for HF
As outlined in *Appendix E*, Keteyian et al have provided a regression equation to account for HR being 10-20 beats lower in HF and to provide a more accurate estimation of HRmax [135]. This regression equation already assumes that individuals are on rate altering medication, and there is no need to subtract further to account for beta-blockers. There is caution that the margin of error can be up to 18 bpm with this equation:

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

An example of how this can be applied in an individual with HF:

Example: 40-50% HRR for deconditioned individual with HF
(aged 80 years; HRrest 60 bpm)

a. **Age estimated HRmax** (Keteyian [135]) =
   119 + (0.5 x 60) – (0.5 x 80) - (0, to estimate for walking) = 109 HRmax
b. **Calculation of HRR** = 109 – 60 = 49 (no need to account for beta-blockers)
c. **Selection of % of HRR**:
   40% HRR = 0.4 x 49 = 19.6   50% HRR = 0.5 x 49 = 24.5
d. **Add HRrest**:
   19.6 + 60 = 79.6   24.5 + 60 = 84.5

THR Result: 40 – 50% HRR = 80 – 85 bpm

Resistance training (RT)

When initiating RT in HF, the guidance outlined in *Standard 6 should* be modified to provide an individualised programme, progressed as follows [188]:

Step	Objectives	Reps	Intensity	Training Volume
Step 1	To learn technique	5-10	<30% 1RM (RPE <12)	1-3 sets 2-3 x week
Step 2	To improve endurance and co-ordination	12-25	30-40% 1RM (RPE 12-13)	1 set 2-3 x week
Step 3	To increase muscle mass	8-15	40-60% 1RM (RPE <15)	1 set 2-3 x week

In those who are very de-conditioned and/or symptomatic (NYHA IV), consider a resistance only training programme. In these individuals, target key functional muscle groups to improve muscle metabolism and improve aerobic capacity and quality of life [191].

Respiratory training and dyspnoea management

Inspiratory muscle training (IMT) may improve exercise capacity and quality of life, particularly in those with inspiratory muscle weakness [3]. IMT may be a useful adjunct to exercise-based rehabilitation in HF, and/or may provide an initial alternative for those who are severely de-conditioned, following these principles [188,192,193]:

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

Diaphragmatic and slowed breathing exercises (e.g. yoga breathing or device-guided) with positions of ease or recovery can be taught to aid management of dyspnoea at rest or during exertion [193]. Educate on the importance of avoiding breath holding/Valsalva during activity, and in very de-conditioned individuals, avoid excessive respiratory accessory muscle use (i.e. bilateral upper limb exercises).

Other considerations and cautions

- Energy conservation techniques as applied to typical daily activities
  - Optimise starting position and balance during activity
  - Introduce aids/equipment as required
- Consider a flexible exercise prescription to account for 'good' and 'bad' days
- Postural training and core strength
- Avoid abrupt positional changes and stooped activities (which will exacerbate postural hypotension)
- Maintain venous return during exercise by keeping legs moving, even if at a gentle pace (particularly during seated exercise)

Arrhythmogenic cardiomyopathy (ACM)
Arrhythmogenic cardiomyopathy (ACM) is an umbrella term for a group of diseases exhibiting biventricular myocardial abnormalities, including fibro-fatty infiltration and scarring, and ventricular arrhythmias [3]. Previously termed arrhythmogenic right ventricular cardiomyopathy (ARVC), there is now recognition that the pathophysiology affects both ventricles.

For those with ACM, the ESC state that participation in high-intensity sports should be discouraged, because it is associated with accelerated disease progression, greater risk of ventricular arrhythmias and major events [3]. This recommendation is also applicable to genetic carriers of pathogenic variants for ACM even in the absence of overt disease phenotype.

The guidelines further state that participation in 150 minutes of low-intensity exercise as **a maximum physical activity dose** per week should be considered for all individuals with ACM [3]. Participation in low-moderate intensity recreational exercise/sports, if desired, may be considered for some individuals with ACM, dependent upon their previous and current cardiac status, and only following rigorous assessment (including an exercise test), and discussion with a specialist cardiology team [3]. Though these individuals may not be suitable to participate in structured rehabilitation programme, they may benefit from physical activity advice.

Key Message

Regardless of ejection fraction or symptoms, and despite those with heart failure being a higher risk, exercise training has potential to increase exercise capacity and quality of life and reduce hospitalisation in this group.

Following thorough assessment, the exercise prescription should incorporate aerobic and resistance training. Additional strategies (energy conservation, flexible prescription, postural/core strength training, inspiratory muscle training) may help those who are more symptomatic and/or lower functioning. Physical activity recommendations should be more cautious in those with arrhythmogenic cardiomyopathy.

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

Implantable devices include:

- Pacemakers
- Cardiac resynchronisation therapy (CRT)
  (this may be combined with a pacemaker [CRT-P] or defibrillator [CRT-D])
- Implantable cardioverter defibrillators (ICD)
- Subcutaneous implantable cardioverter defibrillators (S-ICD)

Pacemakers and CRT pacemakers

Pacemakers are used to treat a variety of abnormal heart rhythm disturbances (e.g. resting bradycardia, blunted HR response to exercise, tachy-bradycardia 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, and reduces symptoms and improves cardiac function by restoring coordinated contraction between the ventricles. Although research has found that CRT can reduce HF mortality and hospitalisations, the device deals with cardiac rhythm and output, and the skeletal muscles still require training. Exercise training in CRT individuals can almost double their improvement in exercise capacity, as well as improve their haemodynamics and quality of life [194-196].

Exercise considerations with pacemakers

Exercise prescription should be adapted, taking into consideration the individual's underlying cardiac status (e.g. when prescribing exercise for an individual with a CRT pacemaker the HF exercise recommendations in *Appendix K* should be taken into account).

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 [195,196]:

- 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 LVEF of 35% and NYHA III or IV status.

An ICD may also be implanted for prophylaxis [196]:

- Familial conditions with high risk of sudden death (e.g. long QT syndrome, hypertrophic cardiomyopathy, Brugada syndrome)
- Surgical repair of congenital heart disease

ICDs, CRT-D or CRT-Ps are also recommended for individuals with EF <35% and the decision regarding which device is based on their NYHA classification, ECG QRS interval and presence of bundle branch block [196].

Evidence for ICD and exercise training

Exercise interventions with those with an ICD have been described as both safe and effective, although there is a lack of consensus on how this should be delivered due to a lack of research in the area [197]. There is however evidence to show a significant improvement in exercise capacity and quality of life, reduced anxiety and depression and a lower incidence of shocks in individuals undertaking exercise interventions [197-199]. Studies have shown the biggest improvement in those who completed longer programmes or attended a greater proportion of sessions with improvements in cardiorespiratory function between 14 and 40% [198,200,201].

Appropriate regular physical activity should be encouraged in individuals with an ICD, to improve parasympathetic tone and HR variability, reducing arrhythmia risk [197-201].

Factors increasing likelihood of arrhythmia during exercise [197,102]

- Reduced vagal tone, increased circulating catecholamines and myocardial demand particularly at the start and on sudden cessation of exercise
- Anxiety
- Habitual physical inactivity
- Unaccustomed vigorous physical activity
- High relative exercise intensity

Exercise can be performed safely without increasing risk of cardiac complications provided the exercise is prescribed at the correct intensity (see *Standard 6*) and the session incorporates an appropriate warm-up and cool down.

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 [11].

Assessment

Within the assessment process *(Standard 2)*, the following points should also be considered prior to prescribing exercise [199-202]:

- Evaluation of the individual's current cardiac status which may vary from structural disease with a poor LVEF, to those 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 concerns
- Knowledge of prior shock history (90% of individuals will have assigned a cause to a shock leading to avoidance behaviour; if a shock has been previously experienced on physical exertion this may be a barrier to exercise)
- Knowledge of the relationship between the ICD and exercise training thresholds (to establish this, an 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. To reduce the risk of this occurring, the exercise prescription should follow the recommended standards for structured exercise training *(Standard 6)* with the following additional considerations [197,199-201]:

Limit upper limb ROM to up to 90 degrees for the first six weeks post device implantation to ensure lead integrity.

Keep the exercise HR 10 bpm below ICD detection threshold 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.

Horizontal and seated arm exercises should be kept to a minimum. Seated arm exercise is associated with reduced venous return, reduced end-diastolic volume, a concomitant decrease in cardiac output and increased likelihood of arrhythmia. 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.

Avoid breath holding 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.

Avoid dangerous alone activities i.e. swimming, climbing ladders.

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 and any necessary medical/medication changes made, to avoid the ICD discharge becoming a psychological block on future activity

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. Recent data shows that although shocks during participation in competitive sports are not rare, there are few serious adverse events, with the majority of individuals who have received shocks returning to their sport. 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 [203-207].

The recommendations for participating in sports should be assessed on an individual basis with consideration of the following factors [203-207]:

- 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 movement, 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, particularly if working at a higher intensity/more competitive level.

Subcutaneous ICDs

Unlike a transvenous ICD, a subcutaneous ICD (S-ICD) sits entirely in the extravascular space. The device is positioned between the chest wall muscles (latissimus dorsi and serratus anterior) at the level of the left ventricular apex, and its lead passes subcutaneously across the chest wall to the sternum [196,208]. This subcutaneous location, plus the more robust design of its lead, means that the S-ICD carries a lower risk of lead damage or infection than a transvenous device [196,208].

For exercise and physical activity, a further advantage is that the S-ICD lead position does not negatively impact upon shoulder function. As with a traditional ICD, contact sports which may damage the device are not advised.

Due to its subcutaneous course the S-ICD is not able to provide long-term pacing for bradycardias, and is currently not suitable for those requiring this function [196]. Typically the device is used in younger, more active individuals, often with inherited or congenital arrhythmias [208].

Key Message

In heart failure, cardiac resynchronisation reduces symptoms, mortality and hospitalisations, however these individuals still have potential to benefit from exercise training to improve skeletal muscle function.

Implantable cardioverter defibrillators are designed to provide immediate emergency treatment rather than restricting activity due to fear of activity provoking an arrhythmia.

Return to regular physical activity improves parasympathetic tone and HR variability, thereby reducing arrhythmia risk. There is evidence that individuals who exercise with devices experience improved functional capacity, quality of life and fewer shocks.

Assessment for exercise prescription and physical activity should include establishing device parameters, and the individual's cardiac and device history.

Appendix M: Considerations for individuals with left ventricular assist devices

Background
The rapidly expanding technology in this field has now enabled those 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. Of the three, an LVAD is the most common device currently being implanted in the UK.

Evidence
Research examining CR post-LVAD implantation is limited; many trials have had small sample sizes are retrospective analyses, or have used training frequencies ≥3 times per week, limiting applicability to a UK healthcare setting [209-211]. There are no studies investigating effects of different exercise training protocols/FITT parameters [209] and, to date, research on HITT has only focused on single case studies [212].

Risk assessment
Before commencing CR, the ESC [209] suggests considering the following factors:

- Individualised assessment and prescription
- Pre-screening with risk stratification
- Prolonged graduated warm-up and cool-down
- Low-to-moderate intensity exercise training
- Avoiding breath holding and Valsalva manoeuvre.
- Avoiding any trauma risk, as ventricular assist device recipients are anticoagulated and (some, not all) treated with antiplatelet drugs
- Adaptation for co-existing morbidities
- Monitoring and supervision
- Keeping the feet moving during active recovery, if appropriate
- Observation of the individual for 15 minutes post-cessation of exercise

Hospital discharge and timeframe for commencing CR
Individuals are discharged home once they can mobilise independently, perform ADLs, climb stairs and have achieved a set level of knowledge regarding the device, enabling them to care for themselves independently. Some will require a carer 24 hours per day, depending on their underlying cardiac function. Others 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.

In research, the timeframe for commencing CR following hospital discharge varied from 1-10.3 months [211]. Many undertook a maximal exercise test before commencement (some as early as six weeks post-implantation).

Exercise testing
Functional capacity should have been assessed maximally (bike or treadmill) or sub-maximally (6MWT) before the individual commences CR [209,213]. Maximal testing may have been completed however as part of their medical follow up at their implantation centre.

Despite increasing survival, LVADs are associated with decreased exercise capacity and lower cardiac outputs at peak exercise. Despite resolution of central haemodynamics, peak VO_2 can be around 50% of age/gender matched controls [214].

Supervision and safety

Staff who will be involved in delivering CR will require basic training surrounding the device and understand the device alarms. If the individual requires a 24-hour carer, a fully trained person must be present at all times 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 should have all necessary emergency equipment to hand. This will include emergency procedure information, spare batteries, controller and battery clips, and any other equipment that may be required should any of the external components of the device fail and require replacing. Every VAD centre has 24-hour access to an on-call VAD co-ordinator for advice via telephone, or in case of emergency.

Exercise prescription

The underlying condition requiring LVAD insertion and post-operative recovery will affect functional capacity and should be considered. The usual format of warm-up, conditioning phase, cool down and resistance work is appropriate in this population [209]. A gradual reduction in intensity after CV exercise is advocated in order to avoid large haemodynamic shifts which may reduce LVAD flows causing lightheadedness/feeling faint.

With continuous flow pumps, HR and BP assessment can be challenging and variable, as the continuous nature of the pump eliminates arterial pulse. 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 CPET at the referring hospital prior to CR attendance and this can be used to prescribe exercise intensity effectively. With a continuous flow pump, the rate of the device remains constant, irrespective of activity and this – plus the individual's underlying myocardial function - may limit their ability to perform at a prescribed intensity of exercise. Subjective measures may be necessary to monitor exercise intensity and responses.

Considerations and preventing complications

Hypotension in low pump flows is common and the individual must be well educated on their normal flow values so they are able to take appropriate action when required. Ensure adequate hydration before and during the exercise session to maintain pump flows.

The position of the drive-line may affect the exercise modality that is recommended. If the drive-line is tunnelled through the abdominal wall, there will be limitations to core muscle strength exercises and trunk ROM. Specific abdominal exercises, or movements causing excessive abdominal stretch/torsion must be avoided; this includes bilateral arm exercise above the head (e.g. bilateral latissimus dorsi pull-down) due to the stresses it imposes upon the abdominal musculature. These restrictions are necessary to prevent drive-line trauma which could lead to infection.

Whole body resisted exercises should also be avoided. These include use of a cross-trainer, ski-machine, rowing machine, star-jumps or swimming/swinging motions with the arms (e.g. use of kettlebells). Fast movements (e.g. jumping or jogging) and ballistic type exercise (e.g. bouncing on a trampette) should also be avoided to reduce any micro-trauma at the drive-line site or damage to the drive-line itself. Check any problems with drive-line infection prior to every exercise session, and ensure that infection control procedures should be followed at all times during exercise.

The device may have been implanted via a sternotomy. Depending on when CR is commencing post-implantation, it may be necessary to limit arm exercises to protect the wound *(see Appendix I).* Many may already have been fitted with an ICD +/- bi-ventricular CRT *(see Appendix L)*. Neurological events due to thrombus formation and/or peripheral neuropathy are a frequently documented complication of LVAD implantation, and may influence choice of the modes of exercise prescribed.

One of the most frequent complications in 10-40% of LVAD surgery is right ventricular failure which increases both mortality and morbidity but can be treated medically or with mechanical support (BiVAD). Knowledge of the individual's right ventricular function is therefore important [215].

Contraindications/when to stop exercise [209]:

- Symptoms and signs indicating exercise intolerance (e.g. light headedness, severe intolerable dyspnoea, chest pain, tachycardia or exaggerated BP response)
- Symptomatic hypotension
- Supine resting HR >100 bpm
- SpO_2 ≤90% (readings might be difficult to obtain due to low pulsatility)
- Increase > 1.8kg in body mass over the previous 1 to 3 days
- VAD complications during or after exercise sessions:
    - Significant drop in LVAD flow, or suction alarm
    - Complex and frequent ventricular arrhythmia on exertion (may be asymptomatic)
    - Infection, mainly at the driveline site
    - Evidence of bleeding (risk increased with anti-coagulant/-platelet therapy)
    - Thrombus (evidenced by increased watts/energy required by device)
    - Request of VAD recipient to stop
    - ICD intervention (anti-tachycardia pacing and shocks)

TAHs

To date, research on total artificial hearts and exercise training has either focused on single case reports or has provided anticipated benefits only. Further research on the impact of CR upon this population is required before recommendations can be made [216].

Key Message

Though evidence for rehabilitation post-ventricular assist device implantation is limited, this population can be supported to exercise safely and effectively. Device functioning, and the individual's underlying cardiac function, post-implantation recovery and co-existing morbidities must all be considered in exercise prescription and closely monitored in every exercise session.

Appendix N: Considerations for individuals post-cardiac transplantation

Background

Cardiac transplantation is an established surgical intervention for selected individuals with severe end-stage heart failure. Although survival and quality of life outcomes continuously improve post-transplant, exercise capacity remains inferior to an age-matched healthy population [217,218]. However, if transplant recipients attend a CR programme readmission rates are substantially reduced during the first year post transplant [219].

Physiological impact of transplantation

Cardiac transplantation is associated with a mêlée of physiological alterations which may influence functional capacity. Pre-operatively these can include [220]:

- Cardiac cachexia
- Decreased exercise tolerance/frailty
- Altered cellular and biomarkers from end-stage organ dysfunction

A combined physical, psychological and nutritional therapeutic approach is often required.

Post-operative physiological changes include [217,221]:

- decreased chronotropic competence due to cardiac allograft denervation
- ventricular diastolic dysfunction
- peripheral vascular dysfunction
- pulmonary diffusion changes
- accelerated graft vascular disease
- reduced bone mineral density
- changes in skeletal muscle morphology

Long-term immunosuppressant therapy increases the risk of infection, plus risk of cancer and advanced atherosclerosis (cardiac allograft vasculopathy) [218], so CR is essential for improving functional capacity and to address their risk factors. In this population, exercise training can increase aerobic capacity, muscle mass, muscle strength and bone density [218]. Much of the training effect occurs through peripheral adaptation. 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 [222].

Implications of denervation on exercise [222,223]

- Loss of vagal tone to the sino-atrial (SA) node resulting in an increased resting HR of approximately 30%
- 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 10-15 minutes, due to the chronotropic effect of circulating catecholamines
- Significantly reduced peak HR and VO_2max

Breathlessness and fatigue are more likely due to:

- Increased CO_2 production
- Decreased O_2 delivery to peripheral working skeletal muscles
- Loss of sensation of pain in the presence of cardiac ischaemia
- Interference with salt and water retention

Effects of denervation on ceasing exercise

Slow decline in HR due to:

- No vagal brake on the SA node (thus HR alone will not reflect exercise intensity)
- Slow removal of catecholamines from the circulation (taking 10-15 minutes)
- Increased risk of hypotension on abrupt cessation of exercise (due to reduced venous return with persisting high HR)

Risk stratification

With a new donor heart in situ, heart transplant recipients may be classified as low risk via the AACVPR criteria [11] however it is always important to consider the overall clinical presentation of the individual, and the presence of all other factors which may influence their risk stratification. Furthermore, as the age limit of donors is increasing, there is an increased likelihood of donor CHD being present. As this population is unlikely to feel chest pain in the presence of ischaemia, other symptoms (e.g. increasing dyspnoea or decreasing exercise tolerance) should be monitored closely [224].

Assessment [225,226]

Ideally an ETT should have been performed using a protocol which allows a warm-up and cool down stage (to allow circulating catecholamines to become effective) and have continuous progressive increments in work rates of 1-2 METs per stage (allowing the denervated heart to adapt to the increased workload). From the ETT, CV endurance training should be set between the anaerobic threshold and 10% below. If this information is not available, % of peak HR should be used to guide training, depending on how the peak exercise capacity compared with predicted measure. Maximal effort can be assumed from the BORG RPE of 19-20 and the ventilatory threshold from a rating of 12-14. The level of energy expenditure on the ETT corresponding to where the ventilatory threshold or RPE 12-14 is achieved, can be translated into training exercise intensity/power output.

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.

There is consensus 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 dyspnea, and checking their description of these feelings against the Borg RPE scale to maintain a rating of 12-14.

Exercise prescription [217,219,221,226-230]

Although there is evidence on the benefits of CV and resistance training for heart transplant recipients there is no consensus upon training FITT parameters. There are very few studies which have investigated early CR exercise programmes for this group.

Exercise considerations [*Appendix E*, 224-229]
As resting HR is 30% higher, exercise prescription as a percentage of HR maximum *(Appendix E)* is not appropriate for these individuals. Cardiac reinnervation, resulting in some normalisation of HR is thought to occur in up to 40% of heart transplant recipients over a period or months or years.

RPE has been found to be effective to guide exercise intensity in this population, however has not been validated. If an individual has received significant doses of steroids to treat rejection episodes, there is a possibility of steroid-induced myopathy. In this instance, exercise intensity may need to be lower (RPE 11-13) initially to allow for muscle adaptations.

Careful prolonged warm-up is necessary (10-15 minutes) to allow catecholamine levels to increase HR. Accordingly, a prolonged cool down (10-15 minutes) will allow a maintenance of venous return (and prevent hypotension) as circulating catecholamines and HR decrease.

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.

Exercise cautions
The recent biopsy score should be considered. Cellular rejection is graded on a scale:

- 0 *No rejection*
- 1 *Mild rejection* – the exercise programme should be progressed slowly
- 2 *Moderate rejection* – maintain at current levels without progression
- 3 *Severe rejection* - discontinue training until the biopsy result is clear

Rejection increases the risk of arrhythmia and reduced cardiac output. Where there is rejection, high dose corticosteroids are given, and aside from myopathy, there is also increased risk of skeletal fractures on high impact exercises. The exercise programme should be tailored to reduce impact/stress on the skeletal system initially with gradual progression back to pre-rejection exercise levels.

Transplant recipients should take their temperature daily to monitor the first signs of an infection. If immunity 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 immunosuppression and infection/rejection episodes are stable. The transplant team should advise when an individual may begin swimming.

Key Message

Rehabilitation has the potential to enhance exercise capacity and reduce hospitalisation in transplant recipients. There is no consensus on training parameters and exercise prescription and monitoring must take into account the impact of denervation, rejection and immunosuppression.

Appendix O: Exercise considerations for individuals with adult congenital heart disease

Introduction

Congenital heart disease is a collective term used to describe a large number and wide spectrum of malformations of the heart and great blood vessels that are present at birth. Due to surgical, medical and technological advances in recent decades, >90% of those born with congenital heart disease now survive into adulthood. Thus, the prevalence of adult congenital heart disease (ACHD) has grown and now far exceeds the number of children with the condition [231,232].

Surgery may be curative, reparative or palliative. Whilst those who have curative surgery rarely suffer long-term sequelae, individuals undergoing reparative or palliative surgery may exhibit clinical improvement but are more likely to require ongoing, lifelong medical support [232,233]. Importantly, palliative surgery does not correct the underlying defect, and there is typically significant residual impairment [232,233].

Many types of complex congenital heart disease can now be treated by interventional cardiology methods, with enhanced medical imaging providing the precision to achieve closure of structural defects, dilatation of valve stenosis, and trans-catheter valve implantation [233,234]. Depending on the anatomy and physiology of the individual, a hybrid approach (incorporating both interventional and surgical procedures) may be indicated. Notably, an ageing population with ACHD means an increasing need for re-intervention and repeat surgery, and an increase in their associated morbidity and mortality [234,235]. In young adults with post-surgical CHD, valve incompetence and arrhythmias are common problems, but with increasing age arrhythmias and HF predominate [3,236].

The ACHD population have an increased risk of developing CV risk factors and acquired heart disease, and are more likely to be sedentary [236]. Inactivity in this group is typically linked to exercise intolerance resulting from the disease itself, safety concerns about exercise, and lack of healthy lifestyle choices [3,236-238]. Poor exercise capacity is common and VO_2 max may be half that of age-matched peers [232]. Long-term physical inactivity may have resulted in physical deconditioning, however exercise intolerance may also be related to the cardiac condition itself [237]. Altered pressures and volume loads within the cardiorespiratory vessels and myocardial chambers may affect the haemodynamic response, leading to arrhythmias and/or a poor chronotropic response to exercise.

In the past, those with ACHD were advised to restrict exercise and sport, both competitive and non-competitive, to prevent exercise-induced cardiac events and sudden cardiac death (SCD). Research confirming the safety and effectiveness of exercise in the ACHD population have rendered this advice obsolete. Though SCD accounts for up to 25% of the mortality in those with ACHD, only ~10% of SCD is estimated to be exercise-related [232].

Assessment
The heterogeneity across the anatomy, physiology and management of ACHD means that, despite growing prevalence overall, the size of the population with one particular abnormality or specific repair may be relatively small and infrequently encountered within any particular CR programme.

Regardless of the exact abnormality, ESC [239] and AHA guidelines [232] describe how ACHD can be classed as mild moderate or severe, depending on the presence and severity of various prognostic variables relating to the native anatomy, management and current physiology of the disease. Of these variables, there are five which should be ascertained in terms of both presence and severity to aid decision making around exercise and physical activity [237,239]:

- Ventricular dysfunction
- Pulmonary hypertension
- Aortopathy (specifically, aortic enlargement)
- Arrhythmia (need for/ impact of therapeutic management)
- Hypoxaemia/hypoxia/cyanosis (where there is reduced SpO_2 +/- signs of cyanosis)

ESC guidelines [239] advocate use of a flowchart [237] to guide exercise prescription, and advice on sports participation, using these parameters.

Other variables of prognostic importance, which should also be established are [232]:
- NYHA classification of symptom severity (I-IV)
- Shunt (of haemodynamically significance)
- Valve disease (mild/moderate/severe)
- End organ dysfunction (particularly renal, hepatic or pulmonary)

Exercise intolerance in this group is a strong predictor of both outcome and SCD. Use of an appropriate functional capacity test is essential for assessing both exercise capacity and the haemodynamic response to exercise. For cyanotic individuals, resting and exercise SpO_2 should be incorporated within the test [237].

Exercise guidelines
Regular moderate-intensity structured exercise is generally safe and effective for most diagnostic groups of ACHD, including those who are symptomatic [237]. The exercise can be aerobic and strength-based and dynamic exercise is generally more suitable than static exercise [232,237].

The ESC [3,239] provides in-depth recommendations for sports and exercise prescription in athletes and further information around ACHD and recreational and competitive sports and higher intensity exercise. For detailed information on exercise and physical activity recommendations for specific types of ACHD, please visit www.acpicr.com.

It is generally recommended to avoid the following [240]:

- Burst activities (sudden acceleration or deceleration over short distance), or those stimulating a sudden adrenergic response (e.g. loud noises in long QT syndrome)
- Activity in extreme adverse environmental conditions due to alterations in blood volume, electrolytes and hydration (particularly important for those with cyanosis)
- Intense static activities with Valsalva manoeuvre
- Extreme sports – hang gliding, bungee jumping (especially if on anticoagulants)

Precautions

As those with ACHD have always lived with their condition and are 'used to poor exercise tolerance' they may deny or ignore symptoms which can be potentially dangerous. They should therefore be educated to identify symptoms which indicate that exercise should be terminated (dizziness, palpitation, fatigue, excessive dyspnoea, chest pain) and not restarted until further advice is sought.

Key Message

Regular moderate-intensity structured exercise is generally safe and effective for most diagnostic groups of adult congenital heart disease, including those who are symptomatic. When assessing these individuals for exercise, consider the cardiovascular anatomy and physiology and medical and/or surgical management of the disease.

Appendix P: Considerations for individuals with left ventricular thrombus

Left ventricular (LV) thrombus formation is a recognised complication of acute MI with a relative incidence of up to 15% and associated with clinically significant systemic thromboembolic events such as cerebrovascular accidents [241]. Acute MI provides all the necessary conditions for the development of a LV thrombus, including blood stasis secondary to regional and global dysfunction, endothelial injury and a systemic hypercoagulable state (Virchow's triad), and it is primarily a complication of the anterior MI, particularly those involving the apex [242].

Formation of a LV thrombus typically occurs in the first week following MI, when the hypercoagulable state and endothelial injury are most intense. However, development can also occur later in the course of infarction where they are usually associated with adverse remodelling including LV dilatation, reduced global function, and aneurysm formation.

In recent years the incidence of LV thrombus has declined [241] possibly due to greater uptake and more prompt deployment of primary percutaneous intervention (resulting in smaller infarct sizes), greater use of neurohormonal agents attenuating adverse LV remodelling, fewer individuals transitioning from acute MI to LV dysfunction to ischaemic cardiomyopathy, and greater use of more potent antithrombotic combinations. Unfortunately, however, the incidence of systemic embolism in those with LV thrombus has remained high.

In those with a diagnosed LV thrombus, oral anticoagulation (OAC) therapy should be started immediately alongside usual post-MI dual antiplatelet therapy (DAPT). If the LV thrombus is large or highly mobile, heparin infusion with close in-hospital monitoring may be considered in select individuals. The efficacy and potential for reduced bleeding risk offered by double therapy (single antiplatelet agent plus OAC) compared with triple therapy (usual DAPT plus OAC) remains a topic of ongoing research, as is the potential use of direct oral anticoagulants (DOACs) as an alternative to vitamin K antagonists (warfarin). Vitamin K antagonists may prove difficult to manage due to their requirement for frequent monitoring, slow onset of action, narrow therapeutic range, dietary restrictions and multiple drug interactions [241].

Indeed, problems in achieving therapeutic range have been noted in this population, and those who fail to achieve a time in therapeutic range of at least 50% have a much higher rate of systemic embolism [243]. Surgical removal is an option reserved for persistent LV thrombus resistant to therapeutic anticoagulation but is rarely performed as an isolated indication for open heart surgery [242].

Exercise considerations

Evidence relating to exercise training in individuals diagnosed with a LV thrombus after acute MI is lacking. Given that time out of therapeutic INR range is associated with a higher risk of embolism in this group of patients, ensuring adequate anticoagulation and encouraging individuals to continue appropriate INR monitoring whilst attending CR is important. Individual centres and cardiologists may have specific local policies regarding this population commencing exercise, however, there is no evidence currently to support delaying an individual from starting the exercise component of CR, working at a low intensity to begin with if deemed appropriate from assessment *(Standard 2)* and risk stratification *(Appendix D).* The benefits of early access to CR and full participation in the associated exercise component far outweigh any notional increase in risk that the presence of LV thrombus may pose.

Key Message

Though evidence relating to exercise training in individuals diagnosed with a left ventricular thrombus after acute myocardial infarction is lacking, the benefits of early access to, and full participation in, exercise and rehabilitation far outweigh any increase in risk caused by the thrombus.

Ensuring adequate anticoagulation and encouraging continued appropriate monitoring whilst attending the programme is important.

Appendix Q: Considerations for individuals with abdominal aortic aneurysm

Background

An abdominal aortic aneurysm (AAA) refers to weakening and expansion of the aortic vessel wall within the abdomen to 1.5 x normal diameter or >3cm [244]. Whilst further stretch of the wall of the aorta and an increase in tension may eventually cause aneurysm rupture, prior to this life-threatening state there is often a long period of sub-clinical, frequently asymptomatic, growth in the diameter of the aneurysm.

In recent years, recognition of AAA has increased following the introduction of national screening programmes, resulting in large populations of individuals who have a small AAA, who are not candidates for surgery, but fall into the category of 'watchful waiting'. Prior to the national screening programmes that now exist, many individuals will have participated in CR exercise programmes with unknown small, asymptomatic AAA disease.

Management of AAA disease depends primarily on its size. Small (aortal diameter of 3-4.4cm) and medium (4.5-5.4cm) aneurysms are managed conservatively with regular monitoring [244]. Rupture rates increase significantly as the diameter of the aneurysm expands, and rate of growth may increase with the presence of CV risk factors. Conservative management thus includes lifestyle and medical risk factor management, incorporating management of HTN in line with NICE guidelines [244,146].

Individuals with a large aneurysm (aortal diameter ≥5.5cm) are referred for vascular surgery as the risk of the aneurysm rupturing is considered greater than the risks associated with surgical repair. Those with a symptomatic aneurysm (pulsating sensation in the abdomen, and back and/or abdominal pain) require urgent medical intervention because symptoms may be an indicator of imminent rupture. In these cases, and in particular when rupture occurs, emergency surgical repair is needed. After both emergency and elective surgery, follow-up checks and management, including both lifestyle and medical management, are important to ensure that further aneurysm growth or risk of rupture is minimised [244].

Evidence and rationale for training

UK guidelines on exercise testing and training for individuals with AAA are lacking, possibly due to AAA not being as widely recognised until recently, but also because until recently little was known about the effects of exercise training in this population.

Historically there was the recommendation that individuals with AAA should not undergo maximal exercise testing, that heart rate should not exceed 100 bpm, and that excessive rises in RPP should be avoided due to concerns about the potential for rupture [245]. However, recent research indicates that concerns about the risks of exercise training appear unfounded, demonstrating that those with small AAAs (3-5cm) are able to participate in regular moderate intensity exercise training with no adverse events and no increase in aneurysm growth rate [246,247].

Furthermore, those with AAA are typically sedentary and low functioning, with multiple (often CV) co-existing morbidities [248], and exercise training has the potential to favourably influence these plus other factors associated with AAA disease including expression of pro-inflammatory cytokines [246], and improvements in vascular function via favourable adaptations in blood flow and vessel wall shear stress in the abdominal aorta [245].

Enhanced preoperative cardiopulmonary fitness levels are associated with higher survival rates in individuals progressing to surgical aneurysm repair [246,247,249]. Those with larger aneurysms awaiting AAA repair have demonstrated improvements in exercise capacity following a period of exercise training with no adverse events, although more research is required to establish the full impact of preoperative exercise training upon post-operative outcomes [250,251].

Notably, the significant haemodynamic stress associated with surgery and general increase in tissue oxygen demand in the immediate postoperative period means that a minimum level of aerobic capacity is needed to maintain an adequate response, and so it seems a reasonable suggestion that improved aerobic fitness should reflect positively on postoperative outcomes. As such, guidelines [244] encourage modest activity in individuals with AAA.

Assessment

To assess functional capacity, sub-maximal tests such as the 6MWT can be applied safely and effectively in this population [245]. The ACSM [245] highlight that early in the course of aneurysmal disease there is usually little difference from age-matched controls with regards to HR response and exercise capacity, though a slightly higher incidence of claudication and hyper-/hypotensive BP responses may be observed.

For those with pre-surgical AAA (3-5cm), in line with ACSM guidance on relative contraindications for exercise outlined in *Standard 2* [10], the upper limit for systolic BP of 200mmHg applies. However, whilst it acknowledged that there is no data to define an 'excessive' RPP, it must be remembered that, the larger the aneurysm, the greater the likelihood of rupture. Where possible, hypertension should always be controlled, and a cautious approach to exercise is advised.

Exercise prescription and cautions [245]

Aerobic exercise is recommended, at moderate intensity (up to 50-70% HRR is safe for people with AAA). Those on beta-blocker medication should use RPE rather than HR to monitor intensity.

Moderate RT (low resistance, high repetition) is appropriate. Maximal strength training is contraindicated.

Contact sports and competitive activities should be avoided, and those with HTN or hypertensive responses to exercise must have this controlled before continuing with an exercise programme.

It is important to consider the individual's overall risk profile and quality of life. For those with large AAA, consideration of the requirement for exercise needs to be balanced against the potential risk of rupture. These individuals should have already seen a vascular surgeon and have a plan for repair. Good communication and shared decision-making between exercise professionals and the surgical team are key in this situation.

Remain aware of signs and symptoms of aneurysm rupture: severe pain, nausea, low BP, rapid HR, light headedness, confusion.

Key Message

Though evidence is limited, those with abdominal aortic aneurysm can safely undertake moderate intensity aerobic and resistance training. In those awaiting surgery, improving cardiopulmonary fitness may improve outcomes.

Those with hypertension or a hypertensive exercise response should have this controlled before participating in an exercise programme.

Appendix R: Considerations for individuals with spontaneous coronary artery dissection

Whilst the exact mechanism of spontaneous coronary artery dissection (SCAD) is not fully understood, it is known to be an acute coronary event with non-traumatic idiopathic separation of the coronary arterial wall, which compresses the vessel's true lumen (creating a false lumen) and reduces blood flow [252]. SCAD is increasingly recognised as an important cause of MI, particularly among women [252,253]. The first systematic review of recovery from SCAD [252] established there are no randomised control trials and concluded an urgent need to develop and test comprehensive CR programmes for this population. The review found that physical activity recommendations following SCAD are conservative and that there is limited evidence that CR generates improvements in fitness in this group [252].

Expert opinion would however suggest that referral to CR is important and general recommendations are that those with SCAD can return to moderate-high intensity CV exercise but should avoid very extreme competitive sport and very heavy weightlifting (especially with Valsalva) as these can lead to rapid alterations in mechanical and/or shear stress within the coronary arteries [254]. Notably, in this group there appears to be a particularly high psychological impact, suggesting need for psychosocial counseling post event, and incorporation of psychosocial support strategies as part of a comprehensive CR programme [252].

Key Message

Though evidence is limited, moderate aerobic and resistance training may improve functional capacity in those with spontaneous coronary artery dissection. The detrimental psychological impact of the condition should be considered in programme delivery.

Appendix S: Non-obstructive coronary artery disease

Non-obstructive coronary artery disease (NOCAD) is an umbrella term describing a range of conditions including endothelial dysfunction, microvascular remodelling, microvascular and epicardial spasm, vasomotor abnormalities and enhanced cardiac pain perception [255,256]. This group may also be described by the term 'INOCA' – presenting with signs and symptoms of ischaemia with no objective coronary artery disease [257].

Evidence for CR in NOCAD has been limited to interventions which are not comprehensive (i.e. consist of one or two core components only) [258,259], although a trial examining stratified medical therapy (interventional diagnostic procedure with targeted drug therapy +/- a CR intervention) showed significant improvements in symptoms of angina and quality of life in this group [257]. With further research required, these outcomes indicated that CR has the potential to benefit those with NOCAD.

There are no specific recommendations for physical activity and exercise in this population. Recent guidelines [3] do however advocate following recommendations that apply to those with angina (see *Appendix H*). Exercise and physical activity advice should take into account the suitability of the activity for the individual (with particular focus upon the CV demands of the exercise), the individual's cardiac risk stratification, and their angina threshold [3].

Key Message

There is limited evidence for rehabilitation in those with non-obstructive coronary artery disease. For physical activity and exercise, guidelines for angina should be followed - taking into account cardiovascular demands of the exercise, the individual's cardiac risk stratification, and their angina threshold.

Appendix T: Considerations for individuals with peripheral arterial disease

Peripheral arterial disease (PAD) covers a spectrum ranging from asymptomatic disease through to critical limb ischaemia, and limb loss [260] Within this spectrum, most people (at least 60-70%) have relatively stable disease (claudication) and symptoms of intermittent claudication (IC; muscular, cramp-like lower limb tightening) [261-263].

In those with haemodynamically significant PAD, a drop in peripheral vascular resistance at rest maintains an adequate calf muscle blood flow despite a reduction in arterial pressure distal to the stenosis. During exercise, the stenosis prevents the marked increase in blood flow required to meet the metabolic demands of the muscle tissue, leading to muscle ischaemia [263]. Cycles of exertional ischaemia and resting reperfusion lead to oxidative stress and inflammation, endothelial and mitochondrial dysfunction, muscle fibre type switching, apoptosis, and myofibre degeneration [263].

Those with IC present as a complex array of symptoms, physical deconditioning and functional impairment, and the decline and functional capacity in those with PAD can be up to 50% less than healthy age-matched controls [261]. As the aims of PAD management - reduction of adverse cardiovascular and limb events, and improved symptoms and quality of life - overlap with the aims of CR [1,263], attendance at a suitably adapted CR programme may help facilitate achievement of these outcomes.

Assessment considerations
To be able to provide appropriate exercise and risk factor guidance, ankle brachial pressure index (ABPI) (if available), IC symptom severity and walking exercise capacity should be established.

ABPI
ABPI is used to assess for presence of, and objectively classify severity of, PAD [264]. ABPI is determined by simultaneously measuring ankle and brachial blood pressure in the supine resting position. The ABPI is obtained by dividing the highest ankle pressure by the highest arm pressure, and is closely linked to mortality risk and the severity of IC symptoms [264]. ABPI ratios of 0.9-1.3 are normal for adults, whilst ratios of <0.9 are indicative of arterial stenosis, and ratios <0.5 are associated with critical limb ischaemia [264].

Walking capacity and symptoms
In this group, this information is typically obtained from either the 6MWT or from a treadmill test [261,263,265]. The 6MWT is used often, is functional/reflective of daily walking pace, and is predominantly used to determine maximum walking distance.

The Gardiner-Skinner treadmill protocol (with a constant speed of 3.2km/hour at a 0% grade, increasing by 2% every 2 minutes) provides standardised means of establishing:

- time to the onset of IC muscle pain
- time to walking cessation due to walking pain becoming unbearable
  (e.g. pain = 5 on Claudication Pain Scale* [261])

*(*Claudication Pain Scale: 1 = no pain; 5 = severe pain or discomfort [261])*

For those unable to sustain exercise up to an intensity of 70%HRR during a walking or stepping assessment, a non-weight-bearing alternative (cycle-/arm-/rowing-ergometry) may be preferable [266].

Exercise considerations
The following parameters are recommended in order to initiate reversal of the vascular and skeletal muscle abnormalities associated with PAD [261,267]:

Frequency:	3 x week
Intensity:	Comfortable walking speed and grade that induces moderate to moderate-to-severe exertional leg symptoms (4-5 on Claudication Pain Scale), within 5-10 minutes (individual can rest in sitting or standing until pain diminishes; repeating to accumulate 30-45 minutes as able)
Time:	30-45 minutes continuous exercise (progressed as able; can be progressed up to 60 minutes, depending on individual tolerance)
Type:	Treadmill walking

Beyond a structured training programme, continuing to exercise will maintain and further improve physical and psychosocial outcomes, however evidence for home walking programs is both conflicting and lacking. Whilst it is acknowledged that simply advising individuals to walk is ineffective [267], more evidence is required to establish the specific factors (e.g. walking prescription, level of guidance/monitoring) required to maximise home-walking outcomes in this group [261].

Considerations for CR
For those attending CR, the training parameters *(Standard 6)* can be modified in line with these PAD treadmill training recommendations, however non-weight-bearing (e.g. rowing or cycling) or upper limb activities may need to be incorporated, and an interval training approach employed, to accommodate symptoms and enable an effective training dose [266]. Cycle or rowing ergometers can be adapted to allow a progressive graded exposure of the affected leg - starting with most of the work being performed by the good leg and then gradually increasing the workload of the PAD-affected leg (e.g. using adjustable cycle cranks). When monitoring exercise intensity and responses, there should be differentiation between overall exercise effort and localised sensations of leg pain.

Regular upper limb exercises have been shown to improve walking performance in PAD, and have the potential to provide a greater CV stimulus than walking in those with severe claudication [261,266]. RT elicits only modestly improves walking distance, and therefore should not be should not be the sole training mode for this group [261].

Key Message

A structured walking programme can improve cardiovascular risk profile, symptoms and walking distance in those with peripheral arterial disease. Cardiovascular rehabilitation programmes can be modified to accommodate the needs of this group.

Appendix U: Considerations for individuals with diabetes mellitus

Background

Diabetes mellitus is generally classed as being either type 1 (T1DM; previously insulin dependent diabetes) or type 2 (T2DM; previously non-insulin dependent diabetes) – with type 2 affecting up to 90% of the UK diabetic population [268,269]. The long-term specific effects of diabetes include complications such as retinopathy, nephropathy and neuropathy [270]. Those with diabetes are also at increased risk of CV diseases obesity, cataracts, erectile dysfunction, non-alcoholic fatty liver disease and some infectious diseases (e.g. tuberculosis). There is considerable evidence to suggest that physical activity and exercise prevents disease progression in both T1DM and T2DM [269-271].

Risk stratification

Whilst the AACVPR criteria [11] does not include diabetes as a risk indicator, diabetes significantly increases cardiac event risk and is an important consideration for CR [270].

Assessment

A comprehensive pre-exercise assessment should be undertaken prior to exercise prescription. Documentation of the following is considered a basic requirement:

- Type of diabetes
- Length of time since diagnosis
- HbA1c*– if known, when/where the test was last obtained
- Diabetes medication – type and dosage
- Other medications – type and dosage and their influence on blood glucose control
- History of hypoglycaemia – frequency, severity and loss of awareness
- History of DKA (diabetic ketoacidosis) or HHS (hyperosmolar hyperglycaemic state) – how frequent and how severe?
- Diabetes review – how often and by whom?
- Capillary blood glucose (CBG) monitoring –
    - is it required pre/post and during CR?
    - does the individual have their own blood glucose testing kit?

**HbA1c provides average haemoglobin glucose level. For a minority HbA1c is not appropriate, and alternative tests are recommended and used **

Contraindications to exercise [268]

- Unstable or 'brittle' diabetes (in past 12 months, ≥4 hypo-/hyper-glycaemic episodes with no obvious cause and requiring hospital admission)
- CBG ≤ 4mmol/L
- Evidence of DKA or HHS
- Inappropriate pre-exercise CBG and NOT taking recommended fast acting carbohydrate (CHO) to prevent hypoglycaemic episode, if on insulin or insulin secretagogues
- A severe episode of hypoglycaemia in the last 24 hours: CBG ≤ 2.8mmol/l and/or help from another person was required to treat the hypoglycaemia
- Unstable proliferative retinopathy (there is risk of a vitreous haemorrhage and retinal detachment – no exercise should be undertaken during this time)

CBG monitoring [268,272]
It is important that individuals who require CBG monitoring begin to learn their own response to exercise/physical activity. This will help them identify potential issues and proactively, preventing problems occurring.

T1DM: All individuals will need to test their CBG pre/post and mid exercise session (if exercise duration is ≥30 minutes). Hypo-/hyper-glycaemia) are more likely to be an issue with those with T1DM.

T2DM: Those using insulin secretagogues (sulphonylureas and meglitinides) and/or insulin will be required to test pre/post and, if deemed necessary, mid exercise session. Increase in insulin sensitivity post exercise/physical activity can continue for as up to 72 hours. It is advisable to warn those at risk of hypoglycaemia to be more aware and monitor their CBG more closely post-exercise/physical activity.

If CBG is required an individual should be encouraged to bring and utilise their own monitor in their exercise session. It is also recommended that departments or exercise professionals working independently have access to a validated CBG monitor and are trained to use it.

Flash glucose monitors (FGM) can provide useful information on an individual's blood glucose trend, however CBG monitors are still required within CR programmes. It may be useful to use the FGM readings alongside the CBG readings to help the individual understand their blood glucose response to exercise. Further guidance on management of CBGs is provided by Turner et al [273].

Diabetic complications to consider
These diabetes-related complications may impact upon ability to safely engage in CR [268]:

Retinopathy
There are various stages of retinopathy. Physical activity/exercise that dramatically elevates BP (e.g. heavy resistance work or vigorous intensity aerobic exercise) should be avoided. Other examples may include jumping, jarring, head down activities and the Valsalva manoeuvre. No exercise should be undertaken during a vitreous haemorrhage.

Peripheral neuropathy
This may cause loss or altered sensation/ proprioception and muscle weakness in the lower and upper limbs. Balance may be compromised and weight bearing activities on unhealed ulcers should be avoided. Hand grip strength should be checked if performing upper body resistance work.

Autonomic neuropathy
This can have a CV impact (e.g. silent myocardial ischaemia, resting tachycardia, and orthostatic hypotension) or can cause hypoglycaemic unawareness, gastroparesis, constipation, diarrhoea, neurogenic bladder, sudomotor dysfunction and altered thermoregulation. In those with autonomic neuropathy, RPE should be used to monitor exercise intensity where objective measures are unreliable. During exercise, the individual should be monitored for signs and symptoms of silent ischemia (unusual dyspnoea).

Nephropathy
Fatigue and dehydration need to be managed. Exercise programmes should be started slowly as muscle function can be substantially reduced.

Musculoskeletal issues
Diabetes carries an increased incidence of shoulder adhesive capsulitis, carpal tunnel, Dupuytren's contracture and neuropathy related joint disorders. Adaptations to physical activity and exercise programmes may be required.

Medication considerations
SGLT2i medication (sodium glucose co-transporter 2 inhibitors, also known as 'gliflozins') have the potential to adversely cause ketosis in normoglycaemic states and have been linked to incidences of Fournier's Gangrene.

Common secondary prevention medications can also have a significant influence on blood glucose levels in individuals with diabetes. These medications include ACE inhibitors, aspirin, thiazides and statins [268]. Notably, non-vasodilating beta-blocker medication can reduce hypoglycaemic awareness [268].

Exercise prescription considerations
A combination of moderate resistance and aerobic training (in that order) within an exercise session appears to be most likely to prevent acute and latent hypoglycaemia [268,272]. Though evidence is more limited, HITT might be considered an alternative to moderate intensity training to further enhance exercise capacity and glycaemic control [270,274]. Most individuals with diabetes should be able to undertake the traditional exercise component of CR [268].

As diabetes elicits a slower response to either initiation of, or a change in intensity of exercise or physical activity a more graduated warm-up and cool down and change in exercise intensity is required. It is important to also consider that this slower response can be magnified again by the use of beta-blocker medication [268].

Individuals who use insulin or insulin secretagogues should know how to adjust their dosages to account for the impact of exercise. If they do not have this knowledge or confidence the individual should seek appropriate advice from their diabetes multidisciplinary team.

Ultimately, the main aim is to manage dosages appropriately, reduce the need for fast CHO loading pre-/during/post- exercise and to avoid hypo-/hyper-glycaemic episodes. For many individuals it can take a few sessions before they learn their own exercise response and reassurance and support with this should be provided. Those using insulin should avoid injecting over the large muscle groups prior to exercise as the increase in blood flow to these areas during exercise has the potential to increase the risk of hypoglycaemia.

Care should be taken to avoid hypo-/hyper-glycaemic episodes where possible. Individuals should be encouraged to manage their own condition and learn their own exercise response. Clinicians should be able to recognise the signs and symptoms and know how to take prompt action to manage any incident safely and promptly.

Exercising in the morning has been shown to reduce the risk of post exercise hypoglycaemia, whilst afternoon and evening exercise has been shown to be more helpful in reducing hyperglycaemia [268].

For those with T1DM, taking part in resistance training prior to aerobic training may lower the risk of hypoglycaemia [10]. In those with T2DM, aerobic exercise should not elapse for more than two consecutive days in order to prevent a period of excessive decline of insulin action [10].

Dehydration can lead to hyperglycaemia – for those on a fluid restriction this needs to be managed carefully. Acute illnesses or infections commonly cause hyperglycaemia. Often a raise in blood glucose is noted before the individual feels symptomatically unwell.

Key Message

There is considerable evidence to suggest that exercise training prevents disease progression in diabetes, and most individuals with diabetes should be able to undertake the traditional exercise component of rehabilitation.

To ensure safe and effective exercise prescription which maintains stable blood glucose levels, the wider impact of the condition and its pharmacological management upon the individual must be considered and monitored, and self-monitoring encouraged and supported.

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Abbreviations

AAA	abdominal aortic aneurysm
AACVPR	American Association of Cardiovascular and Pulmonary Rehabilitation
ABPI	ankle brachial pressure index
ABPM	ambulatory blood pressure monitoring
ACHD	adult congenital heart disease
ACM	arrhythmogenic cardiomyopathy
ACPICR	Association of Chartered Physiotherapists in Cardiovascular Rehabilitation
ACS	acute coronary syndrome
ACSM	American College of Sports Medicine
ADL	activities of daily living
AF	atrial fibrillation
AHA	American Heart Association
ALS	advanced life support
AR	active recovery
ARVC	arrhythmogenic right ventricular cardiomyopathy
AV	atrioventricular [node]
BACPR	British Association for Cardiovascular Prevention and Rehabilitation
BASES	British Association of Sports and Exercise Sciences
BHF	British Heart Foundation
BiVAD	bi-ventricular assist device
BLS	basic life support
BMI	body mass index
BNP	b-type natriuetic peptide
BP	blood pressure
bpm	beats per minute
CABG	coronary artery bypass graft surgery
CBG	capillary blood gas
CEP-UK	Clinical Exercise Physiology UK
CHD	coronary heart disease
CHO	carbohydrate
CIMSPA	Chartered Institute for the Management of Sport and Physical Activity
CK	creatine kinase
CLASP	Cardiovascular Limitations and Symptoms Profile
cm	centimetre
CO_2	carbon dioxide
CPET	cardiopulmonary exercise test
CR	cardiovascular rehabilitation
CR10	10-point Category Ratio Scale
CR100	Borg centiMax® Scale
CRT(-D/-P)	cardiac resynchronisation (defibrillator/pacemaker) therapy
CSP	Chartered Society of Physiotherapy
CST	Chester Step Test
CT	computed tomography
CV	cardiovascular
CVD	cardiovascular disease
DAPT	dual anti-platelet therapy

DASI	Duke Activity Status Index
DBP	diastolic blood pressure
DKA	diabetic ketoacidosis
ECG	electrocardiogram
Echo	echocardiogram
EF	ejection fraction
EPG	Exercise Professionals Group [of the BACPR]
EQ-5D	European Quality of Life Five Dimension Questionnaire
ESC	European Society of Cardiology
ETT	exercise tolerance test
FCT	functional capacity test
FITT	frequency, intensity, time and type
FFR	fractional flow rate
FGM	flash glucose monitor
GDPR	General Data Protection Regulation
GTN	glyceryl trinitrate
HbA1c	haemoglobin blood glucose
HBPM	home blood pressure monitoring
HCPC	Health Care Professionals Council
HF	heart failure
HFmrEF	heart failure with mildly reduced ejection fraction
HFpEF	heart failure with preserved ejection fraction
HFrEF	heart failure with reduced ejection fraction
HHS	hyperosmolar hyperglycaemic state
HIIT	high-intensity interval training
HR	heart rate
HRmax	maximum heart rate
HRR	heart rate reserve
HRrest	resting heart rate
HTN	hypertension
IC	intermittent claudication
ICD	implantable cardioverter defibrillator
INOCA	ischaemia with no objective coronary artery disease
INR	international normalised ratio - prothrombin time
IPAQ	International Physical Activity Questionnaire
ISWT	Incremental Shuttle Walk Test
IVUS	intravascular ultrasound
KCCQ	Kansas City Cardiomyopathy Questionnaire
kg	kilogram
LV	left ventricular
LVAD	left ventricular assist device
LVF	left ventricular function
LVEF	left ventricular ejection fraction
MET	metabolic equivalent
MI	myocardial infarction
MISS	moderate intensity steady-state [training]
MLHFQ	Minnesota Living with Heart Failure Questionnaire

mmHg	millimetres of mercury
MRI	magnetic resonance imaging
MSK	musculoskeletal
NHS	National Health Service
NICE	National Institute for Health and Care Excellence
NOCAD	non-obstructive coronary artery disease
NYHA	New York Heart Association [classification of symptoms]
OAC (D-)	oral anti-coagulation [direct oral anti-coagulation]
O_2	oxygen
PAD	peripheral arterial disease
PND	paroxysmal nocturnal dyspnoea
PROM-CR	Patient-Reported Outcome Measure - Cardiovascular Rehabilitation
QLMI	Quality of Life after Myocardial Infarction questionnaire
QRS	QRS interval [of ECG]
QT	QT segment [of ECG]
REACH	Rehabilitation Enablement in Chronic Heart Failure
reps	repetitions
ROM	range of movement
RPE	rating of perceived exertion
RPP	rate pressure product
RT	resistance training
SA	sino-atrial [node]
SBP	systolic blood pressure
SCD	sudden cardiac death
SCAD	spontaneous coronary artery dissection
SF 36	Short Form-36 questionnaire
SF 12	Short Form-12 questionnaire
SGLT2i	sodium-glucose cotransporter-2 inhibitors
S-ICD	subcuataneous implantable cardioverter defibrillator
SMARTER	specific, measurable, achievable, relevant, timely, evaluated, revised [goals]
SpO_2	oxygen saturation level
SPPB	Short Physical Performance Battery
ST	ST-segment [of ECG]
STS	sit-to-stand
TAH	total artificial heart
TAVI	transcatheter aortic valve implantation
THR	training/target heart rate
T1/T2 DM	type 1/type 2 diabetes mellitus
UK	United Kingdom
VAD	ventricular assist device
VAT	ventilatory anaerobic threshold
VF/T	ventricular fibrillation/tachycardia
VO_2max	maximum rate of oxygen consumption
1RM	1 repetition maximum
6MWT	Six-minute Walking Test
24hr	24 hour

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Standard 1: Recruitment and referral

The physical activity and exercise component, as part of comprehensive CR:

- should be offered to all priority groups irrespective of demographics or other clinical conditions
- may be accessed by a wider population with/without established CVD where resources allow
- should have an agreed and co-ordinated local recruitment policy

Standard 2: Initial assessment

There should be a thorough initial assessment which comprehensively encompasses all available and relevant subjective and objective information relating to the individual's physical and psychosocial health and well-being. This should include a functional capacity test. This assessment should enable establishment of the individual's risk stratification, and should incorporate goal setting.

Standard 3: Informed consent

Consent must be obtained and documented, and reviewed regularly, ensuring that any changes in the individual's condition(s) and treatment plan are taken into account.

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

In meeting the individual's needs, health and behaviour change and education are integral to all components of rehabilitation. The goals belong to the individual; they have to be meaningful for an individual to have ownership and to want to strive to achieve them.

Standard 5: Safety information for physical activity

The individual should receive ongoing education on how to exercise safely, graduating towards being a confident and safe independent exerciser.

Standard 6: Structured exercise programming

Structured exercise should:

- be tailored to the individual's goals and capabilities
- provide an effective dose of training to improve fitness
- include aerobic, muscle strengthening, and balance and flexibility exercise
- include a warm-up and cool down

Standard 7: Screening, monitoring and progression

The individual must be screened before each exercise session, to ensure safety. A comprehensive approach to monitoring, encompassing a variety of subjective and objective measures, should be used. The exercise prescription should reviewed regularly and progressed in line with this review and the individual's goals.

Standard 8: Home-based programmes and independent exercise

Home-based programmes are a safe and effective alternative to group/centre-based sessions. As home programmes are often unsupervised, it is essential that the individual receives thorough instructions and appropriate support and monitoring.

Standard 9: Long-term physical activity planning

After completing the early rehabilitation programme a final assessment should take place to empower the individual to engage and adhere to a long-term physical activity programme. They should be made aware of all physical activity opportunities available to them. There should be a detailed transfer process and clear communication to all relevant care/support providers.

Standard 10: Outcome measures

Consistent measuring of outcomes is an essential component in the evaluation of the effectiveness of rehabilitation and is vital for quality improvement. Outcomes should be valid and reliable, clinically relevant and meaningful to the service and to the individual.

Standard 11: Health and safety

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

There is a professional and legal requirement to maintain accurate and up-to-date health records. These records should adhere to local and government policy on information governance, and can be in the format that best suits the clinical setting.