European Heart Journal (2010) **31**, 1967–1976
doi:10.1093/eurheartj/ehq236

POSITION PAPER

Secondary prevention through cardiac rehabilitation: physical activity counselling and exercise training

Key components of the position paper from the Cardiac Rehabilitation Section of the European Association of Cardiovascular Prevention and Rehabilitation

EACPR Committee for Science Guidelines: Ugo Corrà (Chairperson), Massimo F. Piepoli, François Carré; Peter Heuschmann; Uwe Hoffmann; Monique Verschuren; Julian Halcox
Document Reviewers: Pantaleo Giannuzzi, Hugo Saner, David Wood

Massimo F. Piepoli*, Ugo Corrà, Werner Benzer, Birna Bjarnason-Wehrens, Paul Dendale, Dan Gaita, Hannah McGee, Miguel Mendes, Josef Niebauer, Ann-Dorthe Olsen Zwisler, and Jean-Paul Schmid

Heart Failure Unit, Cardiac Department, Guglielmo da Saliceto Polichirurgico Hospital, Piacenza 29100, Italy

Received 28 July 2009; revised 20 June 2010; accepted 24 June 2010

Cardiac patients after an acute event and/or with chronic heart disease deserve special attention to restore their quality of life and to maintain or improve functional capacity. They require counselling to avoid recurrence through a combination of adherence to a medication plan and adoption of a healthy lifestyle. These secondary prevention targets are included in the overall goal of cardiac rehabilitation (CR). Cardiac rehabilitation can be viewed as the clinical application of preventive care by means of a professional multi-disciplinary integrated approach for comprehensive risk reduction and global long-term care of cardiac patients. The CR approach is delivered in tandem with a flexible follow-up strategy and easy access to a specialized team. To promote implementation of cardiac prevention and rehabilitation, the CR Section of the EACPR (European Association of Cardiovascular Prevention and Rehabilitation) has recently completed a Position Paper, entitled 'Secondary prevention through cardiac rehabilitation: A condition-oriented approach'. Components of multidisciplinary CR for seven clinical presentations have been addressed. Components include patient assessment, physical activity counselling, exercise training, diet/nutritional counselling, weight control management, lipid management, blood pressure monitoring, smoking cessation, and psychosocial management. Cardiac rehabilitation services are by definition multi-factorial and comprehensive, with physical activity counselling and exercise training as central components in all rehabilitation and preventive interventions. Many of the risk factor improvements occurring in CR can be mediated through exercise training programmes. This call-for-action paper presents the key components of a CR programme: physical activity counselling and exercise training. It summarizes current evidence-based best practice for the wide range of patient presentations of interest to the general cardiology community.

Keywords Cardiac rehabilitation • Exercise training • Physical activity • Prevention

* Corresponding author. Tel: +39 0523 303217, Fax: +39 0523 303220, Email: m.piepoli@imperial.ac.uk

Published on behalf of the European Society of Cardiology. All rights reserved. © The Author 2010. For permissions please email: journals.permissions@oxfordjournals.org.

Downloaded from http://eurheartj.oxfordjournals.org/ by guest on August 21, 2013

Rationale

There has been impressive progress in pharmacological therapies and in sophisticated technology-based diagnostic and therapeutic procedures in cardiovascular diseases in recent years. As a consequence, a greater number of men and women now survive acute events but with a heavier burden of chronic conditions and clinical need.

A management approach based on interventional cardiology and medication is thus not effective: '. . .*the burden of established cardiovascular disease may also be reduced by early diagnosis, appropriate disease management, rehabilitation and prevention, including structured lifestyle counselling*' (European Heart Health Charter, Article 7).[1]

After an acute event or with chronic heart conditions, patients need structured support to restore their quality of life and to maintain or improve functional capacity. They require counselling to prevent event recurrence by adhering to a medication plan and adopting a healthy lifestyle. Cardiac rehabilitation (CR) can be viewed as the clinical application of preventive care by means of a professional multidisciplinary integrated approach for comprehensive risk reduction and global long-term care of cardiac patients. This is accompanied by a flexible follow-up strategy, and easy access to a specialized team. Thus, CR programmes are recommended (Class I) by the European Society of Cardiology (ESC),[2,3] American Heart Association (AHA), and American College of Cardiology (ACC)[4–6] in the treatment of patients with coronary artery disease (CAD) and chronic heart failure.[7–9] Moreover, it is a cost-effective intervention following an acute coronary event and heart failure, since it improves prognosis by reducing recurrent hospitalization and health care expenditures, while prolonging life.[10,11]

Despite its well-documented benefits, CR is vastly underutilized. Only about a third of coronary patients in Europe receive any form of CR.[12,13] The results of the EUROASPIRE audits of preventive care of coronary patients over the last 12 years show adverse lifestyle trends and an increasing prevalence of cardiovascular risk factors in cardiac patients.[14] Moreover, even when implemented, most CR programmes are short-term interventions. Some recent studies on prevention and CR (e.g. EuroAction[15] and GOSPEL[16]) have specifically aimed at maintaining beneficial longer term life changes and improving prognosis in cardiac patients.

Structure and aim of the paper

The CR Position Paper[17] adopts a pragmatic approach with practical guidelines on seven clinical conditions: acute coronary syndrome and post primary percutaneous coronary intervention (PCI), stable CAD and elective PCI, cardiac surgery, coronary artery and valve heart surgery, chronic heart failure; cardiac transplantation, diabetes mellitus, and peripheral arterial disease. Core CR components include patient assessment, physical activity counselling, exercise training, diet/nutritional counselling, weight control management, lipid management, blood pressure monitoring, smoking cessation, and psychosocial management.

In this 'Call for action' paper, addressed to the wider community of general cardiologists, we aimed to highlight the key aspects of CR: physical activity and exercise training. Many of the multi-risk factor benefits of the CR programme have been documented to be mediated through regular physical activity and exercise training:[18–20] increased fibrinolysis and decreased coagulability,[21] anti-inflammatory effects,[22] improved autonomic function,[23] prevention and restoration of age-related decline in endothelium-dependent vasodilatation, which may also help explain the improvement in hyperaemic myocardial blood flow.[24] Exercise-related benefits in exercise training slow CAD progression.[25] Since peak oxygen uptake is an important predictor of cardiac and all-cause death, a small gain in aerobic power may improve not only functional capacity but also survival prospects.[26,27] The assessment, counselling, and support in the maintenance of physical activity and exercise training are core tasks for the physicians engaged in the prevention of cardiovascular disease and are addressed here.

The development of the position paper and the present 'Call-for action' manuscript involved a systematic process of evaluation and synthesis of 2003–2009 guidelines including ESC, ACC/AHA, and the National Institutes of Health. When available, Classification of Recommendations and Level of Evidence are expressed in ACC/AHA format. Thereafter, both well-established aspects of physical activity and exercise training, and less-established or more controversial issues in CR are presented and discussed (*Tables 1–3*, and 'Research Needs and Future Directions' section). Finally, a glossary of the more common terms and concepts used here is provided (*Table 4*).

Physical activity counselling

Physical activity is defined as any bodily movement produced by contraction of skeletal muscles and resulting in energy expenditure above the basal level and, as such, part of lifestyle intervention. The following points are established/general agreed activities applicable to all conditions in CR (detailed issues specific for each condition are mentioned separately in *Table 1*):

- *Assess* physical activity level by history: domestic, occupational, and recreational needs; activities relevant to age, gender, and daily life; readiness to change behaviour; self-confidence; barriers to increase physical activity, and social support in making positive changes.
- *Advise* individualized physical activity according to patient's age, past habits, co-morbidities, preferences, and goals.
- *Recommend* a minimum of 30 min/session of moderately vigorous aerobic activity, on most days of the week, or at least three to four times per week; gradual increases in daily lifestyle activities over time with their incorporation into daily routine.
- *Reassure* regarding the safety of the recommended protocol.
- *Encourage* the involvement in leisure activities, positively enjoyable and in group programme because patients tend to revert to their previous sedentary habits over time.
- *Educate* on the need for lifelong continuation of physical conditioning and the risk of relapses. If any interruption has occurred, physical, social, and psychological barriers to attendance should be explored, and alternative approaches suggested.
- *Expected outcomes*: increased participation in domestic, occupational, and recreational activities. Improved psychosocial well-being, prevention of disability, enhancement of opportunities for independent self-care; improved aerobic fitness and prognosis.

Downloaded from http://eurheartj.oxfordjournals.org/ by guest on August 21, 2013

Table 1 Physical activity counselling specific for different clinical conditions

Components	Established/generally agreed issues	Class (level)
Post-ACS and post primary PCI[2–5,44,45]	*Assess*:	
	Risk must be assessed by physical activity history and exercise testing to guide prescription	I (B)
	Symptom-limited exercise testing after clinical stabilization. Submaximal exercise stress testing in selected cases (*Figure 1*)[a]	I (C)[31–33]
	Recommend:	
	After uncomplicated procedure, physical activity can start the next day. After a large and/or complicated myocardial damage, physical activity should start after clinical stabilization, and be increased slowly, according to the symptoms	I (A)
	In the presence of preserved exercise capacity without symptoms, patient can resume routine physical activity for 30–60 min, such as brisk walking, supplemented by an increase in daily activities (such as walking breaks at work, gardening, or household work); otherwise, the patient should resume physical activity at 50% of maximal exercise capacity and gradually increase	I (B)
	Physical activity should be a combination of activities like walking, climbing stairs, cycling	
Stable CAD and post elective PCI[2,45,46,]	*Assess*: exercise capacity and ischaemia threshold by symptom limited exercise stress test (*Figure 1*).[a] Exercise or pharmacological imaging technique in symptomatic patients with un-interpretable ECG	I (B)
	Recommend: refer to 'Post-ACS and post primary PCI' issues	
Post cardiac surgery, coronary artery and valve heart surgery[47–49]	*Assess*: exercise capacity to guide exercise prescription: Submaximal exercise stress test as soon as possible A maximal exercise test after surgical wound stabilization (*Figure 2*) *Recommend*: physical activity counselling according to wound healing and exercise capacity Also refer to 'Post-ACS and post primary PCI' issues	I (C)
Chronic heart failure[7,8]	*Assess*: peak exercise capacity by maximal symptom-limited cardiopulmonary exercise testing. For testing protocol, small increments 5–10 W per minute on bicycle ergometer or modified Bruce or Naughton protocols on treadmill are indicated (in order to achieve max. exercise capacity in 8–12 min)	I (B)
	Recommend: at least 30–60 min/day of moderate-intensity physical activity	I (A)
	Also refer to 'Post-ACS and post primary PCI' issues	
Cardiac transplantation[50,51]	*Assess*: exercise capacity (*Figure 3*). Also refer to 'Post cardiac surgery' and 'Chronic heart Failure' issues	
	Recommend: Long-term dynamic and resistance exercise to prevent many side-effects of immunosuppressive therapy	
	Exercise intensity relies more on the perceived exertion (i.e. around 12–14 Borg scale) or on the anaerobic threshold (if available) than on a specific heart rate; e.g. instruct the patients to start walking 1.5 km five times weekly at a pace resulting in a perceived exertion of 12–14 on the Borg scale. The pace should be increased slowly over time to Nordic walking	
Diabetes mellitus[52]	*Assess*: Functional capacity and exercise-induced ischaemia by maximal symptom-limited exercise stress testing[a]	I (B)
	Recommend: refer to 'Post-ACS and post primary PCI' issues	I (A)
Peripheral artery disease[38,53]	*Assess*: functional capacity (usually markedly impaired, often $<$50% of the predicted value) and cause of exercise limitation (e.g. claudication)	
	Exclude occult CAD: perform treadmill or bicycle exercise testing to monitor symptoms, S-T segment and T wave changes, arrhythmias, heart rate and blood pressure responses, also useful for exercise prescription	
	Pain free and maximal walking distance on a treadmill (3.2 km/h and 10% slope)	
	Recommend: exercise activities, especially walking, lasting $>$30 min, $\geq$3 times/week. Patients should seek to reach their claudication threshold ('walk until near-maximal pain') to stimulate collateral's formation[a]	

[a]See 'Research Needs and Future Directions' section.

Downloaded from http://eurheartj.oxfordjournals.org/ by guest on August 21, 2013

Table 2 Exercise training prescription generally applicable

Mode	Continuous endurance: walking, jogging, cycling, swimming, rowing, stair climbing, elliptical trainers, and aerobic dancing
Duration	At least 20–30 min (preferably 45–60 min)
Frequency	Most days (at least 3 days/week and preferably 6–7 days/week)
Intensity	50–80% of peak oxygen consumption (close to anaerobic threshold) or of peak heart rate or 40–60% of heart rate reserve; 10/20–14/20 of the Borg Rating of Perceived Exertion

A progressive increasing training regimen should be prescribed with regular follow-up controls (at least every 3–6 months), to adjust the duration and the level of the exercise to the reached level of tolerance.
Peak oxygen consumption (Peak VO_2) by cardiopulmonary exercise testing is the ideal physiologic marker of intensity: practically surrogate intensity markers are here presented.

Exercise training programme

Exercise training is defined as a sub-category of physical activity in which planned, structured, and repetitive bodily movements are performed to maintain or improve one or more attributes of physical fitness and thus it is a structured intervention over a defined period of time. It should be integrated within the physical activity intervention: all the activities highlighted in the previous paragraph should apply also to the exercise training plan.

The following points are established/general agreed issues in exercise training applicable to all clinical conditions (*Table 2*) (detailed issues specific for each condition are mentioned separately in *Table 3*):

- *Assess* exercise capacity by symptom-limited stress testing, either on bicycle ergometer or on treadmill. In the routine clinical setting, this is not always applicable, particularly in the presence of left ventricular dysfunction (ejection fraction <40%) or after recent surgical intervention (because of the surgical wounds) and therefore sub-maximal exercise evaluation and/or 6 min walk test should be considered.[28]
- *Advise* individualized exercise training after careful clinical evaluation, including risk stratification.
- *Recommend* as general advice sub-maximal endurance aerobic (*Table 2*).
- *Educate* on the recognition of symptoms induced by effort. Appropriate behaviour and re-definition of exercise training target should be discussed for the individual patient.
- *Expected outcomes*: increased cardio-respiratory fitness and enhanced flexibility, muscular endurance, and strength; reduction of symptoms, attenuated physiologic responses to physical challenges, and improved psychosocial well-being.
- *Programme settings*. During the initial phases supervised in-patient or hospital-based exercise training programmes may be recommended in high-risk cardiovascular patients, i.e. those with impaired systolic left ventricular function, those with severe co-morbidities, leading to significant disability, and in those with recent (<1 week) clinical destabilization. This will verify individual responses and tolerability in a safe clinical setting and will promptly identify signs and symptoms indicating to modify or terminate the programme. The supervision should include physical examination, assessment of exercise-related symptoms or arrhythmias, and monitoring of heart rate and blood pressure before, during, and after exercise training. The supervised period should be prolonged in patients with new symptoms, clinical signs of decompensation, blood pressure abnormalities, and increased supraventricular or ventricular arrhythmia during exercise.

Research needs and future directions

This Position Paper proposes that both general and specific gaps in knowledge to the implementation of physical activity counselling and exercise training as preventive tools in cardiovascular diseases must be addressed to increase their acceptance, feasibility, and sustainability. The general gaps fall into two categories: healthcare provider-related, and specific skills deficit-related.

Most healthcare providers focus on acute disease presentation. They may lack knowledge about current best evidence of the effectiveness of preventive care; lack skills to carry out behavioural interventions; or lack motivation or time to train or deliver such interventions. Patient-related gaps include lack of knowledge of potential benefits of secondary prevention and difficulties with long-term adherence. Health system-related barriers are lack of incentives for preventive care, with no systematic approach to its implementation as well as practical concerns about costs. As a consequence, exercise-related secondary prevention programmes are generally under-funded, with large discrepancies across different European countries.

Approaches to overcome these gaps include continuing education of healthcare professionals about the negative role of sedentary life and their own modelling role in setting a good example with engagement in healthy lifestyles; and incentives and surveys on physical activity programmes and community-based approaches to increase physical activity participation and to evaluate their cost-effectiveness.

Beside these general knowledge gaps, specific knowledge and skills deficits need to be addressed, as summarized next.

1 *Exercise tolerance is affected* by age, gender, conditioning status, and the presence of disease or medications. It typically declines by 10% on average per decade in non-athletic adults, and this decline rate appears to hasten with ageing. It is 10–20% greater in men than in women. Consideration of all these determinants is important when functional capacity in a specific individual is assessed. Equations for age-predicted standards have been published but seldom applied.[29]
2 *Learning a new, different behaviour*, like changing from a sedentary to an active lifestyle, requires the modifications of the several small attitudes and behaviours. Thus, both physiological and psycho-social progression are needed to achieve patient behaviour change by first a gradual and simple promotion of physical activity within one's current domestic, occupational, and leisure settings and only thereafter participation in more structured, more vigorous exercise training. Multiple interventions

Downloaded from http://eurheartj.oxfordjournals.org/ by guest on August 21, 2013

Table 3 Exercise training recommendation specific for different clinical conditions

Clinical conditions	Established/generally agreed issues	Class (level)
Post-ACS and post primary PCI[2–5]	Exercise training should be recommended to all patients (supervised or monitored in moderate- to high-risk ones). The programme should include: at least 30 min, 5 days/week, aerobic exercise	I (B)
	At 70–85% of the peak heart rate, or at 70–85% of the heart rate at the onset of ischaemia (defined as ≥1 mm of ST depression, in case of asymptomatic exercise-induced ischaemia). Prophylactic nitroglycerine can be taken at the start of the training session)[a]	
	At 50% of the peak heart rate in high-risk patients because of left ventricular dysfunction, coronary disease severity, co-morbidities, ageing	
	Resistance training[a]	IIb (C)[5]
Stable CAD and post elective PCI[2,44–45]	Medically supervised exercise training programmes are recommended for patients with multiple risk factors, and with moderate-to-high risk (i.e. recent heart failure episode) for training initiation and motivation to long-term adherence	I (B)
	Expanding physical activity to include resistance training[a]	IIb (C)
	Also refer to 'Post-ACS and post primary PCI' issues	
Post cardiac surgery, coronary artery, and valve heart surgery[47–49]	Exercise training can be started early in-hospital Programmes should last 2–4 weeks for in-patient or up to 12 weeks for out-patient settings Upper-body training can begin when the sternal wound is stable Exercise training should be individually tailored according to the clinical condition, baseline exercise capacity, ventricular function, and different valve surgery (after mitral valve replacement exercise tolerance is much lower than that after aortic valve replacement, particularly if there is residual pulmonary hypertension) Also refer to 'Post-ACS and post primary PCI' issues (including resistance training[a])	I (B)
Chronic heart failure[7,8]	Progression of aerobic exercise training for stable patients	I (A)
	Initial stage (first 1–2 weeks): intensity should be kept at a low level in patients with NYHA functional class III (50% of peak VO_2), increasing duration from 20 to 30 min according to perceived symptoms and clinical status	
	Improvement stage: a gradual increase of intensity (60%, 70–80% of peak VO_2, if tolerated) is the primary aim. Prolongation of exercise session is a secondary goal	
	Supervised, hospital-based (in- or out-patient) programme may be recommended, especially initially, to verify individual responses and tolerability, clinical stability, and promptly identify signs and symptoms indicating to modify or terminate the programme[a]	
	Resistance training[a]	
Cardiac transplantation[50,51]	Training programmes are beneficial in the early post-operative period as well as on the long term	
	Before hospital discharge, respiratory kinesis-therapy, active and systematic mobilization of the upper and lower limbs are advisable	
	After discharge, aerobic exercise may be started in the second or third week after transplant but should be discontinued during corticosteroid bolus therapy for rejection. Low-level aerobic training should be defined according to peak VO_2 (50 or 10% below anaerobic threshold) or peak work load (50%)	
	Resistance exercise can be added after sternal wound stabilization[a]	
Diabetes mellitus[52]	Aerobic training: refer to 'Post-ACS and post primary PCI' issues	I (A)
	Resistance training 2–3 sessions/week for all major muscle groups is advised	
Peripheral artery disease[38]	Initially a supervised hospital- or clinic-based exercise training programme, which ensures that patients are receiving a standardized instruction and effective exercise stimulus in a safe environment	I (A)
	Each training session consists of short periods of treadmill walking interspersed with rest throughout a 60 min exercise session, three times weekly	
	Treadmill exercise appears to be more effective: the initial workload is set to a speed and grade that elicit claudication symptoms within 3 to 5 min. Patients are asked to continue to walk at this workload until they achieve claudication of moderate severity. This is followed by a brief period of rest to permit symptoms to resolve. The exercise–rest–exercise cycle is repeated several times during the hour of supervision	
	Endurance and resistance training, appropriately prescribed, is generally recommended	

[a]See 'Research Needs and Future Directions' section.

Downloaded from http://eurheartj.oxfordjournals.org/ by guest on August 21, 2013

Table 4 Glossary of terms

Aerobic training: training that improves the efficiency of the aerobic energy-producing systems and that can improve cardio-respiratory endurance
Anaerobic training: training that improves the efficiency of the anaerobic energy-producing systems and that can increase muscular strength and tolerance for acid-base imbalances during high-intensity effort
Aerobic endurance training/endurance activities: activity supported by aerobic metabolism that engages large muscle groups in a rhythmical manner, including such activities as walking, jogging, running, swimming, cycling, aerobic exercise to music, circuit training
Heart rate reserve (HRR): the difference between maximal heart rate and resting heart rate
Maximal oxygen uptake (VO_2 max): the maximal capacity for oxygen consumption by the body during maximal exertion. It is determined during dynamic exercise from a 'plateauing' of VO_2 despite work rate continuing to increase. It is also known as aerobic power, maximal oxygen consumption, and cardiorespiratory endurance capacity
Maximal heart rate (HR max): the highest heart rate value theoretically attainable during an all-out effort to the point of exhaustion
Metabolic equivalent (MET): a unit used to estimate the metabolic cost (oxygen consumption) of physical activity. One MET equals the resting metabolic rate of approximately 3.5 mL O_2 kg^{-1} min^{-1}
Peak heart rate (peak HR): highest HR achieved on a test performed to the limit of tolerance
Peak oxygen uptake (peak VO_2): highest VO_2 achieved on a test performed to the limit of tolerance. No additional criteria are needed for its determination
Physical fitness: a set of attributes that people have or achieve that relates to the ability to perform physical activity
Rating of perceived exertion (RPE): a person's subjective assessment of how hard he or she is working. The Borg scale is a numerical scale for rating perceived exertion
Resistance training: training designed to increase strength, power, and muscle endurance by lifting weight
Speed: a skill-related component of physical fitness that relates to the ability to perform a movement within a short period of time
Strength: the ability of the muscle to exert force
Training heart rate (THR): a heart rate (HR) goal established by using the HR equivalent to a selected training level (percentage of VO_2 max). For example, if a training level of 75% VO_2 max is desired, the VO_2 at 75% is determined and the HR corresponding to this VO_2 is selected as the THR

conducted over time may need to be employed to sustain physical activity behaviour modification. It is not yet evident which strategies have most relevance in promoting physical activity across groups.[30]

3 *Exercise testing to initiate an exercise training programme in specific clinical conditions*. In general, there is a dearth of studies comparing different aerobic exercise regimens in cardiac patients.[31] Moreover there are controversial aspects of exercise testing applicable to specific clinical conditions, as discussed in the following paragraphs.

3.1 *Post-ACS and post primary PCI*. Although symptom-limited exercise testing can be safely performed 7 to 14 days after primary PCI (when an exercise training programme can be initiated),[32] its application is scarce in routine clinical practice. The ACC/AHA guidelines recommend pre-discharge submaximal exercise testing at 4–6 days after myocardial infarction for prognostic assessment, activity prescription, ECG monitoring, and evaluation of medical therapy.[28,33] In the training programme, exercise intensity should be set to 70–85% of the peak heart rate. In case of symptomatic exercise-induced ischaemia, patients exercising to a 70–85% ischaemic heart rate, or to the early onset of angina, have been suggested. In asymptomatic exercise-induced ischaemia, exercising to 70–85% of the heart rate at the onset of ischaemia (defined as $\geq$1 mm of ST depression) has been proposed.[31] Another area of uncertainty concerns the need for continuous ECG monitoring and the opportunity to train above the ischaemic threshold.

3.2 *Stable CAD and post elective PCI*. Symptom-limited exercise testing can be safely performed the day after routine PCI, but scarcely performed.[34]

3.3 *Chronic heart failure*. Several controversies still need to be addressed.

3.3.1 Exercise training: this is recommended for NYHA functional class II or III patients, tailored to the individual's exercise tolerance, because it improves exercise capacity and quality of life. However, ExTraMATCH,[11] Cochrane meta-analysis,[35] and HF-ACTION trial[36] have provided somewhat contradictory results about its effectiveness on morbidity and mortality in stable patients.

3.3.2 *Mixed modalities*: limited information about combined aerobic, strength, interval, resistance, and respiratory exercise training is available. Although the safety of all of these exercise modalities is undisputed, the question about the most effective training mode remains to be answered.

3.3.3 *Heart rate*: this can be used for exercise prescription or to monitor exercise intensity. However, its use is inadequate in patients with severely reduced exercise capacity, chronotropic incompetence, negative chronotropic medications, co-morbidites with an impact on exercise performance, atrial fibrillation, or after heart transplantation.

3.3.4 *ICDs and exercise training*: although exercise training seems feasible and safe in patients with ICD, a supervised setting with qualified staff and constant surveillance is needed in patients with frequent ventricular arrhythmias. Experience is limited and data are available from highly specialized centres. Concerning the intensity of exercise, a heart rate training threshold at ICD detection rate minus 20 b.p.m. has been proposed.[37]

3.4 *Cardiac transplantation*. although exercise training would theoretically delay or prevent CAD progression in the transplanted heart, evidence is lacking.

3.5 *Diabetes mellitus*. A symptom-limited maximal exercise test is mandatory for all diabetic patients before commencing regular physical activity. Exercise capacity and maximal heart rate need to be determined, to tailor an individual exercise programme.

Downloaded from http://eurheartj.oxfordjournals.org/ by guest on August 21, 2013

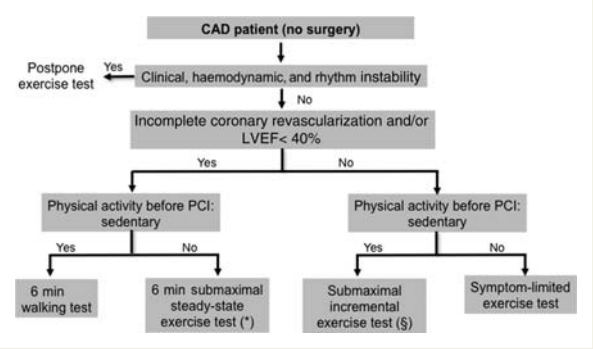

Figure 1 Proposed algorithm for functional evaluation in exercise prescription in coronary artery disease (CAD) patients not treated with cardiac surgery. The following general criteria should be considered in planning an exercise testing modality for exercise prescription. *Safety*: stability of clinical, haemodynamic, and rhythmic parameters (e.g. symptomatic Brady-arrhythmias, persistent or paroxysmal atrial flutter/fibrillation with inadequate rate control, exercise-induced persistent or paroxysmal supraventricular tachycardia, exercise-induced ventricular premature contractions, ventricular tachycardia/fibrillation), ischaemic and angina threshold (in case of incomplete revascularization), degree of left ventricular impairment. *Associated factors*: sedentary habits, orthopaedic limitations, occupational and recreational needs. *Upper limit for terminating submaximal 6 min single stage (steady-state) exercise testing: rating of perceived exertion (Borg scale) 11–13/20 or maximal heart rate = heart rate at standing rest + 20–30 b.p.m.[54] §Upper limit for terminating sub maximal incremental testing: maximal heart rate = 70% HR reserve or 85% of age-predicted maximal heart rate.[55]

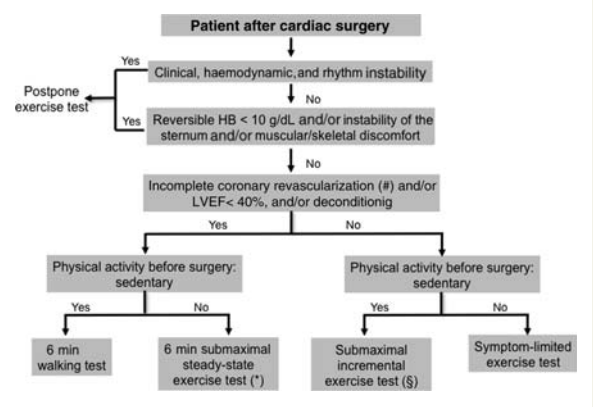

Figure 2 Proposed algorithm for functional evaluation in exercise prescription after cardiac surgery, i.e. coronary artery bypass graft (CABG), valve repair interventions. The following general criteria should be considered in planning exercise testing modality for exercise prescription: *Safety*; *Co-morbidities*: haemoglobin concentration (HB) values; muscular-skletal discomfort, healing issues at the incision sites; *Associated factors*: deconditioning due to prolonged hospitalization, sedentary habits, orthopedic limitations, occupational and recreational needs. #Incomplete revascularization in case of CABG (see also legend to *Figure 1*).

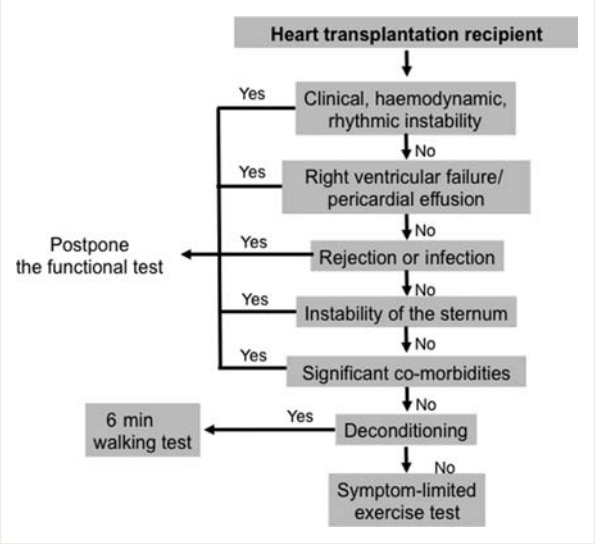

Figure 3 Proposed algorithm for functional evaluation in exercise prescription after heart transplantation. The following general criteria should be considered in planning an exercise testing modality for exercise prescription: *Safety*; *Co-morbidities* [anaemia (HB < 10 gr/dL), kidney failure (creatinine level > 3 mg/dL), neurological disorders, haematological disorders, diaphragmatic failure]; *associated factors* (see also legends to *Figures 1* and *2*).

3.6 *Peripheral artery disease*. The time course of the response to an exercise training programme is not fully elucidated in peripheral artery disease: clinical benefits have been observed as early as 4 weeks after initiation. They may continue to accrue after 6 months of supervised exercise training, three times per week, and sustained when continued for an additional 12 months. There are no data to support the efficacy of the informal '*Go home and walk*' advice, however unsupervised exercise training programmes may be adopted [IIb, (B)].[38]

4. *Resistance training*. As mentioned above, if there is a lack of studies comparing elements of the aerobic training regimen in cardiac patients, there is even less information on resistance exercise training studies.[39] General recommendations for training regimens include using 30–40% of the 1-repetition maximum for the upper body and 40–50% of the 1-repetition maximum for lower body exercises, with 12 to 15 repetitions in 1 set repeated two to three times weekly.[31] Nevertheless, because most of the outcome data discussed above relate to aerobic exercise training, resistance exercise in cardiac patients should be in addition to and not in replacement of the aerobic training component.

According to the most updated recommendations and revisions of the literature,[40–43] three algorithms for functional evaluation in exercise prescription in CAD patients without cardiac surgery (*Figure 1*), in patient after cardiac surgery (*Figure 2*) and after heart transplantation (*Figure 3*), are proposed. Sub-maximal exercise evaluations and 6 min walk tests are presented as alternatives to symptom-limited stress testing, which should be considered the first choice whenever it is possible.

Downloaded from http://eurheartj.oxfordjournals.org/ by guest on August 21, 2013

Conclusion

In CR, all of the goals of secondary prevention are targeted by promoting lifestyle change and patient adherence to pharmacological therapy. While it is clearly understood and accepted that an isolated exercise programme is not CR, physical activity and exercise training must be recognized as the core components from which to build a comprehensive CR programme. Physical activity will be the carrier of change and of maintenance of healthy behaviours in the longer term, with positive consequences on self-confidence and esteem, socialization, return to work, and normalization of daily life activities. In sum, CR programmes, with a core of physical activity and exercise training, promote better quality of life, better control of classical cardiovascular risk factors, and, consequently, a lower rate of events and longer higher quality survival. Advocating for CR programmes for every patient who can benefit must be on every cardiologist's agenda.

Conflict of interest: none declared.

References

1. http://www.heartcharter.org/read-charter/default.aspx (6 July 2010).
2. Van de Werf F, Bax J, Betriu A, Blomstrom-Lundqvist C, Crea F, Falk V, Filippatos G, Fox K, Huber K, Kastrati A, Rosengren A, Steg PG, Tubaro M, Verheugt F, Weidinger F, Weis M, ESC Committee for Practice Guidelines (CPG), Vahanian A, Camm J, De Caterina R, Dean V, Dickstein K, Filippatos G, Funck-Brentano C, Hellemans I, Kristensen SD, McGregor K, Sechtem U, Silber S, Tendera M, Widimsky P, Zamorano JL, Silber S, Aguirre FV, Al-Attar N, Alegria E, Andreotti F, Benzer W, Breithardt O, Danchin N, Di Mario C, Dudek D, Gulba D, Halvorsen S, Kaufmann P, Kornowski R, Lip GY, Rutten F. Management of Acute Myocardial Infarction in patients presenting with ST-segment elevation. The Task Force on the Management of Acute Myocardial Infarction of the European Society of Cardiology. *Eur Heart J* 2008;**29**:2909–2945.
3. Bassand JP, Hamm CW, Ardissino D, Boersma E, Budaj A, Fernández-Avilés F, Fox KA, Hasdai D, Ohman EM, Wallentin L, Wijns W. Guidelines for the diagnosis and treatment of non-ST-segment elevation acute coronary syndromes. Task Force for Diagnosis and Treatment of Non-ST-Segment Elevation Acute Coronary Syndromes of European Society of Cardiology. *Eur Heart J* 2007;**28**:1598–1660.
4. Antman EM, Hand M, Armstrong PW, Bates ER, Green LA, Halasyamani LK, Hochman JS, Krumholz HM, Lamas GA, Mullany CJ, Pearle DL, Sloan MA, Smith SC Jr. 2007 focused update of the ACC/AHA 2004 Guidelines for the Management of Patients With ST-Elevation Myocardial Infarction: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Group to Review New Evidence and Update the ACC/AHA 2004 Guidelines for the Management of Patients With ST-Elevation Myocardial Infarction). *J Am Coll Cardiol* 2008;**51**:210–247.
5. Anderson JL, Adams CD, Antman EM, Bridges CR, Califf RM, Casey DE Jr, Chavey WE II, Fesmire FM, Hochman JS, Levin TN, Lincoff AM, Peterson ED, Theroux P, Wenger NK, Wright RS. ACC/AHA 2007 guidelines for the management of patients with unstable angina/non-ST-elevation myocardial infarction: a report of the AmericanCollege of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Revise the 2002 Guidelines for the Management of Patients With Unstable Angina/Non–ST-Elevation Myocardial Infarction): developed in collaboration with the American College of Emergency Physicians, American College of Physicians, Society for Academic Emergency Medicine, Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons. *J Am Coll Cardiol* 2007;**50**:1–157.
6. Gibbons RJ, Abrams J, Chatterjee K, Daley J, Deedwania PC, Douglas JS, Ferguson TB Jr, Fihn SD, Fraker TD Jr, Gardin JM, O'Rourke RA, Pasternak RC, Williams SV. ACC/AHA 2002 guideline update for the management of patients with chronic stable angina: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Update the 1999 Guidelines for the Management of Patients with Chronic Stable Angina). 2002; www.acc.org/clinical/guidelines/stable/sta-ble.pdf.
7. Dickstein K, Cohen-Solal A, Filippatos G, McMurray JJ, Ponikowski P, Poole-Wilson PA, Strömberg A, van Veldhuisen DJ, Atar D, Hoes AW, Keren A, Mebazaa A, Nieminen M, Priori SG, Swedberg K. ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure 2008: the Task Force for the Diagnosis and Treatment of Acute and Chronic Heart Failure 2008 of the European Society of Cardiology. Developed in collaboration with the Heart Failure Association of the ESC (HFA) and endorsed by the European Society of Intensive Care Medicine (ESICM). *Eur Heart J* 2008;**29**:2388–2442.
8. Hunt SA, Abraham WT, Chin MH, Feldman AM, Francis GS, Ganiats TG, Jessup M, Konstam MA, Mancini DM, Michl K, Oates JA, Rahko PS, Silver MA, Stevenson LW, Yancy CW, Antman EM, Smith SC Jr, Adams CD, Anderson JL, Faxon DP, Fuster V, Halperin JL, Hiratzka LF, Jacobs AK, Nishimura R, Ornato JP, Page RL, Riegel B, American College of Cardiology, American Heart Association Task Force on Practice Guidelines, American College of Chest Physicians, International Society for Heart, Lung Transplantation, Heart Rhythm Society. ACC/AHA guideline update for the diagnosis and management of chronic heart failure in the adult: summary article: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation* 2005;**112**:1825–1852.
9. Rehabilitation after cardiovascular diseases, with special emphasis on developing countries. Report of a WHO Expert Committee. WHO Technical Report Series, No. 831. Geneva, Switzerland: World Health Organization; 1993.
10. Papadakis S, Oldridge NB, Coyle D, Mayhew A, Reid RD, Beaton L, Dafoe WA, Angus D. Economic evaluation of cardiac rehabilitation: a systematic review. *Eur J Cardiovasc Prev Rehabil* 2005;**12**:513–520.
11. Piepoli MF, Davos C, Francis DP, Coats AJ. ExTraMATCH Collaborative.Exercise training meta-analysis of trials in patients with chronic heart failure (ExTraMATCH). *BMJ* 2004;**328**:189–193.
12. Kotseva K, Wood D, De Backer G, De Bacquer D, Pyörälä K, Keil U, EUROASPIRE Study Group. EUROASPIRE III: a survey on the lifestyle, risk factors and use of cardioprotective drug therapies in coronary patients from twenty two European countries. EUROASPIRE Study Group. *Eur J Cardiovasc Prev Rehabil* 2009;**16**:121–137.
13. Bjarnason-Wehrens B, McGee H, Zwisler A-D, Piepoli MF, Benzer W, Schmid J-P, Dendale P, Pogosova NGV, Zdrenghea D, Niebauer J, Mendes M, on behalf of the Cardiac Rehabilitation Section of the European Association of Cardiovascular Prevention, Rehabilitation. Cardiac Rehabilitation in Europe—results from the European Cardiac Rehabilitation Inventory Survey (ECRIS). *Eur J Cardiovasc Prev Rehabil* 2010; published online ahead of print 17 March.
14. Kotseva K, Wood D, De Backer G, De Bacquer D, Pyörälä K, Keil U, EUROASPIRE Study Group. Cardiovascular prevention guidelines in daily practice: a comparison of EUROASPIRE I, II and III surveys in 8 European countries. *Lancet* 2009;**373**:929–940.
15. Wood DA, Kotseva K, Connolly S, Jennings C, Mead A, Jones J, Holden A, De Bacquer D, Collier T, De Backer G, Faergeman O, on behalf of EUROACTION Study Group. Nurse-coordinated multidisciplinary, family-based cardiovascular disease prevention programme (EUROACTION) for patients with coronary heart disease and asymptomatic individuals at high risk of cardiovascular disease: a paired, cluster-randomised controlled trial. *Lancet* 2008;**371**:1999–2012.
16. Giannuzzi P, Temporelli PL, Marchioli R, Maggioni AP, Balestroni G, Ceci V. Global secondary prevention strategies to limit event recurrence after myocardial infarction: results of the GOSPEL study, a multicenter, randomized controlled trial from the Italian Cardiac Rehabilitation Network. *Arch Intern Med* 2008;**168**:2194–2204.
17. Piepoli MF, Corrà U, Benzer W, Bjarnason-Wehrens B, Dendale P, Gaita D, McGee H, Mendes M, Niebauer J, Olsen Zwisler A-D, Schmid J-P. Secondary prevention through cardiac rehabilitation—from knowledge to implementation. A Position Paper from the Cardiac Rehabilitation Section of the European Association of Cardiovascular Prevention and Rehabilitation. *Eur J Cardiovasc Prev Rehabil* 2010;**17**:1–17.
18. Giannuzzi P, Saner H, Björnstad H, Fioretti P, Mendes M, Cohen-Solal A, Dugmore L, Hambrecht R, Hellemans I, McGee H, Perk J, Vanhees L, Veress G, Working Group on Cardiac Rehabilitation, Exercise Physiology of the European Society of Cardiology. Secondary Prevention Through Cardiac Rehabilitation: Position Paper of the Working Group on Cardiac Rehabilitation and Exercise Physiology of the European Society of Cardiology. *Eur Heart J* 2003;**24**:1273–1278.
19. Giannuzzi P, Mezzani A, Saner H, Björnstad H, Fioretti P, Mendes M, Cohen-Solal A, Dugmore L, Hambrecht R, Hellemans I, McGee H, Perk J, Vanhees L, Veress G, Working Group on Cardiac Rehabilitation, Exercise Physiology, European Society of Cardiology. Physical activity for primary and secondary prevention. Position paper of the Working Group on Cardiac Rehabilitation and Exercise Physiology of the European Society of Cardiology. *Eur J Cardiovasc Prev Rehabil* 2003;**10**:319–327.
20. Graham I, Atar D, Borch-Johnsen K, Boysen G, Burell G, Cifkova R, Dallongeville J, De Backer G, Ebrahim S, Gjelsvik B, Herrmann-Lingen C, Hoes A, Humphries S, Knapton M, Perk J, Priori SG, Pyorala K, Reiner Z, Ruilope L, Sans-Menendez S, Op Reimer WS, Weissberg P, Wood D, Yarnell J,

Downloaded from http://eurheartj.oxfordjournals.org/ by guest on August 21, 2013

Zamorano JL, Walma E, Fitzgerald T, Cooney MT, Dudina A, Vahanian A, Camm J, De Caterina R, Dean V, Dickstein K, Funck-Brentano C, Filippatos G, Hellemans I, Kristensen SD, McGregor K, Sechtem U, Silber S, Tendera M, Widimsky P, Zamorano JL, Altiner A, Bonora E, Durrington PN, Fagard R, Giampaoli S, Hemingway H, Hakansson J, Kjeldsen SE, Larsen L, Mancia G, Manolis AJ, Orth-Gomer K, Pedersen T, Rayner M, Ryden L, Sammut M, Schneiderman N, Stalenhoef AF, Tokgözoglu L, Wiklund O, Zampelas A. European guidelines on cardiovascular disease prevention in clinical practice: full text. Fourth Joint Task Force of the European Society of Cardiology and other societies on cardiovascular disease prevention in clinical practice. *Eur J Cardiovasc Prev Rehabil* 2007; **14**(Suppl. 2):S1–S113.

21. El-Sayed MS, El-Sayed AZ, Ahmadizad A. Exercise and training effects on blood haemostasis in health and disease: an update. *Sports Med* 2004;**34**:181–200.
22. Milani RV, Lavie CJ, Mehra MR. Reduction in C-reactive protein through cardiac rehabilitation and exercise training. *J Am Coll Cardiol* 2004;**43**:1056–1061.
23. Malfatto G, Blengino S, Annoni L, Branzi G, Bizzi C, Facchini M. Primary coronary angioplasty and subsequent cardiovascular rehabilitation are linked to a favorable sympathovagal balance after a first anterior myocardial infarction. *Ital Heart J* 2005; **6**:21–27.
24. Hambrecht R, Adams V, Erbs S, Linke A, Kränkel N, Shu Y, Baither Y, Gielen S, Thiele H, Gummert JF, Mohr FW, Schuler G. Regular physical activity improves endothelial function in patients with coronary artery disease by increasing phosphorylation of endothelial nitric oxide synthase. *Circulation* 2003;**107**:3152–3158.
25. Gielen S, Hambrecht R. Effects of exercise training on vascular function and myocardial perfusion. *Cardiol Clin* 2001;**9**:357–368.
26. Belardinelli R, Georgiou D, Cianci G, Purcaro A. A randomized, controlled trial of long-term moderate exercise training in chronic heart failure. Effects of functional capacity, quality of life, and clinical outcome. *Circulation* 1999;**99**:1173–1182.
27. Kobash Gleeson MP, Liu H, Hamilton MA, Moriguchi JD, Kawata N, Einhorn K, Herlihy E, Laks H. A controlled trial of exercise rehabilitation after heart transplantation. *N Engl J Med* 1999;**340**:272–277.
28. Arena R, Myers J, Williams MA, Gulati M, Kligfield P, Balady GJ, Collins E, Fletcher G, American Heart Association Committee on Exercise, Rehabilitation, Prevention of the Council on Clinical Cardiology, American Heart Association Council on Cardiovascular Nursing. Assessment of functional capacity in clinical and research settings: a scientific statement from the American Heart Association Committee on Exercise, Rehabilitation, and Prevention of the Council on Clinical Cardiology and the Council on Cardiovascular Nursing. *Circulation* 2007;**116**: 329–343.
29. Ades PA, Savage PD, Brawner CA, Lyon CE, Ehrman JK, Bunn JY, Keteyian SJ. Aerobic capacity in patients entering cardiac rehabilitation. *Circulation* 2006;**113**: 2706–2712.
30. U.S. Department of Health and Human Services. Physical Activity and Health: A Report of the Surgeon General. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion; 1996.
31. Thompson PD. Exercise prescription and proscription for patients with coronary artery disease. *Circulation* 2005;**112**:2354–2363.
32. Goto Y, Sumida H, Ueshima K, Adachi H, Nohara R, Itoh H. Safety and implementation of exercise testing and training after coronary stenting in patients with acute myocardial infarction. *Circ J* 2002;**66**:930–936.
33. Gibbons RJ, Balady GJ, Bricker JT, Chaitman BR, Fletcher GF, Froelicher VF, Mark DB, McCallister BD, Mooss AN, O'Reilly MG, Winters WL Jr, Gibbons RJ, Antman EM, Alpert JS, Faxon DP, Fuster V, Gregoratos G, Hiratzka LF, Jacobs AK, Russell RO, Smith SC Jr. ACC/AHA 2002 Guideline Update for Exercise Testing: Summary Article: A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Update the 1997 Exercise Testing Guideline). *Circulation* 2002;**106**:1883–1892.
34. Roffi M, Wenaweser P, Windecker S, Mehta H, Eberli FR, Seiler C, Fleisch M, Garachemani A, Pedrazzini GB, Hess OM, Meier B. Early exercise after coronary stenting is safe. *J Am Coll Cardiol* 2003;**42**:1569–1573.
35. Rees K, Taylor RRS, Singh S, Coats AJS, Ebrahim S. Exercise based rehabilitation for heart failure. Cochrane Database of Systematic Reviews, Issue 4, 2009. *Copyright © 2009 The Cochrane Collaboration*. John Wiley & Sons, Ltd; 2009. doi:10.1002/14651858. CD003331.pub2.
36. O'Connor CM, Whellan DJMD, Lee KL, Keteyian SJ, Cooper LSMD, Ellis SJ, Leifer ES, Kraus WE, Kitzman DW, Blumenthal JA, Rendall DS, Miller NH, Fleg JL, Schulman KA, McKelvie RS, Zannad FMD, Pina IL, MD for the HF-ACTION Investigators. Efficacy and safety of exercise training in patients with chronic heart failure. HF-ACTION Randomized Controlled Trial. *JAMA* 2009;**301**:1439–1450.
37. Vanhees L, Kornaat M, Defoor J, Aufdemkampe G, Schepers D, Stevens A, Van Exel H, Van Den Beld J, Heidbüchel H, Fagard R. Effect of exercise training in patients with an implantable cardioverter defibrillator. *Eur Heart J* 2004;**25**: 1120–1126.
38. Hirsch AT, Haskal ZJ, Hertzer NR, Bakal CW, Creager MA, Halperin JL, Hiratzka LF, Murphy WR, Olin JW, Puschett JB, Rosenfield KA, Sacks D, Stanley JC, Taylor LM Jr, White CJ, White J, White RA, Antman EM, Smith SC Jr, Adams CD, Anderson JL, Faxon DP, Fuster V, Gibbons RJ, Hunt SA, Jacobs AK, Nishimura R, Ornato JP, Page RL, Riegel B. ACC/AHA 2005 Practice Guidelines for the management of patients with peripheral arterial disease (lower extremity, renal, mesenteric, and abdominal aortic): a collaborative report from the American Association for Vascular Surgery/Society for Vascular Surgery, Society for Cardiovascular Angiography and Interventions, Society for Vascular Medicine and Biology, Society of Interventional Radiology, and the ACC/AHA Task Force on Practice Guidelines (Writing Committee to Develop Guidelines for the Management of Patients With Peripheral Arterial Disease): endorsed by the American Association of Cardiovascular and Pulmonary Rehabilitation; National Heart, Lung, and Blood Institute; Society for Vascular Nursing; TransAtlantic Inter-Society Consensus; and Vascular Disease Foundation. *Circulation* 2006;**113**:463–654.
39. Pollock ML, Franklin BA, Balady GJ, Chaitman BL, Fleg JL, Fletcher B, Limacher M, Pina IL, Stein RA, Williams M, Bazzarre T. AHA Science Advisory: resistance exercise in individuals with and without cardiovascular disease: benefits, rationale, safety, and prescription: an advisory from the Committee on Exercise, Rehabilitation, and Prevention, Council on Clinical Cardiology, American Heart Association; position paper endorsed by the American College of Sports Medicine. *Circulation* 2000;**101**:828–833.
40. Varat MA, Adolph RJ, Fowler NO. Cardiovascular effects of anemia. *Am Heart J* 1972;**83**:415–426.
41. Hébert PC, Van der Linden P, Biro G, Hu LQ. Physiologic aspects of anemia. *Crit Care Clin* 2004;**20**:187–212.
42. Oski FA, Marshall BE, Cohen PJ, Sugerman HJ, Miller LD. Exercise with anemia. The role of the left-shifted or right-shifted oxygen–hemoglobin equilibrium curve. *Ann Intern Med* 1971;**74**:44–46.
43. Cook JR, Dillie KS, Hakeem A, Bhatti S, Chang SM. Effectiveness of anemia and chronic kidney disease as predictors for presence and severity of coronary artery disease in patients undergoing stress myocardial perfusion study. *Am J Cardiol* 2008;**102**:266–271.
44. Smith SC Jr, Allen J, Blair SN, Bonow RO, Brass LM, Fonarow GC, Grundy SM, Hiratzka L, Jones D, Krumholz HM, Mosca L, Pasternak RC, Pearson T, Pfeffer MA, Taubert KA, AHA/ACC/National Heart, Lung, Blood Institute. AHA/ACC guidelines for secondary prevention for patients with coronary and other atherosclerotic vascular disease: 2006 update. *J Am Coll Cardiol* 2006;**47**: 2130–2139.
45. Thompson PD, Buchner D, Pina IL, Balady GJ, Williams MA, Marcus BH, Berra K, Blair SN, Costa F, Franklin B, Fletcher GF, Gordon NF, Pate RR, Rodriguez BL, Yancey AK, Wenger NK. Exercise and physical activity in the prevention and treatment of atherosclerotic cardiovascular disease: a statement from the Council on Clinical Cardiology and the Council on Nutrition, Physical Activity, and Metabolism. *Circulation* 2003;**107**:3109–3116.
46. Fraker TD Jr, Fihn SD, writing on behalf of the 2002 Chronic Stable Angina Writing Committee. 2007 chronic angina focused update of the ACC/AHA 2002 Guidelines for the Management of Patients With Chronic Stable Angina: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines Writing Group to Develop the Focused Update of the 2002 Guidelines for the Management of Patients With Chronic Stable Angina. *J Am Coll Cardiol* 2007;**50**:2264–2274.
47. Eagle KA, Guyton RA, Davidoff R, Edwards FH, Ewy GA, Gardner TJ, Hart JC, Herrmann HC, Hillis LD, Hutter AM Jr, Lytle BW, Marlow RA, Nugent WC, Orszulak TA, Antman EM, Smith SC Jr, Alpert JS, Anderson JL, Faxon DP, Fuster V, Gibbons RJ, Gregoratos G, Halperin JL, Hiratzka LF, Hunt SA, Jacobs AK, Ornato JP. ACC/AHA 2004 guideline update for coronary artery bypass graft surgery: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation* 2004;**110**:340–437.
48. Vahanian A, Baumgartner H, Bax J, Butchart E, Dion R, Filippatos G, Flachskampf F, Hall R, Iung B, Kasprzak J, Nataf P, Tornos P, Torracca L, Wenink A. Guidelines on the management of valvular heart disease: The Task Force on the Management of Valvular Heart Disease of the European Society of Cardiology. *Eur Heart J* 2007;**28**:230–268.
49. Butchart EG, Gohlke-Barwolf C, Antunes MJ, Tornos P, De Caterina R, Cormier B, Prendergast B, Iung B, Bjornstad H, Leport C, Hall RJ, Vahanian A. Recommendations for the management of patients after heart valve surgery. *Eur Heart J* 2005;**26**:2463–2471.
50. Taylor DO, Edwards LB, Boucek MM, Trulock EP, Aurora P, Christie J, Dobbels F, Rahmel AO, Keck BM, Hertz MI. The registry of the international society for heart and lung transplantation: Twenty-first official adult heart transplant report—2007. *J Heart Lung Transplant* 2007;**26**:769–781.

Downloaded from http://eurheartj.oxfordjournals.org/ by guest on August 21, 2013

51. Niset G, Vachiery JL, Lamotte M, Godefroid C, Degre S. Rehabilitation after heart transplantation. In: Rieu M (ed.), *Physical Work Capacity in Organ Transplantation*. Karger, Basel: Medical and Sport Science; 1998. Vol. 42, p67–84.
52. Rydén L, Standl E, Bartnik M, Van den Berghe G, Betteridge J, de Boer MJ, Cosentino F, Jönsson B, Laakso M, Malmberg K, Priori S, Ostergren J, Tuomilehto J, Thrainsdottir I, Vanhorebeek I, Stramba-Badiale M, Lindgren P, Qiao Q, Priori SG, Blanc JJ, Budaj A, Camm J, Dean V, Deckers J, Dickstein K, Lekakis J, McGregor K, Metra M, Morais J, Osterspey A, Tamargo J, Zamorano JL, Deckers JW, Bertrand M, Charbonnel B, Erdmann E, Ferrannini E, Flyvbjerg A, Gohlke H, Juanatey JR, Graham I, Monteiro PF, Parhofer K, Pyörälä K, Raz I, Schernthaner G, Volpe M, Wood D. Guidelines on diabetes, pre-diabetes, and cardiovascular diseases: executive summary. *Eur Heart J* 2007;**28**:88–136.
53. Stewart KJ, Hiatt WR, Regensteiner JG, Hirsch AT. Exercise training for claudication. *N Engl J Med* 2002;**347**:1941–1951.
54. AACVPR. *Guidelines for Cardiac Rehabilitation and Secondary Prevention*. 4th ed. Human Kinetics; 2003. Chapter 6, p83–84.
55. *ACM's Guidelines for Exercise Testing*. 7th ed. Lippincott Williams & Wilkins; 2006. Chapter 8, p67–71.

Downloaded from http://eurheartj.oxfordjournals.org/ by guest on August 21, 2013