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# **REHABILITATION AFTER CARDIOVASCULAR DISEASES, WITH SPECIAL EMPHASIS ON DEVELOPING COUNTRIES**

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Report of a  
WHO Expert Committee



**World Health Organization**

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# **WHO Expert Committee on Rehabilitation after Cardiovascular Diseases, with Special Emphasis on Developing Countries**

Geneva, 21–28 October 1991

## **Members**

- Professor M. M. Al Nozha, Dean, College of Medicine, King Saud University, Riyadh, Saudi Arabia
- Professor J. P. Broustet, Chief of Cardiology Service, Cardiology Hospital of Haut Léveque, Pessac, France
- Professor A. O. Falase, Professor of Medicine and Cardiology, Department of Medicine, University College Hospital, Ibadan, Nigeria
- Dr A. M. A. Faruqi, Associate Professor of Cardiology, National Institute of Cardiovascular Diseases, Karachi, Pakistan (*Rapporteur*)
- Dr J. Feher, President, Israelita A. Einstein Hospital, Morumbi, São Paulo, Brazil
- Dr A. Goble, Honorary Cardiologist, Cardiology Department, Austin Hospital, Heidelberg, Victoria, Australia
- Professor S. John, Head, Department of Thoracic and Cardiovascular Surgery, Christian Medical College Hospital, Vellore, Tamil Nadu, India
- Professor P. Mathes, Chief, Cardiovascular Diseases, Höhenried Clinic for Cardiovascular Diseases, Bernried, Germany (*Vice-Chairman*)
- Professor W. F. T. Muna, Acting Director and Chief of Internal Medicine, General Hospital, Yaoundé, Cameroon
- Dr Oon Chong Hau, Consultant Physician, Health Maintenance Centre, Singapore General Hospital, Singapore
- Dr Choornpol Vongprateep, Director, Children's Hospital, Bangkok, Thailand
- Professor N. K. Wenger, Professor of Medicine (Cardiology), Emory University School of Medicine, Atlanta, GA, USA (*Chairman*)

## **Representatives of other organizations \***

### *International Society and Federation of Cardiology*

Professor J. P. Broustet (see list of Members)

Professor N. K. Wenger (see list of Members)

### *World Hypertension League*

Dr T. Strasser, Secretary-General, World Hypertension League, Geneva, Switzerland

### *International Council of Nurses*

Ms C. Panchaud, International Council of Nurses, Geneva, Switzerland

## **Secretariat**

Dr E. N. Chigan, Director, Division of Noncommunicable Diseases and Health Technology, WHO, Geneva, Switzerland

Professor H. Denolin, formerly University of Brussels, Brussels, Belgium  
(*Temporary Adviser*)

---

\* Unable to attend: Dr M. C. Queiroz Alvez da Cunha, International Federation of Sports Medicine, Porto Alegre, Brazil.

Dr I. Gyárfás, Chief, Cardiovascular Diseases, WHO, Geneva, Switzerland  
(*Secretary*)

Dr F. W. James, Department of Pediatrics, Division of Cardiology, Children's Hospital  
Medical Center, Cincinnati, OH, USA (*Temporary Adviser*)

Professor J. J. Kellermann, Director, The Ringer's Unit for Clinical Cardiac Research,  
Chaim Sheba Medical Center, Tel Hashomer, Israel (*Temporary Adviser*)

Dr L. F. Nikolaeva, National Research Centre of Medical Rehabilitation and Physical  
Therapy, Ministry of Health, Moscow, USSR (*Temporary Adviser*)



## 1. **Introduction**

A WHO Expert Committee on Rehabilitation after Cardiovascular Diseases, with Special Emphasis on Developing Countries met in Geneva from 21 to 28 October 1991. Opening the meeting on behalf of the Director-General of WHO, Dr Hu Ching-Li, Assistant Director-General, pointed out that cardiovascular diseases were already the leading cause of morbidity and premature mortality in industrialized countries, and that their emergence as a public health problem in developing countries had been recognized by the World Health Assembly as early as 1976. He also emphasized the extremely high human and economic costs of the problem.

Secondary prevention and rehabilitation were part of the WHO strategy for controlling cardiovascular diseases. The quality of each individual's life, of which health is an essential determinant, should be a primary social goal. Rehabilitation aimed not only to train patients disabled by cardiovascular disease to adapt to their environment but also to intervene in their immediate milieu and in society as a whole in order to facilitate their social integration.

The task of the Expert Committee would be to describe the current state of cardiovascular rehabilitation, with particular emphasis on its potential for children, adolescents, young adults, and the elderly, as well as the severely disabled, in developing countries; it would also consider the current and future role of education in the rehabilitation of cardiac patients.

### 1.1 **Developments in rehabilitative care**

Enormous changes in the rehabilitative approach to the care of patients with cardiovascular disease have occurred since the WHO Expert Committee on the Rehabilitation of Patients with Cardiovascular Diseases was organized by WHO in 1963 (1). At that time, rehabilitation was concerned predominantly with individuals recovering from acute, essentially uncomplicated, myocardial infarction; the several rehabilitative interventions recommended for such patients were considered to encompass "the sum of activities required to ensure them the best possible physical, mental and social conditions so that they may, by their own efforts, resume and maintain as normal a place as possible in the community" (2). Now, however, rehabilitation is considered to be an essential part of the care that should be available to *all* cardiac patients. Its goals are to improve functional capacity, alleviate or lessen activity-related symptoms, reduce unwarranted invalidism, and enable the cardiac patient to return to a useful and personally satisfying role in society.

Cardiovascular disease is becoming an increasingly prominent problem in developing countries: rheumatic heart disease, hypertension, and cardiomyopathy are already prevalent, and coronary heart disease is assuming growing significance. Despite differences in patterns of cardiac disease between and within developing countries, current concepts of

cardiac rehabilitative care (e.g. low- to moderate-intensity exercise and appropriate health education and guidance, as well as vocational counselling) can be applied even in societies with minimal medical personnel and equipment resources. However, guidelines are essential for their application. In developing countries, rehabilitative care should be incorporated into the existing health care system, and should conform to cultural traditions and social norms; such an approach is equally applicable to rural areas of industrialized nations. Guidance is also needed on maintenance of cardiovascular health, particularly for societies undergoing social transition, with consequent changes in culture, foods, lifestyle, and economics.

Demographic factors have had a radical influence on the range of cardiac patients considered eligible for exercise therapy during rehabilitation. Among patients with coronary heart disease, it is not only those who have recovered from uncomplicated myocardial infarction, but also patients with complications of the acute episode, those with angina pectoris of varying severity, and those who have undergone coronary artery bypass surgery and coronary angioplasty who are now considered candidates for rehabilitative care. The spectrum of coronary disease is extensive. At one end are the patients treated by acute myocardial reperfusion with coronary thrombolysis and/or early coronary angioplasty or coronary bypass surgery, who exhibit a lesser severity of disease, minimal residual symptoms, little functional impairment, and a characteristically excellent prognosis. At the other are patients who, having survived several acute infarctions and surgical procedures, often have severe end-stage coronary heart disease characterized by varying combinations of myocardial ischaemia, ventricular dysfunction, and ventricular arrhythmias. For all these patients, one of the most significant advances has been the emergence of a variety of test procedures designed to identify both the risk of early recurrent coronary events and the long-term prognosis. These assessments are typically exercise-based, and are designed to distinguish patients who can perform reasonable levels of activity without adverse consequences (low-risk patients) from those with a very limited exercise capacity in whom there is early onset of myocardial ischaemia, ventricular dysfunction, or serious arrhythmias. An intermediate risk group can also be identified. This delineation can serve as a basis for recommending not only medical and surgical therapies but also exercise (including the need for and intensity and duration of professional supervision of exercise). It can also serve as a guide to the resumption of work and other pre-illness activities.

At these extremes of the coronary risk profile, computation of morbidity and mortality is unlikely to be a sensitive measure of the outcome of rehabilitative or other interventions. For very low-risk coronary patients, the morbidity and mortality are so low, at least in the short term, that any intervention is unlikely to affect the outcome. On the other hand, the outlook in end-stage coronary disease is so uniformly poor that other measures are required to ascertain the benefits of any intervention.

Prominent among these are likely to be quality of life measures, which are related to an individual patient's perception of improvements in physical, social, and emotional status, and the value he or she places on such improvements.

Other categories of patients now considered candidates for exercise training during rehabilitation include those who have undergone cardiac valvular surgery, those (both adults and children) who have undergone surgical correction or amelioration of congenital heart disease, those with cardiomyopathy and ventricular dysfunction of other etiology, those with implanted cardiac pacemakers and cardioverter-defibrillators, and even individuals who are recovering from cardiac or cardiopulmonary transplantation.

These categories include large numbers of elderly cardiac patients. In both developed and developing countries, the numbers of "frail elderly" – the oldest members of society – are increasing more rapidly than any other population group. For many elderly patients with cardiovascular disease, return to remunerative work is often not an appropriate outcome measure of rehabilitation: rather, the attainment and maintenance of an independent lifestyle is an outcome that is valued both personally and, given the high cost of institutional care, by society. Thus, small improvements in capacity for physical work may exert a major and favourable impact on the quality of life of elderly cardiac patients.

In addition to the more favourable functional status and prognosis in a variety of cardiovascular illnesses, which reflect improved medical and surgical therapies, changes in a number of aspects of rehabilitative care *per se* have substantially influenced its application.

First, there is evidence that patients classified by stratification procedures as being at low risk can safely exercise without medical supervision and safely and promptly return to pre-illness activities, including remunerative work. Further, it is now accepted that exercise training of low to moderate intensity can produce improvements in functional capacity comparable to those produced by higher intensity exercise. The lower intensity exercise is characterized by greater safety, which is particularly important if exercise sessions are unsupervised; it causes less discomfort and is more enjoyable, and thus makes adherence to the recommended exercise regime more likely. Among patients who can safely perform modest levels of dynamic exercise, the relative safety and substantial value of low-intensity isometric or resistive (strength training) exercise have also been identified. That patients receiving all types of antianginal drugs can benefit from exercise training has been extensively documented. Cardiac enlargement and compensated heart failure are no longer considered contraindications to physical activity, and exercise rehabilitation has improved functional status. Another important observation is the lack of correlation between the extent of ventricular dysfunction and physical work capacity.

Greater attention is now being devoted to the educational and counselling components of rehabilitative care, with new techniques being applied in

these areas as well. Prominent among these is the behavioural approach to reducing coronary risk; this comprises not only transmission of information, but also practical training in the skills needed for adoption of a healthy lifestyle, and provision of opportunity to practise and reinforce these skills. To achieve successful lifestyle changes, patients must actively participate in the management of their disease. Evidence that favourable modification of coronary risk factors can not only limit progression of the disease but even induce regression of the underlying atherosclerosis has encouraged efforts in this area. This is particularly true for individuals with accelerated atherosclerosis, manifest as myocardial infarction or a requirement for myocardial revascularization procedures. The importance of the family – and often the workplace – in encouraging and reinforcing efforts to reduce coronary risk is increasingly acknowledged. It is thus essential that health care professionals at all levels are trained to be effective teachers of their patients.

Perception of health status is recognized as having an influence on clinical outcomes; for example, the perceived ability to exercise correlates better with resumption of work than does objective measurement of exercise capacity during formal testing. There is also substantial correlation between perception of health status and return to usual family and community activities, and recreational and occupational pursuits. Importantly, this perception can be favourably altered by education and counselling.

Psychological problems, predominantly anxiety and depression, are recognized as greater obstacles to the resumption of pre-illness activities by coronary patients than physical incapacity. Return to work is increasingly viewed as an outcome measure that is economically, physically, and socially relevant to a wide variety of coronary patients, but one that may relate poorly to restoration of functional capacity. Total restoration of functional status, occupational as well as physical, remains a challenge to be met.

Another major development is the emphasis that is now placed on the need to tailor rehabilitative care to the needs of the individual, basing it on the patient's clinical status, personal desires, and requirements for specific interventions. This approach is likely to prove more successful, and more cost-effective, than the indiscriminate application of multiple components of rehabilitative care.

Rehabilitative interventions are increasingly undertaken in children and young adults with a variety of cardiovascular disorders. The growing quantity of information about appropriate techniques for these interventions warrants wider dissemination. Medical and surgical treatments have significantly improved longevity in children with cardiovascular disease; subsequent comprehensive rehabilitation will thus have long-term economic and social benefits. Surgical treatment is available for over 95% of congenital cardiac lesions, yet postoperative results after successful surgery show that these children fail to achieve the

same functional capacity as their healthy peers. Children with cardiac disease require significantly different physical activities from adults, and the educational and counselling requirements for both the children and their families are also different. Comprehensive cardiac rehabilitation for children is cost-effective and prudent, benefiting individual patients and the society in which they live. Moreover, a large percentage of cardiac patients in developing countries are children and adolescents. Specific attention should therefore be directed to disseminating rehabilitative guidelines and promulgating the implementation of appropriate programmes for this section of the population.

## 1.2 **Structure of the report**

It was the task of the Expert Committee to identify the current status of rehabilitative care for cardiac diseases, highlighting and interrelating four aspects:

- implementation of cardiac rehabilitation in developing countries;
- exercise testing and training in the rehabilitation of children and young adults with cardiovascular disease;
- rehabilitation of severely disabled cardiac patients with medically complex problems;
- current and future approaches to education in the rehabilitation of patients with cardiovascular disease.

During its deliberations the Committee has assumed that a medical diagnosis of cardiovascular illness must be made if rehabilitative care is to be initiated. In this, the Committee's recommendations differ from those concerned with primary prevention of cardiovascular disease. The recommendations for rehabilitative care have been formulated for cardiac patients characterized as being at high, intermediate, and low risk of early recurrence of cardiovascular events and thus at high, intermediate, and low risk for exercise training. Additionally, the recommendations for functional assessment of patients and for physical activity components of care are divided into those feasible and appropriate at facilities equipped for basic, intermediate, and advanced levels of care.

Recommendations are addressed particularly to medical practitioners involved in a variety of fields, including primary care, cardiovascular medicine and surgery, paediatric cardiology, rehabilitation medicine, sports medicine, occupational medicine, geriatrics, and medical insurance, as well as to non-physician health professionals working in rehabilitative care. Some are also aimed at governmental and voluntary health organizations and agencies and professional medical societies that are instrumental in the areas of public health policy, regulation, and legislation, as well as at educational institutions responsible for the professional training and postgraduate education of health personnel involved in cardiovascular care.

Certain of the Committee's recommendations are concerned with the

results that cardiac patients, their families, teachers, and employers can reasonably expect from rehabilitative care. The Committee finally suggests a variety of roles that can be played by international bodies, including WHO and the International Society and Federation of Cardiology, in supporting or implementing studies, projects, training programmes, etc., designed to enhance the availability and efficacy of rehabilitative care and thus to improve the outcome of cardiovascular disease for patients of all ages.

## **2. Implementation of cardiac rehabilitation in developing countries**

### **2.1 Goals for implementation**

In order to define the nature of the rehabilitative care required for cardiac patients, especially in developing countries, it is helpful to identify the goals of rehabilitation. These may be briefly stated as follows:

- Rehabilitation care should be available to all patients with cardiovascular diseases in all countries.
- Every professional health care worker, and the general public, should be aware of the need for cardiac rehabilitation.
- Appropriate education should be provided to all cardiac patients and their families, and to all health care professionals involved in cardiovascular rehabilitation.
- The type of cardiovascular rehabilitation programme should be matched to the needs and resources of each community, and there should be provision for periodic re-evaluation of the programme.
- Cardiac rehabilitation should be integrated into the existing health care delivery system of each country.

### **2.2 Entry assessment for rehabilitation**

Assessment of a patient for entry into a cardiac rehabilitation programme requires:

- a diagnosis of the cardiac condition, prescription of appropriate medical or surgical treatment, and an opinion on further prognosis and risks;
- identification of the appropriate type of cardiac rehabilitation;
- evaluation of the patient's condition as a basis for future surveillance and further evaluation.

### **2.3 Programme requirements**

In establishing a cardiac rehabilitation programme, the following needs should be considered:

- trained personnel
- physical facility, equipment, and educational materials
- financing arrangements (within the context of the existing health care system)
- programme of exercise and patient education.

These four elements are discussed below for each of the three possible levels of cardiac rehabilitation facility. The simplest level delivers cardiac rehabilitation at the local community level (*basic facility*). At the second level cardiac rehabilitation is developed within a local town or city hospital (*intermediate facility*). The third level is the establishment of a cardiac rehabilitation centre associated with a major medical centre (*advanced facility*).

### 2.3.1 **Basic facility**

A basic rehabilitation facility is located in a village or community and integrated into existing local community health services.

#### *Personnel*

A trained community health worker, preferably a health professional, is required to operate the facility.

#### *Physical facility, equipment, and educational materials*

Any available community centre (local meeting place, hall, school, or place of worship) may be used for the facility. A sphygmomanometer, preferably with a stethoscope, should be available, and the health worker should be able to check patients' pulse rates. Educational material and charts and a suitable area for a walking exercise programme are required.

#### *Financing*

It should be possible to finance the facility from the resources of the existing health care system.

#### *Programme of exercise and patient education*

A minimally supervised exercise programme of low or moderate intensity should be followed (3). It should preferably be conducted in a group setting and consist of calisthenics and light exercise (see Annexes 1 and 2). Patients and their families should be given a certain amount of basic information (see section 5.4) and their long-term compliance with the programme should be encouraged.

### 2.3.2 **Intermediate facility**

An intermediate facility for rehabilitation is normally located in a local hospital where general medical services are available.

#### *Trained personnel*

A facility of this type requires the following categories of trained personnel:

*Physician.* At least one physician should be trained in cardiological

practices, including exercise physiology, exercise testing, cardiac rehabilitation, and cardiopulmonary resuscitation techniques. This physician, who will have overall responsibility for the service, may be the only fully trained person available at this level and may have to train all other personnel.

*Nurse/health professional/administrative assistant.* Personnel at this level will often have to fulfil several functions and therefore be trained as, for example, exercise specialists, physical therapists, or dietitians. They may need to be sent to other facilities for specialized training. There must be at least one clerk/secretary to help maintain records and perform other administrative functions. All or some of these personnel may be part-time and may have additional responsibilities elsewhere in the hospital.

#### *Physical facility and equipment*

An intermediate facility will require at least one office for administrative purposes. It will also require a multipurpose exercise room with one area specifically for exercise testing (with treadmill, bicycle ergometer, or at least steps). A 3-channel ECG recorder and display (or at least a single-channel ECG machine with a modified exercise lead but without monitor) should be available. Another area could serve as classroom, but the main space should be reserved for exercising.

#### *Financing*

A simple budget plan is required, even for the smallest facility of this type.

#### *Programme of exercise and patient education*

A minimally supervised exercise programme of low to moderate intensity should be followed. It should preferably be conducted in a group setting and consist of calisthenics and light exercise (see Annexes 1 and 2). Patients and their families should be given a certain amount of basic information (see section 5.4), and their long-term compliance with the programme should be encouraged. It should be noted that for patients returning to certain high-intensity, demanding jobs, a higher level of exercise training may be necessary, either to improve their general fitness or to increase muscular strength for specific tasks (4).

### **2.3.3 Advanced facility**

The advanced cardiovascular rehabilitation centre is associated with a major medical centre where medical services of high standard are available. It should be a leading referral centre for patients with cardiovascular diseases.

#### *Trained personnel*

An advanced rehabilitation centre requires the following personnel:

*Medical director.* The director should be a trained cardiologist with experience in rehabilitative techniques.



*Programme co-director.* The co-director of the programme should be a highly trained health professional.

*Exercise specialist.* This person should have extensive knowledge of exercise physiology and practical experience in cardiac rehabilitation.

*Administrative executive*

*Physiotherapist*

*Dietitian*

*Occupational/vocational therapist.* This person must have background experience and preferably specialized training in this area.

*Psychologist*

All or some of these personnel may be part-time and may have other responsibilities elsewhere in the hospital.

*Physical facility and equipment*

An advanced facility will require offices for senior medical staff, for examination of patients, and for administration. There should be an exercise testing area and a comfortable exercise room and/or gymnasium with exercise testing and resuscitation equipment. Access to two-dimension echocardiography and a nuclear medicine facility is essential. Classrooms for lectures/counselling and a library/audiovisual room are required and there should be space for special clinics and blood collection.

*Financing*

A budget plan should be developed, appropriate for the programme that will be undertaken at the tertiary level.

*Programme of exercise and patient education*

In a fully equipped and staffed cardiac rehabilitation centre, it is possible to select either a high-intensity exercise training programme which requires exercise testing (possibly with imaging and monitoring) or a non-equipment-based exercise programme of low or moderate intensity as recommended for basic and intermediate rehabilitation facilities.

In making the choice of programme, it is important to embrace the concept of risk stratification and to be aware of the relative benefits and risks of high-intensity and low- or moderate-intensity exercise programmes. Accurate clinical risk stratification is possible (5, 6) for most patients (see Annex 3), but exercise testing and other investigations may be required in selected individuals. In an advanced medical centre, the recurrent evaluation of clinical accuracy will justify the costs involved by confirming the value of the techniques used and underlining their cost-effectiveness.

The minimal difference in outcome between high- and low-level exercise training programmes (7, 8) has led some centres to reduce the level of

physical training in their cardiac rehabilitation programmes. If a high-intensity exercise programme is followed, the approach recommended by the American Heart Association should be adopted (4). High-intensity exercise programmes necessitate exercise testing (9; see Annexes 4, 5 and 6). If an exercise programme of low or moderate level is preferred, this could be based upon calisthenics and light exercise (see Annexes 1 and 2). However, the same educational programme is required (see section 5.3) regardless of the type of exercise programme.

## **2.4 Special considerations applicable to diagnostic groups**

### **2.4.1 *Coronary heart disease***

The categories of patients with coronary heart disease and its complications who may need rehabilitation services are the following:

- those who have sustained myocardial infarction;
- those who have been admitted to hospital for unstable angina;
- those with chronic ischaemic heart disease who are starting an exercise programme;
- those who have undergone coronary bypass surgery and percutaneous transluminal coronary angioplasty.

The largest group will be patients who have sustained acute myocardial infarction, and this should be taken into consideration in planning personnel training and facilities for exercise programmes.

Risk assessment of patients entering exercise programmes is essential, as is the identification of any factors that would contraindicate exercise. Individually prescribed exercises should take account of the degree and type of surveillance necessary for safety and for assessment of results. It is also important to assess patients' education needs and to develop plans for secondary prevention. Any special needs (e.g. psychological or vocational) must also be considered.

### **2.4.2 *Rheumatic heart disease/congenital heart disease***

In many developing countries, rheumatic heart disease is a problem of childhood, adolescence, and young adulthood. The disease progresses rapidly and few of those affected survive into middle age without proper medical and surgical treatment. In both rheumatic heart disease and coronary heart disease, many of the common residual defects and haemodynamic derangements leave post-surgical patients with varying degrees of disability. This is further compounded by problems of chronic anticoagulation in patients with mechanical prosthetic valves.

Patients who may need rehabilitation generally belong to one of the following categories:

- those who have become inoperable or whose lesions are too complex for the available surgery;
- postoperative patients in whom results and prognosis are good;

- postoperative patients with significant residual defects;
- those who need chronic anticoagulation and prophylaxis for rheumatic fever.

While patients with rheumatic heart disease and congenital heart disease may have to be cared for in the same rehabilitation facility as those with other cardiac problems, it is apparent that patients in the first group may be of a very different age and will need special care and assessment. These concepts are further developed in later sections (see sections 3 and 5).

#### **2.4.3 *Cardiomyopathy***

Cardiomyopathies are heart muscle diseases of unknown origin and are classified as (a) dilated, (b) hypertrophic, and (c) restrictive varieties. They are distinct from specific heart muscle diseases of known cause or associated with disorders of other systems. The most common are the dilated and hypertrophic varieties, while the restrictive variety, though rarer in many countries, is common in Africa and South America. All ages and both sexes are affected. The disease may be very mild and chronic, or severe enough to result in death in a short period of time. There is increasing evidence that some form of exercise is of benefit to patients with dilated cardiomyopathy. Careful exercise training may result in sufficient peripheral cardiovascular and musculoskeletal adaptation for there to be significant improvement in effort tolerance; it can thus transform a totally dependent person into one capable of independent self-care and even of training for a sedentary job.

It has become apparent that exercise capacity may not correlate with left ventricular function in the individual patient. The special needs of patients with cardiomyopathies include strict medical management of congestive failure and arrhythmias. Some patients with dilated cardiomyopathy will need long-term anticoagulation, and exercise in hypertrophic cardiomyopathy may carry the risk of arrhythmia and sudden death.

Requirements for trained personnel, facilities and equipment, patient evaluation, exercise programmes, and surveillance are no different from those discussed previously for medically complex cardiac patients, and need only to be suitably modified for the local conditions in a developing country.

#### **2.4.4 *Pregnancy in patients with heart disease***

In planning the care of pregnant women with heart disease, certain information is essential:

- Is this a planned pregnancy in a patient with a mild or corrected lesion who has been medically evaluated and cleared for pregnancy, or is it an unplanned pregnancy in a patient with either a previously undiagnosed cardiac condition or an inadequately treated or severe cardiac condition? Obviously, the risk is higher in the latter case than the former,

and such a patient may need to be referred to a specialized centre or considered for termination of pregnancy when appropriate.

- What is the functional class of the pregnant patient? Irrespective of the etiology of the heart disease, there is a clear relationship of fetal loss and maternal morbidity and mortality to the functional class of the patient before and during the pregnancy. The highest morbidity and mortality occur in patients of classes III and IV (see Annex 7).

While pregnancy is not usually a problem in a number of cardiac conditions, it is generally a high-risk situation and may be contraindicated in the presence of severe right ventricular hypertension or Eisenmenger reaction, severe aortic stenosis, peripartum heart disease, Marfan syndrome, or severe coarctation of aorta. Correction of disease and disability must be attempted before pregnancy is considered. A patient must also be informed of the greater chances of transmission of heritable disease to the child, particularly in the case of Marfan syndrome.

## 2.5 **Non-equipment-based exercise training**

Clearly, programmes that rely heavily on equipment-based exercise techniques will encounter financial difficulties in acquiring equipment and maintaining it in good working condition, and in training the necessary personnel. For most developing countries, particularly in rural areas, such programmes are an unrealistic proposition. Thus, non-equipment-based cardiovascular rehabilitation programmes are the most practicable option for developing countries.

### 2.5.1 ***Important considerations in design of a programme***

In designing a non-equipment-based exercise programme to be both efficient and cost-effective, certain critical factors must be considered. These factors relate to the individual patient, to the resources available in the patient's community, to the patient's physical environment, and to the national health care structure.

The second stage in design involves considering the type, severity, and prevalence of cardiovascular disability and choosing appropriate types of non-equipment-based exercise with well defined minimal end-points or goals. These considerations govern the choice of potential exercise sites.

*Stage I: Consideration of socioeconomic, cultural, and physical factors related to the patient and the environment*

*The patient.* In both equipment- and non-equipment-based programmes, the ability to communicate with the individual is crucial for success. The health professionals involved should be able to explain the content and purpose of the exercise programme to each patient, and should anticipate – and be prepared to answer fully – the questions that patients are likely to ask. This may involve preparing appropriate educational and instructive materials.

Routine information that should be recorded for each patient includes age, sex, and anthropometric measurements related to body size and other relevant characteristics. Information on sociocultural factors such as the time, type, and size of major daily meals, sleep patterns, sexual habits, and religious practices may be critical to the implementation and outcome of an exercise programme. Since professional and psychosocial integration are important goals of most rehabilitation programmes, information on profession and/or income (in the sense of employment or unemployment, physical or sedentary work) may be important but is unlikely to be particularly relevant in some rural settings. Careful investigation and understanding of the “role” of the individual in a given social or cultural setting may be crucial. The concept of the “individual” may be quite complicated in some cultures where there is a strong sense of “collectivity” and where the accomplishments of “all” rather than those of the “individual” are emphasized. Moreover, an understanding of some of the rites and taboos (such as those related to sexual practices or to standards of dress, e.g. requiring the head or face to be covered) may reveal certain limitations in terms of potential programme options for some individuals.

*Resources available in the community.* It is essential to have detailed information on all potential health facilities available in each community, from basic health units to relatively sophisticated and more complex units such as hospitals, paying particular attention to details such as their capacity and capabilities. Since these units will be sources of patients, points of reference around which rehabilitation centres will be located, or resources for training the health professionals who will be involved in rehabilitation programmes, the potential value of this detailed information (particularly in regard to handling complications or accidents) cannot be overemphasized. Equally detailed attention must be given to transportation facilities and the quality of the road network available in each community. Local schools or other educational facilities, places of worship, clubs, and cultural groups may provide suitable environments for initiating programmes in which group participation, education, and interpersonal communication are important elements.

The heterogeneous nature of most urban communities in developing countries renders any rigid distinction between rural and urban settings – in terms of health care potential and availability – invalid. Some individuals in urban communities will be able to afford and benefit from the most modern equipment- and non-equipment-based exercise programmes, where others in the same communities may be limited to non-equipment-based programmes as the only option. Similarly, individuals in rural areas that are close to urban communities may be able to benefit from both equipment- and non-equipment-based programmes.

*Physical environment and climatic conditions.* Non-equipment-based exercise programmes may be undertaken indoors or outdoors but, in either case, air quality, the effects of altitude, and potential temperature

and humidity variations must be carefully assessed. In regions where highways and pedestrian areas are not separately designated, appropriate flat or sloping open areas must be identified. If nowhere suitable is readily available, closed structures of appropriate dimensions can be erected, or pedestrian paths or open spaces created by the community. Aquatic exercises may be an option for some cardiac patients with other physical disabilities, although the necessary degree of supervision, the need for initial training of personnel, and other safety considerations may make this an unrealistic option.

*The national health care structure.* Most programmes should be designed to permit their easy integration into the existing health care structure in order to limit operating costs and ensure continuity. In most developing countries, the private sector is scarcely established, and the state remains the major health care provider, a fact that is particularly critical for rural communities. The most difficult task in establishing new programmes may be to alert governments to the growing significance of cardiovascular disorders and the costs of resulting disability, and to convince them of the importance of rehabilitative and preventive techniques in reducing actual and potential health care costs.

Consideration should also be given, however, to other sources of health care, such as nongovernmental organizations, whose contributions in terms of financial and human resources, and to some extent infrastructure, may be important determinants of implementation of rehabilitation programmes in a particular community or region.

### *Stage II: Consideration of medical and technical factors*

*Type and degree of cardiovascular disability (10).* It is important to consider the type and degree of functional impairment, i.e. to examine the relationship between functional class, clinical status, and maximal oxygen consumption (see Annex 7).

*Principles and types of non-equipment-based exercise training.* It has been clearly shown that the intensity and frequency, and the rate of increase in intensity and duration, of exercise are crucial determinants of the benefits of exercise training. It may be extremely useful to develop a subjective “quantitative” scale based on the patient’s own perception of exertional intensity: this might be similar to the Borg scale (11; see Annex 8).

## **2.5.2 Selection of an exercise programme**

In the final selection of an exercise programme, the following considerations are of prime importance:

- Each exercise protocol must be adaptable to or integrated into a general multidisciplinary programme of cardiovascular rehabilitation.
- The choice of an exercise programme must be guided by clearly stated goals regarding the future role of the patient in a given community or

particular sociocultural setting, and by whether or not these goals include the patient's resumption of work.

- When decisions on possible exercise intensity are being made, a concept of energy expenditure (combining elements based on patients' own perception of expenditure and the actual energy expenditure involved in a given activity) should be used in counselling and motivating patients (9, 12; see Annexes 9 and 10).
- Most studies suggest that a reasonable duration for high-intensity exercise sessions is 20-30 minutes (at least three times a week for at least 6-8 weeks) and that this leads to significant improvement in physical working capacity. However, similar improvements can be achieved with a lower intensity exercise programme (30-60 minutes in duration, at least twice a week for 6-8 weeks). Both types of programme should be supplemented by walking and other moderate activity at home and in the community.
- At leisure and at work, most patients can function satisfactorily at 50-70% of peak physical working capacity for short periods. For sustained effort, a comfortable level is about 30% of peak physical working capacity.
- The choice of the type of exercise and the exercise site must take into consideration:
  - The quality and availability of trained personnel to implement and supervise the exercise.
  - A well defined strategy for handling potential accidents and complications. This may involve training personnel to recognize problems and to administer cardiopulmonary resuscitation to patients if the need arises. A minimal chain of communication, with carefully formulated plans for evacuation of patients to units with more resources, is important, especially when high-risk patients are involved.
  - The physical environment, including the effects of altitude and other climatic variables (temperature, humidity, and air quality in general).
- It is essential to train and maintain teams of personnel capable of designing, implementing, supervising, and evaluating exercise programmes. These teams may be based in central and well developed health facilities and be responsible for training other personnel for peripheral health units with particular emphasis on the education of patients in each community.

### **2.5.3 *Special considerations for non-equipment-based exercise training and education in remote areas***

Communication, accessibility, and sociocultural considerations may be limiting factors for education in most rural communities in developing countries (13). Education cannot be effective if these factors present significant obstacles. Financial investment and investment in trained human resources are frequently the only options available to overcome these obstacles.

Sociocultural factors may be quite subtle, so that considerable insight is required to design an effective programme capable of producing acceptable results. For instance, standard energy expenditure tables use terms like “light or heavy housework” and give the associated metabolic cost of such activity. “Housework” for a woman in a rural community may include fetching water, which may frequently involve carrying heavy containers several times daily over considerable distances. The role of a 9-year-old in a similar community may involve activities with associated energy expenditure levels usually expected of adults. In some cultures, individuals can be ostracized if they are unable to assume the minimal roles expected of them; the repercussions of this social rejection may range from damage to the psychological equilibrium of the individual to the eventual disintegration of entire family groups.

In developing countries, the distribution of types of problem, socioeconomic factors, and people’s access to health care are quite different from those in developed countries. Different types of cardiovascular disease require different programmes, but most requirements can probably be met by simple community-based programmes working with groups of patients with family support. Although the requirements of patients in small towns and villages are likely to differ somewhat from those of patients in cities, the aim for all should be minimal sophistication within the framework of good medical and community practice at affordable cost.

In summary, lower intensity programmes are an attractive solution to the problem of exercise rehabilitation: sophisticated testing is not required for the vast majority of patients, and even relatively simple testing may be unnecessary for most.

## **2.6 Assessment of patients for return to work**

The assessment of patients with cardiovascular disease for ability to resume work depends upon the exact nature of the disease and upon the type of work to be undertaken.

### **2.6.1 *The nature of work and its physical demands***

The physical demands of a wide range of specific activities undertaken in different occupations are set out in Annex 9, where the work done is expressed, in terms of oxygen consumption, as metabolic equivalents of the task (METs). For the average person,  $1 \text{ MET} = 3.5 \text{ ml O}_2/\text{minute per kg of body weight}$ , which is oxygen uptake at rest. Oxygen uptake is a guide to the effort required for a specific task, but considerable variation occurs according to the duration and pace of activity. It is therefore also important to have an understanding of the nature of the work being undertaken.

#### ***Managerial, secretarial, or clerical work***

This type of work is not usually physically demanding. Moving about an office, carrying files, filing documents, etc. should be regarded as generally



beneficial and can be undertaken at a pace chosen by the individual. Stairs can be managed, if necessary, at a slow pace or a few at a time. Since an office job seldom requires energy expenditure in excess of 3 METs, this type of work could be physically performed – and therefore resumed – by all who have the appropriate skills.

#### *Office support work*

This type of job may involve cleaning, removal of waste, shifting of files, and movement of furniture. Assistance is often available, and it should therefore be possible to undertake the work at a chosen pace. While short periods of greater effort may be needed, the energy requirement of most office support work would usually be in the range 3-5 METs; the work should thus be possible for most cardiac patients.

#### *Production line work*

Work on a production or sorting and packing line in a mechanized factory usually involves repeated rapid movement of the arms and a degree of mental alertness. Some workers are seated and others may have to stand; there may be a need to move from one production line or machine to another at intervals. The effort involved in the arm movements is relatively low – about 2-4 METs – but greater than in office work. The energy requirement may be as high as 4-5 METs when rapid movement between machines is needed, but this is intermittent and of short duration. Work of this type should be within the capacity of all cardiovascular patients except the most severely disabled.

#### *Factory work*

The physical requirements of work in factories where there is little or no mechanization can be extremely variable. Operating a lathe or press may involve little effort, but there may be an intermittent need to lift or move material of sufficient weight or bulk to require significant muscular or straining effort. Although such efforts may appear strenuous to the coordinator of a rehabilitation programme, to a patient who has worked in this type of job for years they may seem negligible. The opinion of the patient regarding his or her capacity to manage a particular job is thus most valuable. The nature of the straining efforts required may necessitate a visit to the work site to evaluate a patient's fitness to return to work; alternatively, it may be possible to modify the job or provide on-site assistance. As factory workers have commonly acquired specific skills or received specific training, an employer may be prepared to consider providing alternative work that will make use of those skills but involve considerably less straining effort.

The energy demands of factory work are usually in the range 3-5 METs, but this figure takes no account of the occasional, short-lived demand for efforts with an energy requirement that may exceed 10 METs, sometimes with a significant isometric content.

### *Outdoor heavy industrial and construction work*

The degree of effort required in heavy outdoor work depends upon the availability of mechanical handling devices, elevators, and other aids. Where these are not available, the work is highly physically demanding. Building materials, for example, may have to be carried, loaded onto lifting devices at ground level, and then lifted by cranking. They may have to be carried up stairs, ladders, and scaffolding at the work site. A worker may do this alone or form part of a chain, passing material upwards from hand to hand. Although the most strenuous efforts may be intermittent, their energy demands may be as high as 7-10 METs over several minutes or longer. Such work is generally unsuitable for cardiac patients with any significant functional impairment.

### *Rural work*

*Traditional rural work.* Many of those involved in traditional rural work have also persisted with traditional, physically active, non-smoking lifestyles and prudent diets. As a result, acquired coronary heart disease is appreciably less common in their communities than rheumatic or cardiomyopathic problems.

Jobs such as vegetable cultivation or rice planting and harvesting are usually conducted at a steady pace requiring moderate efforts and commonly involving arm work and bending. The work level of 3-6 METs should be within the capacity of all patients except those with incipient cardiac failure. Certainly, those with controlled atrial fibrillation or drug-controlled cardiac failure should be able to resume work of this nature. On a family farm, even patients who are quite severely incapacitated could undertake some of the work on a part-time basis. Employees, however, may find that pressure from overseers or farm managers to complete tasks within a limited time could prevent them from resuming or continuing work of this type.

*Mechanized rural work.* In operating a tractor or other mechanical farming equipment, the actual driving demands little effort; however, twisting and turning to observe the progress of the equipment is more demanding. Adjusting and changing equipment can involve very considerable straining effort, which may well be beyond the capacity of the deconditioned, apprehensive, or partly disabled cardiac patient unless assistance is available. This aspect of mechanized rural work would thus need to be carefully assessed in considering a patient's return to work. The intensity of effort could be significantly lessened by attachment of jockey wheels to equipment or by the use of jacks, but these are usually unavailable.

*Farm produce handling.* From time to time, rural workers have to undertake the bulk handling of farm produce. This involves the lifting, carrying, and stacking of bags or boxes that may weigh about 50 kg, and stacking bales of grass, straw, and other products that each weigh about 25 kg. During a harvest, this effort may have to be sustained for many hours each day. The work is stressful to muscles and the cardiovascular system,

and cannot be managed by patients with impaired cardiac function or by those who are generally deconditioned or unfit. It is likely to lead to musculoskeletal chest pain after cardiac surgery. After conditioning and rehabilitation, patients with stable coronary heart disease can often manage such work, but this is rarely the case for those with rheumatic heart disease or incipient cardiac failure from other diseases. Many patients, however, could manage handling of rural merchandise on a non-harvest basis, i.e. removing smaller quantities from the stack for domestic use, sale to the public (not in bulk), or feeding to animals.

#### **2.6.2 *The effect of climate***

While the degree of effort required for particular work is readily appreciated, the pace of work in a hot, humid environment or at high altitude should also be considered. Rehabilitation programmes should therefore be conducted in an environment similar to that in which patients will resume work. It is inappropriate to conduct rehabilitation programmes in air-conditioned areas, generally available only in major city hospitals, and draw conclusions about capacity to perform work that would be undertaken in vastly different climatic circumstances.

#### **2.6.3 *Assessment of work capacity***

Apart from clinical examination, assessment of an individual patient for return to work or for social reintegration involves consideration of several factors:

- the diagnostic group into which the patient most readily fits;
- the attitude and understanding of the patient's family;
- the nature and extent of the patient's work experience and the availability of suitable work;
- the cooperation of the potential employer.

#### **2.6.4 *Resumption of work after myocardial infarction***

Preparing patients for return to work and other normal activities after myocardial infarction should follow a similar pattern in developing and developed countries, with rehabilitation programmes directed towards restoration of both physical capacity and confidence. Individual assessment can be made after patients have spent some weeks in exercise programmes and discussion groups.

Patients in developing countries often have the additional benefit of good family support, even if sophisticated social services are lacking. However, the interviewing of spouses, in the course of assessment, particularly of women concerning their husbands, may be unacceptable in some societies. Psychological assessment may be interpreted as implying mental instability, and be similarly unacceptable. For government employees who are unable to continue working, pension plans or compensation for redundancy are usually available. Many of those who are privately employed work for family businesses and retirement or resumption of

employment is thus facilitated. For some patients, however, there may be no suitable arrangements, either for retirement or for return to work.

#### *Assessment and preparation of the patient*

Each patient will know the physical and psychological demands of his or her job and be well aware of the environment in which the work is performed. Assessment for return to work will therefore be facilitated by asking the following two questions early in the rehabilitation programme:

- What is the nature of the job to which you hope to return?
- What is the most strenuous or demanding aspect of the job?

The nature of work and possible problems related to its resumption should be the topics for at least one hour's group discussion during a programme of 6-8 weeks. Patients should be encouraged to talk about how they perceive their resumption of work and to raise any anticipated problems with the programme coordinator.

Many problems can be resolved by discussion with the patient and close family members, and one of the most important features of a rehabilitation programme, especially for severely disabled patients, is thus a thoughtful and well prepared educational programme for patients and their families. Group education, especially in developing countries, has proved to be a most effective tool for promoting hygiene, encouraging compliance with therapy, and teaching preventive measures. Clearly, the content of these programmes must take account of and be adapted to patients' educational, cultural, and ethnic backgrounds.

#### *Physically demanding work*

Any significant physical demands imposed by particular work should be defined; the patient's programme should then be modified to increase progressively the physical demands of specific activities, by repeated use of relevant muscle groups or by simulation of the actual work. Activities could include lifting weights, carrying buckets or boxes, or ascending stairs, steps, or scaffolding. Straining efforts and physical demands should be increased slowly and repeatedly until they can be achieved at the rate normally required in the work. It may be assumed that cardiac recovery has usually occurred within 2 months, and muscular recovery been achieved within 3 months of an acute myocardial infarction.

#### *Patients with poor recovery*

A patient who notices undue breathlessness, chest tightness, anginal chest pain, palpitations, or swelling of the ankles should be medically reviewed and treated appropriately. Once his or her condition has been stabilized with medication, the programme of increasing activity to normal work levels should continue. After cardiac surgery, major considerations in assessing fitness to return to work include incisional pain and psychological problems. The latter may require specific support and reassurance. For self-employed patients, appropriate modification of

work is usually no problem, but changes in the work pattern or specific tasks of employees may require agreement between patients, programme coordinator, and employers.

#### **2.6.5 *Patients with acquired or congenital heart disease***

In cases of acquired or congenital heart disease, patients usually attend a rehabilitation programme after an episode of cardiac failure. The episode is commonly provoked by the onset of atrial fibrillation or flutter, respiratory or other infection, or some other precipitating event. If comprehensive cardiac assessment and surgery are unavailable, the best that can be done for these patients is to ensure that the causal event has been controlled, physical deconditioning overcome, and function maximized. The stable optimal dosage of each medication a patient is taking should be established during a period of some weeks of light exercise and education. When heart rate is appropriate at rest and during light exercise, when there is no oedema, and dyspnoea is absent on light activity, the patient can be assessed for resumption of work and/or social reintegration. Work capacity is usually limited to non-strenuous tasks, which in some cases should be of short duration, physically non-demanding, and undertaken at a reasonable pace. Employers' cooperation is often required to ensure these limitations.

#### **2.6.6 *Work simulation***

Assessment of fitness to resume work may necessitate simulation of specific aspects of work. The physical stresses to which a patient will be subject should be identified early in the rehabilitation programme. Simulation is the next step, and should be as close to reality as possible. If the rehabilitation programme is conducted in a hospital, it may be possible to cooperate with another hospital or with workshops to achieve this. If rehabilitation takes place in a community setting, the cooperation of a suitable nearby work facility should be sought.

#### **2.6.7 *Work trial***

In some instances, a trial of fitness for work may be required at the actual workplace. If this is to be attempted, work simulation with substitute materials should already have been organized elsewhere. Employers, managers, overseers, and fellow workers are likely to have the same apprehensions about capacity to work and the safety of work as do patients, their families, and other members of the community.

#### **2.6.8 *Modification of physical work***

Work that is particularly physically demanding may often be accomplished with assistance from fellow workers or mechanical handling devices. Modification of demanding work that may be possible for the self-employed or for those working in a family industry may be difficult in a competitive work environment. Often, however, there may be only one or

two aspects of a job that are strenuous, in which case a simple modification of the task or tasks may make it possible for the patient to resume work. For example:

- carrying (separately) two containers of manufactured objects each weighing 25 kg rather than one container weighing 50 kg;
- lifting objects to mid-chest level rather than head height, or using a step so that part of the terminal lifting effort is made with the legs rather than the arms;
- using a hook or bar to pull materials from a platform rather than climbing and/or stretching for them.

## **2.7 Considerations for secondary prevention**

Education is an important element of secondary prevention and constitutes a major part of all rehabilitation programmes. Exercise increases cardiovascular functional capacity and reduces oxygen demand for any level of physical activity, although regular physical activity is essential to sustain the benefits of training. The risks of complication can be reduced by timely medical evaluation, appropriate supervision of exercise, and avoidance of strenuous activity among high-risk patients (see Annex 3).

### **2.7.1 *Coronary heart disease***

For patients with coronary artery disease there is great potential for secondary prevention. More precise identification of patients most likely to benefit from secondary prevention and other therapeutic measures should reduce morbidity and mortality for those participating in rehabilitation programmes.

In the urban centres of the developing countries, the predominant cardiovascular problems are hypertension and coronary heart disease. They represent the dominant cause of total mortality, especially among people aged over 50 years. Prognosis may be affected by all of the many factors that can adversely affect the baseline state of the disease and that may be liable to ethnic and cultural influences, e.g. risk of hypertension, changes in lipid metabolism, and the habit of cigarette smoking.

Increasing evidence supports the need for widespread application of specific measures to prevent recurrence after a first coronary event. In the short term, abstinence from cigarette smoking is extremely effective in reducing morbidity and mortality. In the long term, correcting serum lipid abnormalities appears to slow the progress of coronary atherosclerosis and may improve outcome (14).

Meta-analysis of trials of cardiac rehabilitation programmes applied in addition to standard care has revealed a significant reduction in mortality (15). In one long-term study of multifactorial intervention following acute myocardial infarction (involving exercise training and control of risk factors), follow-up of patients after 3 and 10 years showed that mortality

was lower in the intervention group than in the control group (who received no additional rehabilitative care) (16, 17).

Criteria for admission of patients to cardiac rehabilitation programmes vary in terms of the extent of myocardial infarction and residual cardiac function. This variability, added to poor adherence to the programmes, makes comparison of results from different rehabilitation centres very difficult. Generally, however, return to work after myocardial infarction is a parameter for evaluation of programme efficacy in patients of appropriate age and where jobs are available.

#### *Advanced rehabilitation programmes*

Advanced facilities for medically supervised rehabilitation programmes exist only in a limited number of places. Elements of these programmes include the following.

*Early post-infarction exercise testing.* Exercise testing soon after myocardial infarction may be useful in formulating plans for the discharge of patients from hospital, and in determining the activity threshold at which symptoms and signs appear. The safety of early exercise testing appears to be related more to the severity of the disease than to the interval between infarction and exercise testing or to the test protocol.

*Intermediate convalescence.* On discharge from hospital, patients should be able to perform customary activities at home and continue the activities started in hospital. The immediate objective of exercise training is thus the reversal of deconditioning. The patient is asked to walk every day on level ground, increasing the distance as exercise tolerance improves. Approximately 6 weeks after hospitalization, a symptom-limited maximal exercise test can be conducted. (Contraindications to exercise testing and reasons for termination of the exercise (18) are detailed in Annexes 11 and 12.) If results are acceptable, activity levels can be increased.

*Group programmes.* An exercise facility with trained personnel and monitoring equipment and the provision of educational components are essential for group exercise programmes. Patients should learn to monitor their own pulse rates and to recognize the symptoms of exercise intolerance.

#### *Intermediate and basic rehabilitation programmes*

*Group programmes.* Group programmes based on education and light exercise, even when monitoring and sophisticated technical facilities are unavailable, are ideal means of promoting secondary prevention (see section 2.3).

*Home programmes.* In small communities with limited resources, programmes of unsupervised but medically directed home exercise are common practice. In the developing areas, where the high cost of medically supervised exercise programmes and lack of appropriate infrastructure are limiting factors, home programmes represent the ideal approach to

physical rehabilitation. Exercise designed to train the specific muscles that the patient uses principally in his or her work should be included in the programme, as should guidance on secondary prevention and compliance with the programme.

### *Long-term programmes*

The concept of long-term rehabilitation programmes is equally applicable to advanced, intermediate, and basic facilities. The purpose of such programmes is to help patients retain and reinforce learned behaviour and to motivate them towards further progress. Long-term programmes are recommended for all patients and must therefore be cost-effective. However, it is possible to establish exercise facilities without expensive equipment. Both individual and group activities can help patients maintain changed behaviour and may also lead to behavioural changes in the community as a whole.

#### **2.7.2 *Non-coronary disease, including postoperative patients, with attention to anticoagulant therapy***

In patients with cardiomyopathy and valvular disease, haemodynamic variables may be only slightly altered at rest but become markedly abnormal during stress or exercise. Oxygen demand is met by means of an increase in the arteriovenous  $O_2$  difference. In stable patients, light exercise of major muscle groups may facilitate oxygen utilization and extraction and lead to improved physical performance. However, in cases of myocarditis or acute decompensation, exercise may prove to be hazardous and is contraindicated.

Patients with rheumatic heart disease should be taught the importance of antibiotic prophylaxis of infective endocarditis (19) and the regular use of antibiotics to prevent recurrence of rheumatic fever (20).

Cardiac surgery is advised when it is most likely to yield cure or prolonged palliation, particularly in cases of patent ductus arteriosus, atrial septal defect, ventricular septal defect, mitral stenosis, tetralogy of Fallot, and coarctation of the aorta. Some repairs are currently accomplished with percutaneously introduced devices. Reconstructive valvular procedures are not always wholly successful and further surgery may be needed. Biological cardiac valve replacements generally have the advantage of requiring no permanent anticoagulation, but their durability is limited. Other prosthetic devices necessitate permanent anticoagulant therapy.

In rehabilitation programmes, it is important to develop a general set of recommendations for all patients receiving anticoagulant therapy, but particularly to familiarize them with the method of administration and daily adjustment of the dose of the anticoagulant, and to teach them about drug interactions, complications, and the need for prothrombin time testing. Group discussions with patients, spouses, and other family members should be encouraged. Exercise for these patients must be carried out carefully to avoid trauma, bleeding, and other complications.



In summary, cardiac rehabilitation programmes facilitate functional recovery; associated education and counselling improve patients' psychological outlook. Moreover, inclusion in these programmes of a vocational rehabilitation component can yield significant economic benefits. As the principles of cardiac rehabilitation become more broadly applied, larger numbers of patients with cardiovascular disease will benefit medically, socially, and psychologically.

### **3. Exercise testing and training in rehabilitation of children and young adults with cardiovascular disease**

#### **3.1 Introduction**

Examination of circulatory and cardiac responses to stress is often much more sensitive and informative than evaluation of cardiovascular function at rest. Since exercise is a physiological form of stress, dynamic exercise testing (or ergometry) has become a valuable non-invasive method for diagnosis and evaluation of heart disease in children and young adults (21); many individuals with cardiovascular disease show abnormal responses to exercise as well as reduced endurance and functional capacity. In clinical practice, an objective estimate of performance or fitness can be obtained through standardized exercise tests (4).

Such tests provide objective and reliable estimates of physical working capacity and maximal oxygen uptake, and provide clues to the mechanisms that limit physical working capacity.

Exercise performance and working capacity may be limited by factors that include type and severity of heart disease, intolerance to stress, arterial oxygen saturation and acidosis, maximal heart rate, arrhythmia, blood pressure, stroke volume, cardiac output, and parental over-protection.

A multi-stage bicycle ergometry test is often used: heart rate, respiration, blood pressure, oxygen consumption, or other variables may be simultaneously measured and recorded while workloads are increased step-wise. Graded exercise testing helps in estimating cardiac reserve, obtaining an objective assessment of endurance, and identifying serious arrhythmias that may not be apparent at rest. The test can be performed with minimal risk to the patient.

Exercise tests are performed to:

- evaluate specific symptoms and signs that may be induced or aggravated by exercise;
- identify abnormal adaptive responses occurring in patients with cardiac and other disorders;
- assess the effectiveness of specific medical and surgical treatment;

- estimate levels of functional capacity for participation in vocational, recreational, and athletic activities; and
- estimate prognosis.

In deciding on the best approach to management of specific cardiac conditions and/or clinical situations, it is of great benefit to the clinician to combine the results of exercise testing with other relevant medical data.

## 3.2 General application

### 3.2.1 *Physical activity*

Many physicians rely upon the instincts of children with cardiovascular disease to regulate the intensity of their physical activity. The success of this approach, however, may be limited by the fact that other major risk factors may result in a morbid or fatal event. An abnormal fall or rise in blood pressure, significant ischaemia-like S-T segment changes, and rate, rhythm, and conduction abnormalities may occur in the absence of symptoms or a reduction in working capacity. Medical history and physical examination can often identify the children or young adults in whom exercise testing will contribute to clinical management.

Children and young adults with cardiovascular disease whose working performance and adaptive responses to exercise are normal can probably participate in various physical activities with no greater risk than normal individuals (21). During exercise testing, ventilation and respiratory gas-exchange, cardiac performance and function, myocardial perfusion, cardiac electrical stability, working performance, and perceived exertion can be assessed with techniques of reasonable sensitivity and reliability. Exercise testing can reveal the abnormal response to exercise and the intensity of exercise required to produce abnormality. Tests results, especially when combined with other relevant clinical data, provide information on which recommendations regarding physical activity in specific individuals can be based.

Physicians must be aware that a child with mild heart disease, or referred for cardiovascular evaluation and found to be normal may be restricted in physical activity by an over-protective parent. Exercise testing can provide a functional assessment for the physician to use in the education of both parent and child.

### 3.2.2 *Diagnosis and therapeutic intervention*

Exercise testing primarily identifies mechanisms of cardiovascular responses to stress. Myocardial ischaemic and exercise-induced arrhythmias can be identified with a high degree of reliability. Other abnormalities, such as restricted stroke volume causing a change in systolic arterial pressure and pulse pressure during exercise, can be inferred from

specific measurements and observations or from measurements made during routine testing. These abnormalities may occur in many different types of lesions that affect the systematic circulation and pulmonary systems.

Serial exercise testing using the same protocol before and after therapeutic intervention can provide valuable and objective information about the success of the intervention.

### **3.2.3 *Exercise training in rehabilitation***

Exercise testing is recommended in the evaluation of children and young adults with cardiovascular disease before special exercise training is undertaken in rehabilitation programmes. The evaluation will reflect an individual's exercise tolerance, suggest the appropriate type and intensity of exercise training, and perhaps indicate the required specific physical activity (8). Patients' progress and accomplishments in a special programme can be followed by serial exercise testing.

## **3.3 *Specific variables measured during exercise testing***

### **3.3.1 *Working capacity***

Working capacity, assessed by maximal oxygen uptake, power output, or work output, may be affected by the type of heart disease and its severity. Given estimates of working capacity, the physician can monitor the severity of a lesion, and prescribe appropriate recreational and vocational activities, special exercise training, and rehabilitation programmes.

### **3.3.2 *Cardiac rhythm***

In some patients with or without recognizable heart disease, abnormal changes in cardiac rhythm during exercise may be revealed by electrocardiogram. Exercise testing is useful in evaluating cardiac dysrhythmias in patients with specific types of disease (mitral valve prolapse and postoperative tetralogy of Fallot) and a history of sudden death in the family.

Premature ventricular contractions are a frequent clinical problem in patients without recognizable heart disease, and may be suppressed or aggravated by exercise. Ventricular dysrhythmias that are induced or aggravated by exercise, particularly in postoperative patients, should be taken seriously and evaluated for treatment with anti-arrhythmic drugs.

Atrial dysrhythmias may be affected by exercise: dysrhythmias that were considered insignificant at rest may become significant during exercise. Exercise testing should be included with other procedures (i.e. ambulatory ECG monitoring and electrophysiological studies) in evaluating cardiac dysrhythmias.

3.3.3 **Blood pressure**

Mean blood pressure increases during exercise primarily because of an increase in systolic pressure. Diastolic pressure changes are minimal. A lack of increase in systolic blood pressure, or a decrease below the normal resting level indicates serious impairment of cardiac performance. In patients with aortic valvular insufficiency, coarctation of the aorta, and systemic arterial hypertension, an exaggerated increase of systolic pressure may occur with exercise. An exaggerated systolic pressure response during exercise may thus have important implications for therapeutic measures and levels of physical activity.

3.3.4 **Exercise-induced S–T depression**

Myocardial ischaemia revealed by exercise-induced S-T depression occurs in several types of cardiac problems in the young (see Table 1), and the frequency and amplitude of the depression increase with the severity of the cardiac abnormality. There may or may not be associated chest pain. In severe disease, S-T depression tends to develop at lower levels of work than in mild or moderate disease. Information about S-T segments has been used in both medical management of patients and evaluation for surgical treatment. It is important to record the electrocardiogram for up to 10 minutes after exercise in order to increase the chance of observing any abnormal S-T depression occurring during the recovery period.

3.3.5 **Onset of symptoms**

The nature and time of onset of any specific symptoms should be recorded during the exercise test.

Table 1  
**Examples of conditions that can cause significant S–T segment depression during exercise in the young**

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Significant aortic stenosis
Significant pulmonary stenosis
Cardiomyopathies
Coarctation of aorta
Severe mitral regurgitation
Significant aortic regurgitation
Hypertension
Anomalies of coronary arteries
Severe chronic anaemia
Premature atherosclerosis
Kawasaki disease
Myocarditis
Mitral valve prolapse
Other myocardial diseases

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### 3.4 Principles of exercise testing

Exercise testing is used to determine patients' capacity to adapt to physical stress. In patients with heart disease whose capacity is severely impaired, exercise intensity should be increased stepwise, starting at a low level of physical activity. The following principles should be applied to exercise testing, to avoid risk to patients:

- A multi-stage workload test is preferred. However, a single-stage test, using the step test or a bending and stretching test, is acceptable in areas where resources are limited.
- Testing should begin at a work level below the estimated level of impairment.
- The workload at each level should be maintained for a sufficient time to stabilize the individual response: 1 minute for lower levels, 3 minutes for higher levels.
- Progress towards maximal working capacity should be achieved stepwise.
- As a minimum, it is essential to monitor the patient's general condition, plus blood pressure and heart rate, during each workload and during the recovery phase. Where resources are available, ECG monitoring is highly desirable.
- With due allowance for the medical care setting and local culture, informed consent should be obtained from patients before exercise testing.
- Exercise testing should be terminated in accordance with the commonly used criteria (see Annex 11).

### 3.5 Methods of exercise testing

#### 3.5.1 *General recommendations*

The patient (or parents or guardian) should be fully informed about the test, and should give written consent to its performance, on the understanding that testing will be terminated upon demand by the patient, parents, or guardian. The exercise test may be performed with the parents or guardian in the testing area; any decision to the contrary should be made at the local level, based on usual clinical practice.

Each patient should be given a general explanation of the equipment and test procedure as well as of the tasks expected during the test. He or she should avoid food intake for at least 2 to 3 hours before the study; comfortable clothing should be worn, with suitable soft, rubber-soled shoes (or bare feet). Medical history, including medications, physical examinations, and routine 12-lead electrocardiography (if available) should be reviewed to identify any patient for whom this test is contraindicated or should be performed only with special considerations. A cardiologist should be consulted before any patient with symptoms of cardiovascular disease is tested.

3.5.2 **Equipment**

*Basic level facilities*

*Step test* (see Table 2). The step test is simple, and the equipment is portable and highly suitable for testing in a doctor's office and for field studies. A constant step height and gradual increase in the rate of stepping are recommended for the test. Music of increasing tempo or a metronome can be used to increase the stepping rate. Pulse rate and blood pressure should be measured at specific intervals and recorded. The step ergometer can be constructed using locally available materials.

*The bending and stretching test* is used to evaluate changes in heart rate respiration, and cardiac arrhythmias. The subject squats 30 times, as rapidly as possible; there is minimal monitoring before and after the test.

Data for this and the step test in normal children are scanty; studies are needed for different populations and different conditions.

*Intermediate level facilities*

The *step test* may be used, but the *bicycle ergometer* is most appropriate in care facilities at the intermediate level. Normal data are available for each ergometer. The *bending and stretching test* may be used for evaluation of arrhythmias. *Single-lead electrocardiography* is useful in detecting regional ischaemia-like signs in varied types of congenital heart disease but of limited value compared with multi-lead ECG. However, heart rate, arrhythmia, and 85% of S-T segment changes during testing can be recorded using a single lead in the V5 position. During exercise, blood pressure can be measured using a *mercury sphygmomanometer*. Estimates of working capacity, assessment of heart rate, rhythm, and myocardial conduction, and blood pressure responses observed during tests with this equipment reflect cardiac performance and afterload resistance.

Table 2  
**Specifications for single step test<sup>a</sup>**

*Notes:* Sturdy construction and firm attachment of the step to the floor are essential.  
Rates below 60 paces/min may be uncomfortably slow, and rates above 180 paces/min may lead to tripping.

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Height:	23 cm (9 inches)
Width:	50 cm (20 inches)
Depth:	25 cm (10 inches)
Rate:	60–180 paces/min
Pacer:	metronome, or pendulum (weight attached to string, 150 cm long), or music

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<sup>a</sup> Source: reference 22.

### *Advanced level facilities*

The equipment available in advanced level facilities should include either a bicycle ergometer or a treadmill (but ideally both). Electrocardiographic equipment is essential and should be readily available; it should be able to monitor three leads of electrocardiographic data in different orthogonal vector planes simultaneously, and instrumentation should be available to record all data. A manual or automatic sphygmomanometer is also essential. For more objective measures of aerobic fitness, measurements of respiratory gas exchange are required. Measurement of oxygen uptake is standard for assessing fitness and the effects of training; appropriate equipment should be available in a paediatric cardiac centre. The Douglas bag type of apparatus for expired gas collection is adequate, but new devices are available which integrate a gas analyser and pneumotachograph with a microcomputer for oxygen uptake. Measurements of heart rate, blood pressure, oxygen saturation, ventilation, gas exchange, and end-tidal gas concentration are also possible with these computerized systems, which offer a high level of data processing and presentation.

### **3.5.3 Basic observations and measurements**

Certain basic observations and measurements should be made before, during, and after the exercise test. Some are made continuously and others intermittently, depending upon the particular test protocol.

- During the exercise test, the patient should be observed for *symptoms* of cardiorespiratory distress, such as chest pain, premature exhaustion, claudication, headache, dizziness.
- During the exercise test, the patient should be observed for *signs* of cardiovascular instability, i.e. pallor, sweating, inappropriate affect, and respiratory distress (such as wheezing).
- *Heart rate* can be determined by measuring the R-R intervals on the electrocardiogram or by using a digital heart-rate meter triggered by the electrocardiogram.
- S-T depression as evidence of myocardial ischaemia and dysrhythmias are detected by *electrocardiogram*.
- *Blood pressure* must be recorded from the right arm during the exercise test, with cuff sizes appropriate to patients' sizes where feasible; a conventional mercury sphygmomanometer or a remotely controlled pneumatic cuff system is recommended.
- Estimates of *working capacity* are made using the following indices from standardized exercise procedures:
  - maximal power output: the highest rate of work achieved during a continuous or intermittent graded test;
  - endurance time: total exercise time to exhaustion or to predetermined endpoints in a continuous graded test;
  - physical working capacity: the highest rate of work at which heart rate and respiratory rate do not exceed 170 beats/minute and 30 breaths/minute, respectively, during a continuous graded bicycle exercise;

- total work: accumulated work to exhaustion or to predetermined endpoints during cycle or treadmill exercise.
- *Ventilation and pulmonary gas exchange* are commonly measured during exercise by collecting expired gas over time and determining the average fractional concentration of oxygen in inspired and expired gas. This method yields respiratory rate, respiratory minute ventilation, oxygen uptake, and carbon dioxide production. The respiratory exchange ratio and oxygen ventilatory equivalent can be calculated. The measurements are simple to perform and economical for most advanced clinical laboratories.

### 3.5.4 ***Optional measurements, and techniques for assessing cardiovascular function and performance***

#### *Cardiac output*

Rebreathing methods based on the indirect Fick principle have the greatest potential and seem to have the widest application; invasive methods are rarely used. Comparison of data from intravascular and rebreathing methods reveals a stable and predictable relationship between cardiac output and oxygen uptake during exercise.

Measurement of cardiac output during exercise is potentially useful in assessing cardiac performance: in some patients with cardiac disease, cardiac output with exercise may be lower than expected for the amount of oxygen consumed.

#### *Systolic time intervals*

Systolic time intervals are an indirect index of left ventricular performance and correlate with other measurements of left ventricular performance. They are affected by acute changes in preload, afterload, and intrinsic contractile state of the left ventricle. These factors must be considered in assessing the degree of left ventricular dysfunction during exercise.

#### *Intravascular catheterization*

Exercise during cardiac catheterization provides important data about cardiac performance and function. It is usual to measure flow, pressure, oxygen uptake, and heart rate during exercise. However, the technique is not popular because it is time-consuming and expensive, and because of its invasive nature.

#### *Echocardiogram*

Echocardiography (for measurement of left ventricular dimension, percentage fractional shortening, systolic time intervals, and other indices of left ventricular performance) is becoming a practical method as the technology advances and knowledge of the technique increases.

#### *Scintigraphic (radionuclide) techniques*

Scintigraphic techniques are used to assess regional myocardial perfusion using radionuclide preparations, and to measure cardiac dimensions,



performance, and function by blood pool imaging studies. For measurement during upright exercise, the gamma camera is strapped to the subject to reduce motion-artifact during pedalling on a bicycle ergometer. Data are collected during and after exercise. The clinical results of using scintigraphy during exercise are encouraging, but the technique remains very expensive and thus impractical for developing countries.

### 3.5.5 **Protocols**

The increased use of the *step test* (Table 2) and the *9- and 12-minute walk/run test* for estimating level of fitness in the paediatric population is being studied. These tests do not require expensive equipment or highly trained personnel. However, there is a need for standardization of testing, increased reliability of data, and more data for normal children.

Several protocols are available for bicycle ergometer or treadmill testing (Tables 3–10). Generally, these protocols increase working intensity (graded or stepwise loading) over time, using either a continuous or an intermittent mode of exercise. A common goal of exercise protocols is to estimate or measure maximal oxygen uptake. The principal use of these tests is in measuring exercise responses during a steady state.

Using either the bicycle or treadmill ergometer, with a continuous or intermittent protocol, recordings of heart rate, blood pressure, and electrocardiogram, and estimates of oxygen uptake and working capacity can be satisfactorily made. Different protocols and normal data for bicycle and treadmill ergometers are detailed in Tables 3 to 20, and Figs 1 to 10 (21, 22–34).<sup>1</sup> These protocols are used principally for paediatric patients.

### 3.5.6 **Data processing and management**

A simple and relatively inexpensive computerized system, capable of handling and transmitting data generated in the laboratory, producing reports, and storing data, would greatly benefit an exercise laboratory.

The general features of a data management system should allow both further analysis and editing of data and its subsequent permanent storage. Facilities for statistical analysis and for graphic presentation of exercise data should also be available.

## 3.6 **Clinical situations and recommendations** (Tables 21–24) (35–37)

### 3.6.1 **Diagnosis of exercise-induced symptoms**

Reproduction of symptoms such as syncope, dyspnoea, palpitations, and chest pain may provide valuable diagnostic information if the symptoms can be clearly linked to exercise.

<sup>1</sup> Tables and figures based on reference 21 quote workload in kg·m/min. The more usual unit is kgf·m/min, which may be converted to watts as follows: 1 kgf·m/min = 0.167 W.

### 3.6.2 ***Evaluation of dysrhythmias***

In some patients, tachyarrhythmias may be precipitated by exercise; in others, high-grade ectopy or arrhythmias may be worsened by exercise or occur during the recovery period.

Stress testing may reveal latent dysrhythmias in postoperative patients who have undergone repair of tetralogy of Fallot. Serial exercise testing may be used to test the effectiveness of antidysrhythmic treatment.

Ambulatory monitoring of the electrocardiogram is also useful in detecting significant dysrhythmia and determining the efficacy of treatment. In many instances, both exercise testing and ambulatory ECG monitoring may be necessary for clinical diagnosis and management.

### 3.6.3 ***Assessment of potential myocardial ischaemia***

S-T depression or T-wave changes occurring with exercise may indicate myocardial ischaemia in patients with left ventricular outflow tract obstruction, cardiomyopathies, or coronary artery disease (see Table 1).

### 3.6.4 ***Uncomplicated lesions***

If there are no abnormal findings clinically and no ECG and chest X-ray abnormalities, uncomplicated lesions such as mild aortic insufficiency, mitral insufficiency, or patent ductus arteriosus usually impose no restrictions on patients' activity. Surgical correction of atrial septal defect, ventricular septal defect, and pulmonary stenosis usually yields excellent results, allowing most adolescents full and unrestricted activity.

Examples of lesions that impose major restrictions on activity include moderate to severe aortic stenosis, severe pulmonary stenosis, heart disease with pulmonary hypertension, cyanotic heart disease, significant postoperative arrhythmia, and hypertrophic cardiomyopathy (the commonest cause of sudden death in young athletes). Pulmonary valve insufficiency is not usually a problem if oxygenation remains satisfactory during a graded exercise test.

### 3.6.5 ***Hypertension***

Significant hypertension is present if serial measurements of resting blood pressure are between the 95th and 99th percentiles for age.

In the USA, recent 99th percentile blood pressure values (38) by age are:

- 6- 9 years – 130/86 mmHg (17.3/11.5 kPa)
- 10-12 years – 134/90 mmHg (17.9/12.0 kPa)
- 13-15 years – 144/92 mmHg (19.2/12.3 kPa)
- 16-18 years – 150/98 mmHg (20.0/13.1 kPa)

Some patients will have diastolic pressures below the values given above, but higher systolic pressures. If these individuals have no evidence of end-organ damage, they should be evaluated and followed up in the same

manner as patients with significant, but not severe, hypertension. In all cases where there is no secondary to severe essential hypertension, athletes may continue with sports activities. Dangerous elevations of blood pressure will not occur in this group during static activity. However, dynamic exercise programmes are preferred for persistently hypertensive children, although power weightlifting should be excluded. Major attention should be directed towards weight control, and avoidance or cessation of smoking.

### **3.6.6 *Congenital complete atrioventricular block***

Abnormal findings during exercise testing of patients with congenital complete atrioventricular block include a higher atrial than ventricular rate, and moderate ventricular ectopy. Usually, with good myocardial function, there are no abnormal changes during physiological exercise, and no restriction is necessary. Regular follow-up of these patients should include monitoring of heart rate and of the development of arrhythmias in response to exercise.

### **3.6.7 *Atrial septal defect***

Atrial arrhythmias and, rarely, sick sinus syndrome may occur in patients with atrial septal defect. Evaluation before sports activities are permitted should therefore include an ambulatory ECG recording and an exercise test in an attempt to elicit dysrhythmias and to document a normal heart rate response to exercise.

### **3.6.8 *Ventricular septal defect***

A small residual ventricular septal defect without haemodynamic consequences is not a reason to limit activity. Since ventricular dysrhythmias can occur, especially after operative ventriculotomy to close the defect, patients should be evaluated in the same way as those with atrial septal defect before being allowed to take part in sports.

### **3.6.9 *Pulmonary stenosis***

With no abnormalities detected on other tests and a resting residual gradient  $<50$  mmHg ( $<6.67$  kPa), patients with pulmonary stenosis should be permitted full participation in sports.

### **3.6.10 *Aortic stenosis***

Abnormal findings during exercise of patients with aortic stenosis include chest pain, S-T depression, failure of normal increase in exercise systolic pressure or a fall in exercise systolic blood pressure (a cause for test termination), and ventricular dysrhythmias. Full participation in sport is allowed in cases of mild aortic stenosis (gradient  $<20$  mmHg,  $<2.67$  kPa) and a normal exercise test (38). For gradient  $\geq 20$  mmHg ( $\geq 2.67$  kPa), it is recommended that training, recreational, and vocational activities are modified to limit physical exertion.

### 3.6.11 ***Coarctation of thoracic aorta***

In patients with coarctation of the thoracic aorta, abnormal findings during exercise include upper extremity hypertension, increased coarctation gradient, and S-T depression. Heart catheterization or digital subtraction angiography should exclude a recoarctation. Anatomically unexplained hypertension should be treated medically. No patient should participate in body collision sports or heavy isometric exercise (weightlifting). Those with a gradient of  $\leq 20$  mmHg ( $\leq 2.67$  kPa) and mild resting or exercise hypertension without S-T segment changes can participate in high-intensity recreational activities; all others should be limited to activities of low to moderate intensity.

### 3.6.12 ***Tetralogy of Fallot***

Abnormal findings during exercise of patients with tetralogy of Fallot include diminished exercise tolerance and maximal oxygen uptake (maximal  $\text{VO}_2$ ), slow heart rate response, and atrial and ventricular arrhythmias. Patients with residual pulmonary stenosis (gradient  $\leq 50$  mmHg,  $\leq 6.67$  kPa), mild pulmonary regurgitation, residual small ventricular septal defect, and ventricular ectopy (Lown grade I) should be restricted only minimally, if at all. For pulmonary gradients  $>50$  mmHg ( $>6.67$  kPa), mild to moderate restrictions are recommended (Table 21).

### 3.6.13 ***Transposition of great arteries after arterial switch***

Abnormal postoperative findings during exercise after arterial switch include diminished exercise tolerance and maximal  $\text{VO}_2$ , slow heart rate response, diminished blood pressure response, and atrial and ventricular arrhythmias.

Participation in high-intensity sports is prohibited because of the unknown long-term effects of heavy dynamic and static work on the systemic right ventricle. Patients with a normal heart rate response to exercise and no supraventricular tachycardia or ventricular ectopy other than occasional junctional rhythm during exercise can take part in recreational activities with moderate-high dynamic or static demands in a recreational setting only. All other patients should be allowed low-intensity activity *only* (see Table 21, “Other” category, line c).

The growth and development, and exercise capacity of children following the arterial switch procedure are as yet unknown.

### 3.6.14 ***Kawasaki disease***

Children with Kawasaki disease may develop myocardial ischaemia and left ventricular dysfunction due to coronary artery aneurysm. Exercise-induced S-T segment depression occurs in a significant percentage of patients. Further studies are in progress to characterize the clinical course of coronary artery aneurysms in these young patients.

### 3.7 Exercise training in rehabilitation

Exercise training and cardiovascular rehabilitation are essential components of the treatment of children with cardiovascular disease (36, 37, 39-44). Increased physical activity, education and counselling of the child and family, and reduction of morbidity and mortality are major goals of a comprehensive cardiovascular rehabilitation programme. Programmes that involve a variety of enjoyable and spontaneous physical activities, encourage group participation and parental involvement for role-modelling, use peer-directed approaches, and contain an incentive/reward element are particularly acceptable and successful in the paediatric age group.

Exercise tolerance is unimpaired in some patients, but most have mild to severe aerobic capacity impairment. Evaluation of exercise tolerance may therefore be mandatory for every patient with a cardiovascular disease, unless contraindicated. Any subsequent exercise programme must be based on the results of the evaluation.

Simple physical performance tests for endurance, flexibility, strength, and coordination are suggested for assessment of children before and after exercise training. Training activities that require minimal skill and equipment for participation are most desirable. Personnel with practical knowledge and experience of exercise, and of the limitations of children with disease of varying severity, can supervise and monitor the training sessions.

A modified Borg Scale (see Annex 8) for perceived exertion can be used to estimate intensity and affect during exercise testing and training. Tables 25 to 27 detail flexible exercise training programmes that are suitable for use in young patients with cardiovascular disease of varying severity and that require minimal skills and equipment. These programmes can be executed at the basic, intermediate, or advanced level of care (37, 41, 43, 44).

A satisfactory training effect may be obtained by dynamic exercise (working, jogging, or bicycling) at 50-80% of the maximal  $\text{VO}_2$ , which is approximately equivalent to 60-85% of the maximal attainable heart rate ("target" heart rate). For safety, ECG change (see Table 1) or serious haemodynamic changes as a result of exercise testing (see Annex 11) should be avoided, and the "target" heart rate zone should therefore be below this level.

Exercise training programmes that emphasize aerobic fitness, flexibility, strength development, and coordination – performed indoors and outdoors – are most effective and acceptable to children. All young cardiac patients, especially those with severe disease, should begin the exercise training programme at a low intensity and progress stepwise towards their exercise training goal. The training period should be maintained for at least 20-60 minutes, preceded by a warm-up and followed by a cool-down period.

It is possible that results similar to those of high-intensity exercise programmes may be achieved in children by longer-lasting, less intensive exercise; this has been recently recognized in adults. However, the possibility has not yet been investigated or adequately reported in the medical literature.

### 3.7.1 ***Facilities, personnel, equipment, and protocols***

The components essential for the establishment of an exercise testing and training unit (for advanced care facilities, unless otherwise indicated) are outlined below.

#### *Exercise laboratory*

The laboratory should have an area of at least 25 m<sup>2</sup>, adequate ventilation, and an optimal ambient temperature of 22 °C with approximately 50% humidity. The size of the room, the number of people in it, and the amount of heat generated by equipment are important determinants of temperature control. Most exercise data have been collected in such settings. Appropriate modifications should be made according to available resources and climatic conditions.

#### *Personnel*

At the basic level, clinically trained personnel administering the exercise test should be capable of recognizing external signs and symptoms of cardiopulmonary distress and of performing basic cardiopulmonary resuscitation. In the absence of a physician, another trained health professional may conduct the test. At intermediate and advanced levels, personnel who administer exercise tests should have training in exercise physiology, and should be familiar with children who have serious cardiac illness. At least one person trained in advanced cardiac life support (according to American Heart Association standards) should be present. A physician who is experienced in exercise testing may conduct the test or be available nearby, and resuscitative equipment must be immediately available in the event of an emergency.

#### *Equipment (intermediate or advanced level)*

Clinical exercise laboratories of advanced care facilities should ideally have three types of ergometer (bicycle, treadmill, and handgrip) because each has a particular use in evaluating patients. Both bicycle and treadmill ergometers are adequate for collecting diagnostic or functional information, and generally provide more reliable and reproducible loads on the oxygen transport system than other methods. Selection of the appropriate ergometer will depend upon a patient's needs and the characteristics of the facility. Bicycle ergometers are portable, convenient where space is limited, and relatively silent. They allow easy access to the patient and, because the patient's trunk and arms are stable during exercise, permit several measurements and specialized diagnostic tests, e.g. radionuclide imaging and echocardiography, to be accomplished.

Mechanical friction ergometers are less expensive and easier to calibrate than electromagnetic resistance bicycle ergometers, which deliver a constant level of work throughout the range of pedalling speeds.

The treadmill is generally noisy, occupies a relatively large space, and requires a ceiling height of at least 2.7 metres to permit its use by tall subjects. Strenuous levels of exercise and high levels of oxygen uptake can be achieved on the treadmill, which is useful for evaluating physical working capacity and the effects of training, especially in healthy individuals. The treadmill can be calibrated with relative ease, without the need for special equipment, but it is usually more costly than the bicycle ergometer.

The handgrip dynamometer is used to produce isometric or static exercise. During isometric exercises, the cardiovascular responses relate proportionally to the percentage of maximal tension in the muscle group involved. The technique requires rapid squeezing to determine maximal hand strength; then, after a recovery period, the dynamometer is held with a sustained grasp at a percentage of the maximal hand strength, usually for 3 minutes.

### *Protocols*

Exercise training protocols designed to teach techniques of exercise and self-monitoring, and to utilize a variety of physical activities for improving flexibility, physical strength, aerobic fitness, and coordination are the most desirable for the paediatric age group. These protocols allow patients with severe disease to begin training at low intensity levels and to progress stepwise to a symptom- or sign-limited level. Tables 25 to 27 are descriptions of exercise training protocols that are used in young adults with cardiovascular diseases (37, 41, 43, 44).

## **3.8 Normal values (21, 28, 37, 38, 42, 43, 45–47)**

Interpretation of test results and comparison with normal values must take country and race into consideration. There are small, but significant, differences in expected average fitness between the USA and Europe, for example, and also differences in exercise physiology between races. This is especially true for the African and Caucasian races in the USA: body size and thoracic height/body height ratio are different in the two races. There are also differences between the Caucasian populations of North America and Europe: European Caucasians tend to be taller and thinner for age. Normal values were established largely by work done in Germany, North America, and Scandinavia (Norway and Sweden), and cannot simply be applied to other races or national groups. Maximum exercise values should therefore be reported as absolute numbers and percentages of predicted values for age, weight, body surface area, and maximal oxygen uptake (estimated or measured).

3.9 Conclusions

Exercise testing and training in rehabilitation can be established at acceptably low cost but require the cooperation of physicians, government and voluntary organizations, and the patients themselves. Successful rehabilitation of paediatric patients will assist them in leading long and productive lives, and is thus of economic benefit to society.

Exercise testing in developing countries can be performed at a basic level of care using the step test with manual measurement of pulse rate and blood pressure. Given appropriate guidelines, properly trained personnel can undertake such testing in the absence of a physician.

At higher levels of care, treadmill and/or bicycle ergometers are recommended for multi-stage testing with additional measurements of cardiovascular responses. Electrocardiographic recordings are essential to provide specific details of rate, rhythm, and conduction changes, and S-T segment displacement during testing. In some institutions, ventilation, oxygen consumption, carbon dioxide production, and cardiac output are also measured. Isometric stress can be measured by means of a sustained handgrip test against resistance (dynamometer).

During exercise, it is also possible to examine the ventricular shortening fraction by means of echocardiography and the ejection fraction by means of radionuclide angiography. Radionuclide preparations can be used during exercise and again at rest to confirm suspected localized ischaemia.

An exercise test may be used to determine peak exercise capacity and identify any cardiovascular limitations that may affect the design and intensity of individual rehabilitation programmes.

*Note:* Text continues on page 70.

Table 3  
**Continuous graded exercise test for bicycle ergometer: Adams et al., 1961 (23, 24)<sup>a</sup>**

The protocol consists of a specific exercise programme for subjects within each of four weight groups. The workloads within each programme are scheduled ultimately to produce a peak heart rate of 170 beats/minute. The workload that produces a heart rate of 170 beats/minute is used as an estimate of physical working capacity (PWC<sub>170</sub>).

*Notes:* Normal test data are given in Table 12.  
Duration of exercise at each level: 6 minutes.  
Pedal speed: 60–70 rev/min.

Exercise level	Body weight, kg			
	< 30	30–40	40–60	> 60
	Workload, kg-m/min (W)			
1	100 (17)	100 (17)	100 (17)	100 (17)
2	200 (33)	300 (50)	300 (50)	500 (83)
3	300 (50)	500 (83)	600 (100)	800 (133)

<sup>a</sup> Source: reference 21.



Table 4

**Continuous graded exercise test for bicycle ergometer: Bengtsson, 1956 (25)<sup>a</sup>**

This continuous protocol is designed to produce a heart rate within a certain range by selecting one of three workloads (100, 150, or 300 kg-m/min). The three levels of exercise are identified by specific heart rate limits, with minimal rate of 125 at level 1 and maximal rate of 170 at level 3. The goal of the test is to reach a steady state defined by a heart rate within the specific limits for each level. Cardiorespiratory responses are measured during the steady state.

- Notes: Normal test data are given in Figs 1–3.
- Duration of exercise at each level: 6 minutes.
  - Pedal speed: 45 or 60 rev/min.
  - Goals
    - to reach steady state
    - to adjust the workload so that the heart rate levels listed below are reached.

Exercise level	Heart rate range beats/minute	Workload kg-m/min (W)			
1	125–130	100 (17)	or	150 (25)	or 300 (50)
2	140–150	100 (17)	or	150 (25)	or 300 (50)
3	160–170	100 (17)	or	150 (25)	or 300 (50)

<sup>a</sup> Source: reference 21.

Table 5

**Continuous graded exercise test for bicycle ergometer: Godfrey et al., 1974 (26)<sup>a</sup>**

This continuous protocol consists of a specific exercise programme for each of three height groups. Workloads are increased at intervals of 1 minute until a level of exhaustion is reached. The maximal power output or highest rate of work achieved is measured and related to height and sex. The objective of the test is a preliminary screening before more detailed studies are undertaken.

Note: Normal test results are shown in Figs 4–8.

Height cm	Workload increments	
	kg-m/min	W
< 120	60	10
120–150	90	15
> 150	120	20

<sup>a</sup> Source: reference 21.

Table 6  
**Continuous graded exercise test for bicycle ergometer: Goldberg, Weiss, Adams, 1966 (27)<sup>a</sup>**

This continuous protocol consists of a specific exercise programme for each of three groups based on body surface area. For each group, exercise level 1 is a 1-minute warm-up period. Exercise periods for levels 2 and 3 are of 2 minutes' duration. After level 3, the workload is increased progressively by increments of 100 or 200 kg-m/min until exhaustion or a predetermined end-point is reached.

Notes: Normal test data are given in Table 13.  
Duration of exercise at each level: 2 minutes.  
Pedal speed: 60–70 rev/min.

Exercise level	Body surface area, m <sup>2</sup>		
	< 1.0	1.0–1.2	> 1.2
	Workload, kg-m/min (W)		
1	100 (17)	100 (17)	100 (17)
2	200 (33)	300 (50)	300 (50)
3	300 (50)	500 (83)	600 (100)
Increments	100 (17)	100 (17)	200 (33)

<sup>a</sup> Source: reference 21.

Table 7  
**Continuous graded exercise test for bicycle ergometer: James et al., 1980 (28)<sup>a</sup>**

This continuous protocol consists of a specific exercise programme for each of three groups based on body surface area. When the three progressive levels of exercise have been successfully completed, the workload is increased by 100 or 200 kg-m/min until a maximal level of voluntary effort is reached. The test is then terminated. The goals are: to reach a state of exhaustion or a predetermined end-point; to estimate the highest rate of work (maximal power output); and to measure other physiological variables.

Notes: Normal test data are given in Table 14.  
Duration of exercise at each level: 3 minutes.  
Pedal speed: 60–70 rev/min.

Exercise level	Body surface area, m <sup>2</sup>		
	< 1.0	1.0–1.19	≥ 1.2
	Workload, kg-m/min (W)		
1	200 (33)	200 (33)	200 (33)
2	300 (50)	400 (67)	500 (83)
3	500 (83)	600 (100)	800 (133)
Increments	100 (17)	100 (17)	200 (33)

<sup>a</sup> Source: reference 21.

Table 8  
**Continuous graded exercise test for bicycle ergometer: Strong et al., 1978 (29), modification of Adams et al., 1961 (23, 24)<sup>a</sup>**

Exercise programmes are designed for each of four groups based on body weight. The workload within each programme is estimated to produce a heart rate at or near the expected value. After successful completion of exercise levels 1 to 3, subsequent workloads are increased by increments of 75–300 kg-m/min at 1-minute intervals according to the weight and current performance of the subject. The goal is to determine physical working capacity at a heart rate of 170 beats/minute and the highest rate of work producing exhaustion or a predetermined end-point.

Notes: Normal test data are given in Table 15.  
Workload increments: 75–300 kg-m/min for 7-minute intervals.  
Pedal speed: 60–70 rev/min.

Exercise level	Body weight, kg				Expected heart rate
	< 30	30–40	40–60	> 60	
	Workload, kg-m/min (W)				
1	100 (17)	100 (17)	100 (17)	100 (17)	120
2	200 (33)	300 (50)	300 (50)	500 (83)	150
3	300 (50)	500 (83)	600 (100)	800 (133)	170

<sup>a</sup> Source: reference 21.

Table 9  
**Continuous graded exercise test for treadmill (Bruce protocol): Cumming, Everatt, Hastman, 1978 (30)<sup>a</sup>**

This continuous graded protocol involves stages at which the speed and slope are progressively increased at 3-minute intervals from 1.7 to 6 miles/hour (2.7 to 9.6 km/hour) and from 10% to 22% respectively. The goal is to reach the maximal level of voluntary effort beyond which the subject is unable or unwilling to continue.

Note: Normal test data are given in Tables 16 and 17 and Fig. 9.

Exercise stage	Speed		Slope %	Time minutes
	miles/h	km/h		
1	1.7	2.7	10	3
2	2.5	4.0	12	3
3	3.4	5.4	14	3
4	4.2	6.7	16	3
5	5.0	8.0	18	3
6	5.5	8.8	20	3
7	6.0	9.6	22	3

<sup>a</sup> Source: reference 21.

Table 10  
**Continuous graded exercise test for treadmill (modified Balke): Riopel, Taylor, Hohn, 1979 (32)<sup>a</sup>**

This continuous protocol increases the slope from 2% to more than 10%, while maintaining a constant speed of 3.5 miles/hour (5.6 km/hour). The slope is increased by increments of 2% until the subject reaches exhaustion.

*Notes:* Normal test data are given in Table 18 and Fig. 10.

miles/h	Speed km/h	Slope %	Time minutes
3.5	5.6	2	1
3.5	5.6	4	1
3.5	5.6	6	1
3.5	5.6	8	1
3.5	5.6	10	1
	etc.	etc.	etc.

<sup>a</sup> Source: reference 21.

Table 11  
**Data from exercise electrocardiograms in healthy children<sup>a</sup>**

*Bengtsson, 1956 (25)*

In several leads, including anterior-posterior, right-left, and superior-inferior, the S–T segment was measured from an isoelectric line of consecutive PQ segments at 50 ms after J-point. Horizontal S–T depression exceeding 1.5 mm did not occur in any lead either during or following exercise. Disturbances of cardiac rhythm were uncommon.

*James et al., 1980 (28)*

Multiple electrocardiographic leads were recorded during peak exercise. Depression of the S–T segment was assessed below a baseline joining the PR or PQ junctions of 3 to 5 consecutive P–QRS–T complexes for about 60 ms. S–T depression of 1 mm occurred in 12% of healthy children at peak exercise, more commonly in girls than in boys. S–T depression greater than 2 mm occurred rarely. Rhythm or conduction disturbances during exercise testing were rare without previous documentation of dysrhythmias.

*Thapar & Strong, 1978*

J-point displacement was determined in relation to extension of a line superimposed upon the preceding PR segment. The slope (mV/s) of the S–T segment was calculated from a line superimposed upon the first 80 ms of the S–T segment. J-point depression occurred in 2.3% of children at maximal exercise. The mean slope of S–T segment was 1.5–4.3 mV/s at maximal effort. Information about displacement of the S–T segment was not provided. Dysrhythmia was not observed during or after exercise.

<sup>a</sup> Source: reference 21.

Table 12  
**Continuous graded exercise test for bicycle ergometer: Adams et al., 1961 (23, 24).**  
**Mean physical working capacity of healthy white children<sup>a</sup>**

Age years	Height cm	Weight kg	Workload kg-m/min	W
<i>Boys</i>				
6	121	24	331	55
7	127	29	368	61
8	131	30	438	73
9	140	35	472	79
10	145	40	551	92
11	152	46	650	109
12	155	48	703	117
13	160	51	739	123
14	170	59	964	161
<i>Girls</i>				
6	120	24	265	44
7	124	25	287	48
8	132	30	343	57
9	133	32	337	56
10	144	38	406	68
11	148	44	488	81
12	158	46	483	81
13	163	55	564	94
14	165	60	542	91

<sup>a</sup> Source: reference 21.

Table 13  
**Continuous graded exercise test for bicycle ergometer: Goldberg, Weiss, Adams, 1966 (27). Mean data for healthy children aged 6–16 years<sup>a</sup>**

	Boys	Girls
Total work, kg-m/min (W)	4856 (809)	2696 (449)
Workload at heart rate 170/min, kg-m/min (W)	633 (106)	475 (79)
Maximal endurance index <sup>b</sup>	491	430
Maximal workload, kg-m/min (W)	884 (147)	692 (115)
Maximal heart rate, beats/min	194	193

<sup>a</sup> Source: reference 21.

<sup>b</sup> Maximal endurance index =  $\frac{\text{total work performed}}{\text{total time (min)} \times \text{body surface area (m}^2\text{)}}$

Table 14  
**Continuous graded exercise test for bicycle ergometer: James et al., 1980 (28).**  
**Mean exercise data for normal children<sup>a</sup>**

Height metres	Total work		Power output		Heart rate beats/min	Maximal blood pressure			
	kg-m/min	W	kg-m/min	W		Systolic mmHg	kPa	Diastolic mmHg	kPa
Boys and girls, body surface area < 1 m <sup>2</sup>									
< 1.20	1222	204	267	45	195	119	15.9	70	9.33
≥ 1.20	2144	358	375	63	191	130	17.3	73	9.73
Boys and girls, body surface area 1–1.19 m <sup>2</sup>									
< 1.40	2911	486	493	82	194	145	19.4	77	10.03
≥ 1.40	3428	572	540	90	199	148	19.7	71	9.46
Boys, body surface area ≥ 1.2 m <sup>2</sup>									
< 1.50	2986	499	629	105	187	142	18.9	83	11.1
1.50–1.59	4885	816	800	133	189	156	20.8	82	10.9
1.60–1.69	11225	1875	1180	197	193	178	23.7	77	10.3
1.70–1.79	15448	2580	1390	232	199	199	26.6	71	9.46
≥ 1.80	13835	2310	1320	220	196	200	26.7	80	10.7
Girls, body surface area ≥ 1.2 m <sup>2</sup>									
< 1.60	3865	645	670	112	198	160	21.3	84	11.2
1.60–1.69	6218	1038	910	152	199	170	22.7	88	11.7
≥ 1.70	9622	1606	1089	182	197	181	24.2	83	11.1

<sup>a</sup> Source: reference 21.

Table 15  
**Continuous graded exercise test for bicycle ergometer: Strong et al., 1978 (29).**  
**Normal values for blood pressure, working capacity at heart rate 170, and maximal heart rate in healthy black children<sup>a</sup>**

Age years	PWC <sub>170</sub> <sup>b</sup>		SP <sub>170</sub> <sup>c</sup>		heart rate  beats/min	Maximal systolic pressure	
	kg-m/min	W	mmHg	kPa		mmHg	kPa
<i>Boys</i>							
7	321	53.6	139	18.6	186	139	18.8
8	369	61.6	139	18.6	186	151	20.2
9	373	62.3	135	18.0	193	150	20.0
10	399	66.6	140	18.7	193	163	21.8
11	434	72.5	144	19.2	192	166	22.1
12	398	66.5	156	20.8	194	167	22.3
13	417	70.0	148	19.7	187	167	22.3
<i>Girls</i>							
7	326	54.4	128	17.1	188	142	18.9
8	314	52.4	130	17.3	188	140	18.7
9	372	62.1	139	18.6	184	145	19.4
10	336	56.1	142	18.9	193	156	20.8
11	298	49.8	144	19.2	193	159	21.2
12	325	54.3	141	18.8	197	154	20.5
13	328	54.8	149	19.9	193	163	21.8

<sup>a</sup> Source: reference 21.  
<sup>b</sup> PWC<sub>170</sub> = physical working capacity at heart rate 170 beats/minute.  
<sup>c</sup> SP<sub>170</sub> = systolic pressure at heart rate 170 beats/minute.

Table 16  
**Continuous graded exercise test for treadmill (Bruce protocol): Cumming, Everatt, Hastman, 1978 (30). Endurance times (minutes) of children<sup>a</sup>**

Age group years	No. of subjects	Percentiles					Mean	SD <sup>b</sup>
		10	25	50	75	90		
<i>Boys</i>								
4–5	40	8.1	9.0	10.0	12.0	13.3	10.4	1.9
6–7	28	9.7	10.0	12.0	12.3	13.5	11.8	1.6
8–9	30	9.6	10.5	12.4	13.7	16.2	12.6	2.3
10–12	31	9.9	12.0	12.5	14.0	15.4	12.7	1.9
13–15	26	11.2	13.0	14.3	16.0	16.1	14.1	1.7
16–18	12	11.3	12.1	13.8	14.5	15.8	13.5	1.4
<i>Girls</i>								
4–5	36	7.0	8.0	9.0	11.2	12.3	9.5	1.8
6–7	34	9.5	9.6	11.4	13.0	13.0	11.2	1.5
8–9	26	9.9	10.5	11.0	13.0	14.2	11.8	1.6
10–12	28	10.5	11.3	12.0	13.0	14.6	12.3	1.4
13–15	24	9.4	10.0	11.5	12.0	13.0	11.1	1.3
16–18	12	8.1	10.0	10.5	12.0	12.4	10.7	1.4

<sup>a</sup> Source: reference 21.  
<sup>b</sup> SD = standard deviation.

Table 17

**Continuous graded exercise test for treadmill (Bruce protocol): Cumming, Everatt, Hastman, 1978 (30). Achieved heart rate (mean  $\pm$  standard deviation)<sup>a</sup>**

Age group years	Rest	1	2	Stage		4	Max.	R2	Recovery <sup>b</sup>		Lowest max.
				3					R5		
<i>Boys</i>											
4-5	97 $\pm$ 13	135 $\pm$ 15	161 $\pm$ 17	189 $\pm$ 13	194 $\pm$ 6	200 $\pm$ 9		121 $\pm$ 16	114 $\pm$ 10		180
6-7	92 $\pm$ 14	131 $\pm$ 12	154 $\pm$ 12	188 $\pm$ 12	203 $\pm$ 14	201 $\pm$ 7		125 $\pm$ 13	116 $\pm$ 17		183
8-9	84 $\pm$ 13	127 $\pm$ 10	146 $\pm$ 15	177 $\pm$ 12	198 $\pm$ 8	200 $\pm$ 6		122 $\pm$ 11	116 $\pm$ 9		183
10-12	84 $\pm$ 15	122 $\pm$ 11	140 $\pm$ 12	174 $\pm$ 13	194 $\pm$ 9	199 $\pm$ 7		125 $\pm$ 11	116 $\pm$ 10		180
13-15	72 $\pm$ 9	112 $\pm$ 12	129 $\pm$ 14	163 $\pm$ 14	191 $\pm$ 10	198 $\pm$ 6		122 $\pm$ 13	112 $\pm$ 13		188
16-18	77 $\pm$ 10	105 $\pm$ 15	137 $\pm$ 18	174 $\pm$ 12	189 $\pm$ 7	201 $\pm$ 6		138 $\pm$ 14	127 $\pm$ 10		183
<i>Girls</i>											
4-5	102 $\pm$ 19	144 $\pm$ 13	173 $\pm$ 19	195 $\pm$ 14	—	199 $\pm$ 10		128 $\pm$ 19	121 $\pm$ 12		183
6-7	102 $\pm$ 19	136 $\pm$ 20	163 $\pm$ 18	196 $\pm$ 6	—	206 $\pm$ 4		141 $\pm$ 18	132 $\pm$ 15		193
8-9	79 $\pm$ 13	117 $\pm$ 17	144 $\pm$ 17	180 $\pm$ 13	198 $\pm$ 6	202 $\pm$ 9		121 $\pm$ 16	112 $\pm$ 14		188
10-12	84 $\pm$ 13	126 $\pm$ 11	150 $\pm$ 13	188 $\pm$ 11	197 $\pm$ 5	204 $\pm$ 8		134 $\pm$ 18	122 $\pm$ 12		188
13-15	85 $\pm$ 12	127 $\pm$ 19	153 $\pm$ 18	180 $\pm$ 16	186 $\pm$ 11	196 $\pm$ 6		128 $\pm$ 21	117 $\pm$ 18		180
16-18	92 $\pm$ 12	134 $\pm$ 15	164 $\pm$ 19	186 $\pm$ 9	—	193 $\pm$ 5		142 $\pm$ 18	124 $\pm$ 13		186

<sup>a</sup> Source: reference 21.

<sup>b</sup> R2, R5 = recovery at 2 and 5 minutes, sitting with feet elevated.



Table 18

**Continuous graded exercise test for treadmill (modified Balke): Riopel, Taylor, Hohn, 1979 (32).**  
**Exercise data (mean values in normal black and white children)<sup>a</sup>**

Body surface area m <sup>2</sup>	Duration of exercise minutes	Heart rate		systolic pressure				Maximal diastolic pressure			
		beats/min		mmHg		kPa		mmHg		kPa	
		B	W	B	B	W	W	B	B	W	W
Boys											
0.72–1.09	10	179	183	145	19.4	142	18.9	85	11.3	85	11.3
1.10–1.39	11	185	186	154	20.5	145	19.4	87	11.6	84	11.2
1.40–1.89	11	186	192	181	24.2	171	22.8	84	11.2	77	10.3
1.90–2.31	10	181	190	206	27.5	200	26.7	87	11.6	95	12.7
Girls											
0.72–1.09	9	194	187	145	19.4	147	19.6	83	11.1	79	10.5
1.10–1.39	8	185	191	154	20.5	145	19.4	85	11.3	84	11.2
1.40–1.89	9	186	191	161	21.5	155	20.7	84	11.2	79	10.5

<sup>a</sup> Source: reference 21.

<sup>b</sup> B = black children, W = white children.

Table 19  
**Summary of exercise data from bicycle ergometer in normal children using different protocols<sup>a</sup>**

Source	Heart rate	Blood pressure	ECG	Ventilation Pulmonary gas exchange	Respira- tory rate	Cardiac output	Working capacity
Adams et al. (23, 24)	+	—	—	—	—	—	+
Bengtsson (25)	+	—	+	+	+	+	—
Godfrey et al. (26)	+	—	—	+	+	+	—
Goldberg, Weiss, Adams (27)	+	—	—	—	—	—	—
James et al. (28)	+	+	+	—	—	—	—
Strong et al. (29)	+	+	+	—	—	—	—

<sup>a</sup> Summarized from Tables 3–8. Source: reference 21.

Table 20  
**Summary of exercise data from treadmill ergometer in normal children using different protocols<sup>a</sup>**

Source	Heart rate	Blood pressure	ECG	Working capacity
Cumming, Everatt, Hastman (30)	+	—	—	+
Rioped, Taylor, Hohn (32)	+	+	+	+

<sup>a</sup> Summarized from Tables 9 and 10. Source: reference 21.

Table 21

**Guidelines for physical and occupational activities, exercise testing and training for young patients with cardiovascular disease of varying severity**

Note: The symbols used in this table are explained on page 57.

Cardiovascular disease	Physical exertion intensity	Recreation choice restriction	Occupation choice restriction	Exercise testing requirement	Exercise training risk	Exercise training intensity	Exercise training supervision
<b>Aortic valve stenosis</b>							
<i>Operated/unoperated</i>							
a Mild: peak systolic gradient < 20 mmHg (< 2.67 kPa)	+++	—	—	Yes	+	+++	1
b Moderate: gradient 20–40 mmHg (2.67–5.33 kPa)	+/++	+	++	Yes	++	+/++	1–2
c Severe: gradient > 40 mmHg (> 5.2 kPa)	+	++	+++	Yes	+++	+	2–4
<b>Aortic regurgitation</b>							
a Minimal or no cardiomegaly, or elevation of systolic pressure	+++	—	—	Yes	+	+++	1
b Moderate or marked cardiomegaly and increased systolic pressure	+/++	+/++++	+/++++	Yes	++	+/++	1–4

Table 21 (continued)

Cardiovascular disease	Physical exertion intensity	Recreation choice restriction	Occupation choice restriction	Exercise testing requirement	Exercise training risk	Exercise training intensity	Exercise training supervision
<b>Atrial septal defect</b>							
<i>Unoperated</i>							
a Normal pulmonary artery pressure with or without mitral valve prolapse, regurgitation, or ventricular arrhythmia	+++	—	—	Optional	+	+++	1
b Mean pulmonary artery pressure > 20 mmHg (> 2.67 kPa)	+	++	++	Yes	+	++	1
<i>Operated</i>							
a Normal haemodynamics, conduction, and heart size	+++	—	—	Optional	+	++/+++	1
b Mean pulmonary pressure > 20 mmHg (> 2.67 kPa), conduction disturbance and/or cardiomegaly	+	++	++	Yes	++	++	1–3
<b>Cardiomyopathy</b>							
a Hypertrophic, non-obstructive	+/+	—	—	Yes	++	++	1–4
b Hypertrophic, obstructive	+	++/+++	++/+++	Yes	+++	+	2–4
c Dilated type	+/+	++/+++	++/+++	Yes	+++	+	1–4
d Restricted type	+/+	++/+++	++/+++	Yes	+++	+	1–4

Table 21 (continued)

Cardiovascular disease	Physical exertion intensity	Recreation choice restriction	Occupation choice restriction	Exercise testing requirement	Exercise training risk	Exercise training intensity	Exercise training supervision
<b>Coarctation of aorta</b>							
<i>Unoperated</i>							
a Without severe systemic hypertension, and associated defects	+++	—	—	Yes	+	+++	1
b With severe hypertension	+	++	++	Yes	+++	+	2-4
<i>Operated</i>							
a With normal blood pressure and no aortic valve disease	+++	—	—	Yes	+	+++	1
b With hypertension and/or aortic disease	++	++	++	Yes	++	+/++	1-3
<b>Congenital complete heart block</b>	++/+++	—	—/+	Yes	+	++/++++	1
<b>Mitral regurgitation</b>							
a No or mild cardiomegaly	+++	—	+	Optional	+	++/++++	1
b Moderate or marked cardiomegaly	+	++	++	Yes	++	+	1-3
<b>Myocarditis</b>							
a Active	—	+++	+++	Contra-indicated	+++	—	3-4
b Chronic	+	++/++++	++/++++	Yes	++	+	1-3

Table 21 (continued)

Cardiovascular disease	Physical exertion intensity	Recreation choice restriction	Occupation choice restriction	Exercise testing requirement	Exercise training risk	Exercise training intensity	Exercise training supervision
<b>Patent ductus arteriosus</b>							
<i>Unoperated</i>							
a Small shunt with normal pulmonary artery pressure	++	—	—	Optional	+	+++	1
b Moderate to large shunt with:							
— normal pulmonary artery pressure	+++	—	—	Yes	+	+++	1
— pulmonary artery pressure < 0.5 x aortic pressure	+++	—	+	Yes	+	++/+++	1
— pulmonary artery pressure > 0.5 x aortic pressure	++/+++	—/+	++	Yes	++	++/+++	1–2
c Severe pulmonary vascular disease	+/+	++/+++	++/+++	Yes	+++	+/+	2–4
<i>Operated</i>							
a Closed defect with normal pulmonary artery pressure	++	—	—	Optional	+	+++	1
b Closed defect with pulmonary hypertension	++/+++	+	++/+++	Yes	++	+/+	1–3
<b>Pulmonary stenosis with intact ventricular septum</b>							
a Peak systolic gradient < 50 mmHg (< 6.67 kPa)	+++	—	—	Yes	+	+++	1
b Peak systolic gradient > 50 mmHg (> 6.67 kPa)	+/+	—/+	—/+	Yes	++	++/+++	2–4

Table 21 (continued)

Cardiovascular disease	Physical exertion intensity	Recreation choice restriction	Occupation choice restriction	Exercise testing requirement	Exercise training risk	Exercise training intensity	Exercise training supervision
<b>Tetralogy of Fallot</b>							
<i>Unoperated/palliated by aortopulmonary/shunt</i>	+ /++	+	+	Yes	++	+	1-3
<i>Operated</i>							
a Right ventricle to pulmonary gradient < 50 mmHg (< 6.67 kPa)	++ /+++	—	+	Yes	+	++ /+++	1
b Residual ventricular septal defect and/or right ventricle to pulmonary gradient > 50 mmHg (> 6.67 kPa) and/or significant pulmonary valve regurgitation	+ /++	+	++	Yes	+++	+ /++	2-4
<b>Ventricular septal defect</b>							
<i>Unoperated/operated</i>							
a Small defect	+++	—	—	Optional	+	+++	1
b Moderate defect	+ /++	+ /++	+ /++	Yes	+	++ /+++	1
c Large defect	+	+++	+++	Yes	++	+	1-3
<b>Hypertension, systemic</b>							
a Blood pressure < 95th percentile for age	++ /+++	—/+	—/+	Yes	+	+++	1
b Blood pressure > 95th percentile for age	+ /++	++ /+++	+ /+++	Yes	++	+ /++	1-3

Table 21 (continued)

Cardiovascular disease	Physical exertion intensity	Recreation choice restriction	Occupation choice restriction	Exercise testing requirement	Exercise training risk	Exercise training intensity	Exercise training supervision
<b>Other</b>							
<i>a</i> Prosthetic valve replacement:							
— no or mild cardiomegaly	+	+	+	Yes	+	+/+	1
— moderate or marked cardiomegaly	+	+/+	+/+	Yes	++	+	1-3
<i>b</i> Mild heart disease not requiring heart surgery							
	++	—	—	Optional	+	++	1
<i>c</i> Severe heart disease, palliative, uncorrectable							
	+	+/+	+/+	Yes	+	+/+	1-3
<i>d</i> Severe heart disease, correctable							
	+	++	++	Yes	++	+	2-4
<i>e</i> Eisenmenger syndrome							
	+	++	++	Yes	++	+	2-4
<i>f</i> Heart disease with S-T segment depression:							
— depression < 2 mm	+/+	—	—	Yes	+	+/+	1
— depression > 2 mm	+/+	+/+	+/+	Yes	+	+/+	1-4



**Explanation of symbols**

*Physical exertion intensity*

+	= low	= activities of low dynamic and low static demands
++	= moderate	= activities of moderate dynamic and/or moderate static demands
+++	= high	= activities of high dynamic and/or high static demands

*Recreation/occupation restriction*

—	= none	
+	= mild	= lift up to 23 kg (50 lb) carry up to 12 kg (25 lb) non-athletic team sports
++	= moderate	= lift up to 9 kg (20 lb) carry up to 5 kg (10 lb) modified physical education programme no team sports
+++	= severe	= mostly sitting some walking consider surgical and/or medical treatment to modify the restrictions

*Exercise training risk*

+	= low
++	= intermediate
+++	= high

*Exercise training intensity*

(for patients more than 13 years of age, using the modified Borg scale of rate of perceived exertion — see Annex 8)

+	= low	= perceived exertion score < 10
++	= moderate	= perceived exertion score 10–13
+++	= high	= perceived exertion score > 13

*Exercise training supervision*

(Supervision is provided by trained staff members or by the patient’s parent or spouse who has observed previous sessions and been instructed and tested in measuring heart rate and assessing changes related to cardiopulmonary distress.)

1	= unsupervised	— self-monitored
2	= supervised	— self-monitored
3	= unsupervised	— medically monitored
4	= supervised	— medically monitored

Table 22

**Guide to physical activity and sports participation for children and young adults with cardiovascular disease**

*Note:* Individual sports are specified in Table 23.

Cardiovascular condition <sup>a</sup>	Intensity of physical effort	Physical demands dynamic	static	Restriction if danger of collision <sup>b</sup>
Mild	High	High	High	No
Moderate	Low to moderate	Low to moderate	Low to moderate	Yes
Severe	Low	Low	Low	Yes

<sup>a</sup> Medically determined severity.

<sup>b</sup> Applies to sports with a high risk of body or object impact.

Table 23

**Classification of sports<sup>a</sup>**

*Note:* This table is not exhaustive, and should be used simply as a guide to types and intensity of sports and dangers of body collision.

<i>High to moderate dynamic and static demands</i>	
Boxing	Rugby
Cycling	Running (sprint)
Fencing	Skiing (downhill)
Football	Skiing (cross-country)
Handball (international)	Speed skating
Ice hockey	Water polo
Rowing	Wrestling
<i>High to moderate dynamic and low static demands</i>	
Badminton	Racket-ball
Baseball	Running (distance)
Basketball	Soccer
Field hockey	Squash
Handball (American)	Swimming
Lacrosse	Table tennis
Orienteering	Tennis
Race walking	Volleyball

<sup>a</sup> Source: reference 35.

Table 23 (continued)

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*High to moderate static and low dynamic demands*

Archery	Judo
Aerobic dancing	Motorcycling
Cricket	Motor racing
Dancing	Mountaineering
Diving	Rodeoing
Equestrianism	Sailing
Field events (jumping)	Ski-jumping
Field events (throwing)	Water aerobics
Gymnastics	Water-skiing
Karate	Weightlifting

*Low dynamic and static demands*

Bowling  
Curling  
Golf  
T'ai chi chu'an

*Sports in which there is danger of body or object collision*

Boxing	Motorcycling <sup>a</sup>
Cycling <sup>a</sup>	Motor racing <sup>a</sup>
Diving <sup>a</sup>	Rodeoing <sup>a</sup>
Equestrianism <sup>a</sup>	Rugby
Football	Skiing (downhill) <sup>a</sup>
Gymnastics <sup>a</sup>	Ski-jumping
Handball (American)	Soccer
Handball (international)	Water polo <sup>a</sup>
Ice hockey	Water-skiing <sup>a</sup>
Karate	Weightlifting <sup>a</sup>
Judo	Wrestling
Lacrosse	

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<sup>a</sup> The risk increases if syncope occurs.

Table 24

**Recommendations for physical and recreational activities according to oxygen consumption<sup>a</sup>**

<i>VO<sub>2</sub> 3.5–10 ml/min per kg</i>	<i>VO<sub>2</sub> 20–25 ml/min per kg</i>
Horseback riding, slow	Mowing grass (hand mower)
Walking, normal pace	Walking, fast
1 mile in 24 min	1 mile in 12.5 min
(1 km in 15 min)	(approx. 1 km in 8 min)
<i>VO<sub>2</sub> 10–16 ml/min per kg</i>	Canoeing
Mowing grass (power mower)	Deep knee-bends, 30 min
Cycling, 5.5 miles/h (8.8 km/h)	Push-ups, 30 min
1 mile in 11 min	<i>VO<sub>2</sub> 25–30 ml/min per kg</i>
(approx. 1 km in 7 min)	Skiing, downhill
Straight leg raising	Squash
Swimming	Walking, level
20 yds/min	in 2.5 inches (approx. 6 cm) of snow
(approx. 20 m/min)	Running
Walking, briskly	1 mile in 11 min
1 mile in 20 min	(approx. 1 km in 7 min)
(1 km in 12.5 min)	Cycling, 13 miles/h (21 km/h)
Carrying 20 lb (9 kg)	1 mile in 4.5 min
Cycling, 10 miles/h (16 km/h)	(approx. 1 km in 3 min)
1 mile in 6 min	Walking, 5 miles/h (8 km/h)
(approx. 1 km in 4 min)	1 mile in 12 min
<i>VO<sub>2</sub> 16–20 ml/min per kg</i>	(1 km in 7.5 min)
Rowing, alone	<i>VO<sub>2</sub> 30–35 ml/min per kg</i>
Walking, moderately fast	Shovelling snow (moderately wet)
1 mile in 15 min	Swimming, fast
(1 km in 9.5 min)	50 yd/min
Ice skating	(approx. 45 m/min)
Table tennis	Skiing, cross-country
Carrying 50 lb (23 kg)	Walking, briskly uphill
Swimming	10% slope
30 yd/min	<i>VO<sub>2</sub> &gt; 35 ml/min per kg</i>
(approx. 30 m/min)	Running
Tennis, doubles	1 mile (approx. 1600 m) in ≤ 5 min.
Walking, briskly uphill	
5% slope	

<sup>a</sup> Adapted from reference 36.

Table 25

**Exercise training programme for patients with cardiomegaly and signs of congestive heart failure (compensated)<sup>a</sup>**

Week no. (3 sessions per week)	Warm-up time minutes	Walk/jog minutes	Cool-down time minutes	Stretch minutes	Total exercise time minutes
1	5	10/0	3	2	20
2	5	5/1	3	2	16
3	5	5/3	3	2	18
4	5	4/5	3	2	19
5	5	4/5	3	2	19
6	5	4/6	3	2	20
7	5	4/7	3	2	21
8	5	4/8	3	2	22
9	5	4/9	3	2	23
10	5	4/13	3	2	27
11	5	4/17	3	2	31
12	5	4/17	3	2	31
13	5	2/19	3	2	31
14	5	1/20	3	2	31
15	5	0/20	3	2	30

<sup>a</sup> Source: reference 44.

Table 26

**Exercise training programme for children and young adults with cardiovascular disease<sup>a</sup>**

Note: The activities are performed each day in the order listed from left to right in the table, i.e. starting with flexibility and progressing to strength exercises.

Week	Flexibility	Distance metres	Aerobic (jogging) Rest interval minutes	Frequency/ session	Coordination (15 min/day, any or all activities)	Sit-ups	Strength Push-ups <sup>b</sup> Stairs, both legs
1	Repeat three times; remain in position to count of 10: — hurdler's stretch — elbow behind head — arms behind head — legs — straightening while holding feet	100	3	3	Catching a ball Skipping with a rope Hopscotch Kicking a ball Jumping rope Climbing trees or park equipment (Other equivalent activities may be substituted)	5	5 level 2 10
2	Same as above	150	3	3	Same or equivalent activities	10	10 level 2 10 2 sessions
3	Same as above	200	3	3	Same or equivalent activities	15	5 level 3 10 2 sessions

Week	Flexibility	Distance metres	Aerobic (jogging)		Coordination (15 min/day, any or all activities)	Sit-ups	Strength Push-ups	Stairs, both legs
4	Same as above	250	3	3	Same or equivalent activities	20	10 level 3	10 2 sessions 5 stairs each on R and L legs
5	Same as above	300	3	3	Same or equivalent activities	25	5 level 4	10 2 sessions 10 stairs each on R and L legs
6	Same as above	375	3	3	Same or equivalent activities	30	10 level 4	15 2 sessions 10 stairs each on R and L legs

<sup>a</sup> Adapted from reference 37.

<sup>b</sup> *Level 2:* Feet together, body facing wall more than arm's length away. Elbows extended with hands against wall at shoulder height. Lean forward until chest nears wall, push back to starting position.

*Level 3:* Body horizontal with elbows extended. hands shoulder-width apart, knees on floor. Knees flexed and ankles crossed. Lower body towards floor, then push up to starting position.

*Level 4:* Body horizontal with elbows extended, hands shoulder-width apart, toes on floor. Lower body towards floor, then push up to starting position.

Table 27  
**Exercise training for children and young adults with cardiovascular disease<sup>a</sup>**

Stage (duration) <sup>b</sup>	Indoor activity	Session time minutes	Instructions	Fre- quency	Exercise training intensity	Outdoor training supervision <sup>c</sup>	Target distance miles      km	Perceived exertion target
I (1 to 3 weeks)	Treadmill: brisk walking	15–30	Proper technique for foot placement, body position, and arm motion	5 of 7 days	Low	Level 2	Up to 2      Up to 3	10 or 11
II (7 to 10 weeks)	Walking/running	15–30	Running technique	5 of 7 days	Low	Level 2 to level 4	Up to 3      Up to 5	< 13
III (12 to 16 weeks)	Increase in slope, but not speed	15–30	Running technique	5 of 7 days	Low to moderate	Level 2 to level 4	Up to 3      Up to 5	< 13
IV (> 16 weeks)	Independent practice: running/ walking on both flat and sloping courses	> 30	Practise and perfect the technique	5 of 7 days	Low to moderate	Level 1 to level 2	Up to 3      Up to 5	< 13
V	Patients are expected to have reached their aerobic efficiency within the limits imposed by their training programme and disease. A greater aerobic efficiency requires re-evaluation and an increase in intensity of the training programme.							

<sup>a</sup> Adapted from references 41 and 43.

<sup>b</sup> The training schedule is flexible. Duration should be adapted to individual patient's needs and abilities.

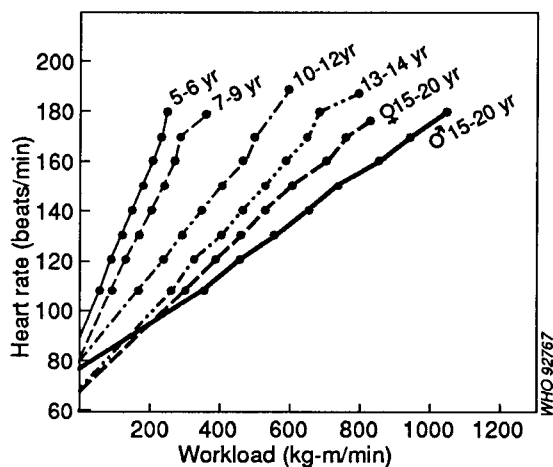
<sup>c</sup> Levels of supervision are specified in Table 21.

<sup>d</sup> See Annex 8.



Figure 1

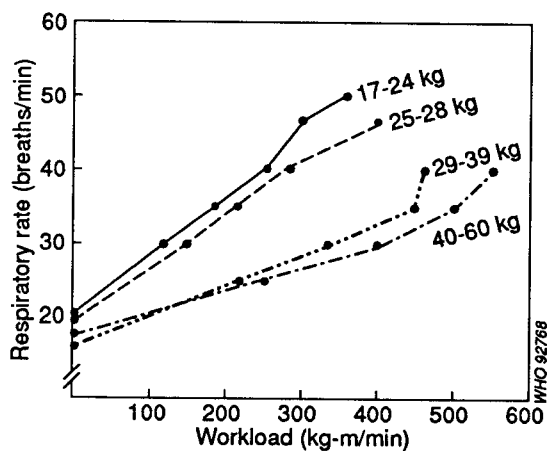
**Continuous graded exercise test for bicycle ergometer: Bengtsson, 1956 (25).**  
**Relationship between heart rate and workload at various ages<sup>a</sup>**



<sup>a</sup> Source: reference 21.

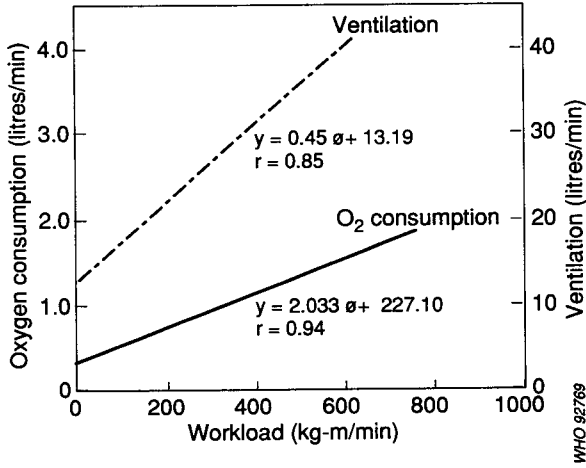
Figure 2

**Continuous graded exercise test for bicycle ergometer: Bengtsson, 1956 (25).**  
**Relationship between respiratory rate and workload at various weights<sup>a</sup>**



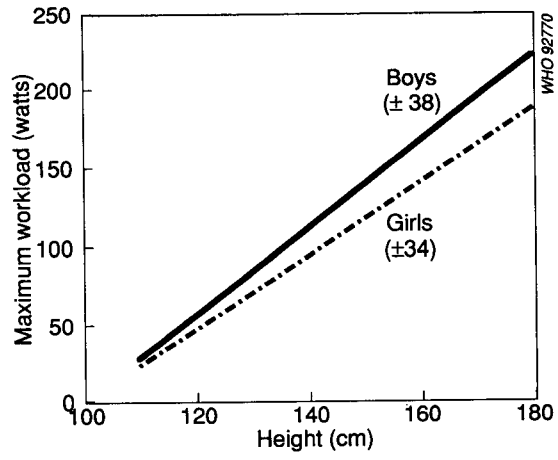
<sup>a</sup> Source: reference 21.

Figure 3  
**Continuous graded test for bicycle ergometer: Bengtsson, 1956 (25).**  
**Relationship between oxygen consumption, ventilation and workload<sup>a</sup>**



<sup>a</sup> Source: reference 21.

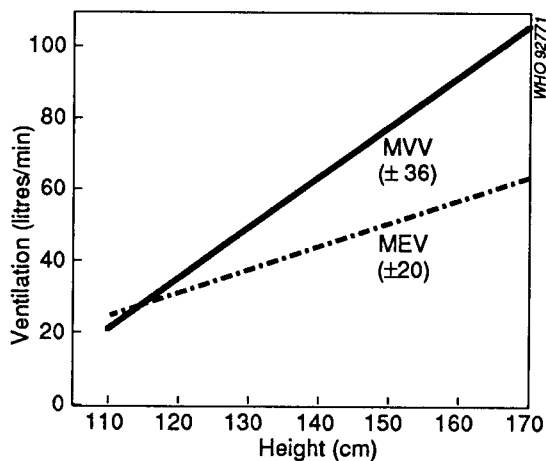
Figure 4  
**Continuous graded test for bicycle ergometer: Godfrey et al., 1974 (34).**  
**Relationship between maximal workload and height ( $\pm 95\%$  confidence limits)<sup>a</sup>**



<sup>a</sup> Source: reference 21.

Figure 5

**Continuous graded exercise test for bicycle ergometer: Godfrey et al., 1974 (34).**  
**Relationship between ventilation and height ( $\pm 95\%$  confidence limits)<sup>a</sup>**



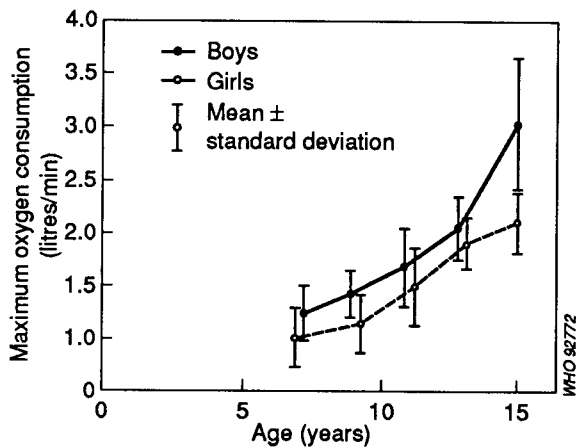
MEV = maximal exercise ventilation

MVV = maximal voluntary ventilation

<sup>a</sup> Source: reference 21.

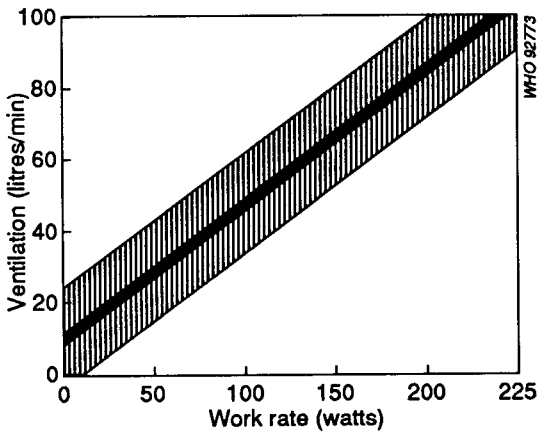
Figure 6

**Continuous graded exercise test for bicycle ergometer: Godfrey et al., 1974 (34).**  
**Relationship between maximum oxygen consumption and age<sup>a</sup>**



<sup>a</sup> Source: reference 21.

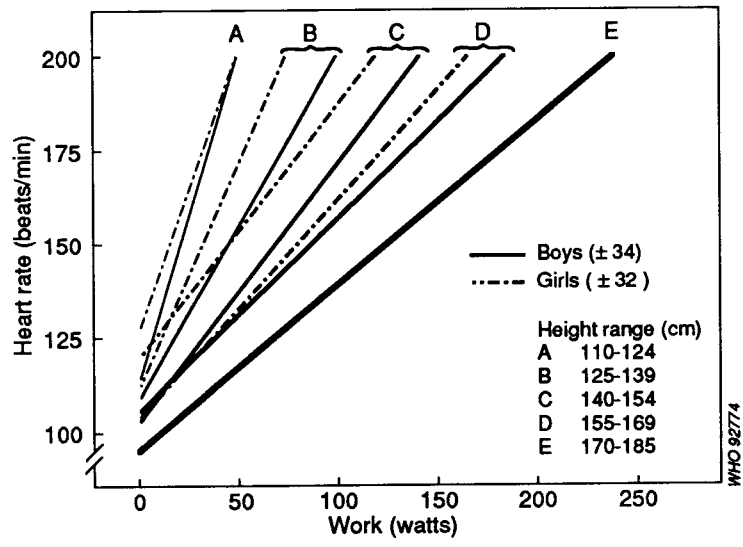
Figure 7  
**Continuous graded exercise test for bicycle ergometer: Godfrey et al., 1974 (34).**  
**Relationship between ventilation and work rate<sup>a</sup>**



Note: The shaded area represents  $\pm 95\%$  confidence limits.

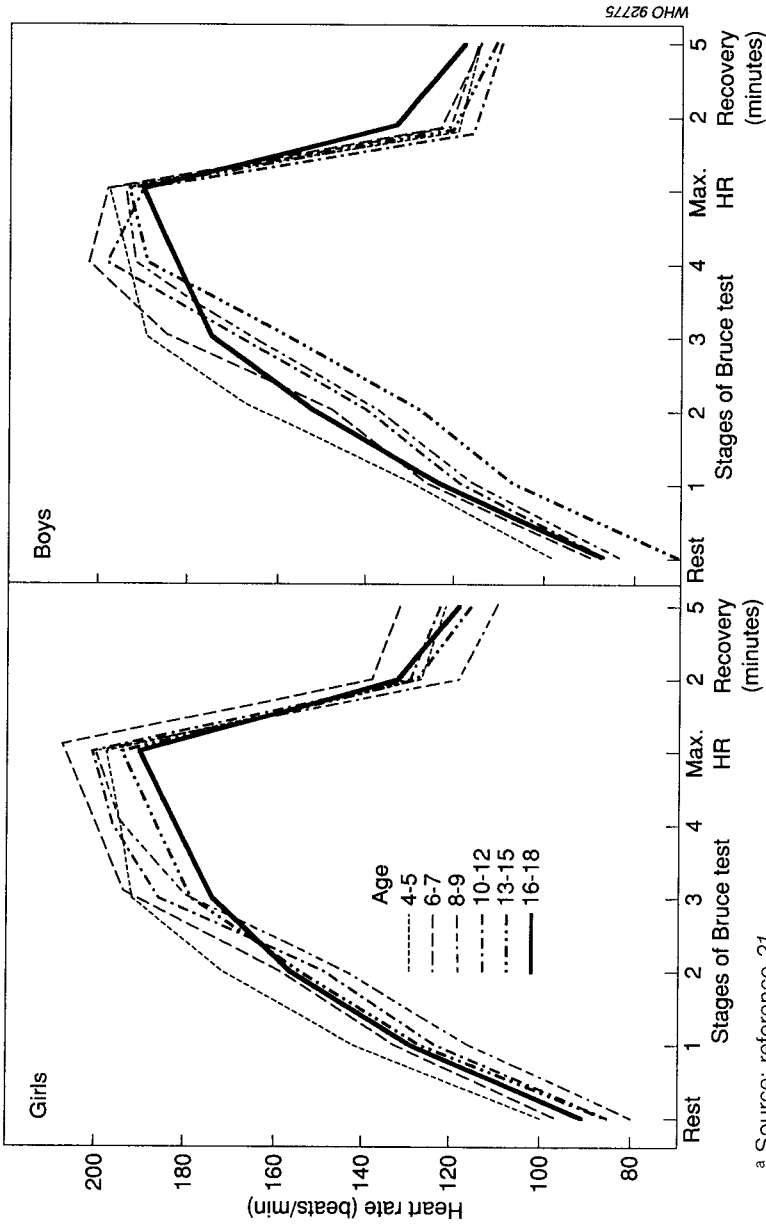
<sup>a</sup> Source: reference 21.

Figure 8  
**Continuous graded exercise test for bicycle ergometer: Godfrey et al., 1974 (34).**  
**Relationship between heart rate and work at various heights ( $\pm 95\%$  confidence limits)<sup>a</sup>**



<sup>a</sup> Source: reference 21.

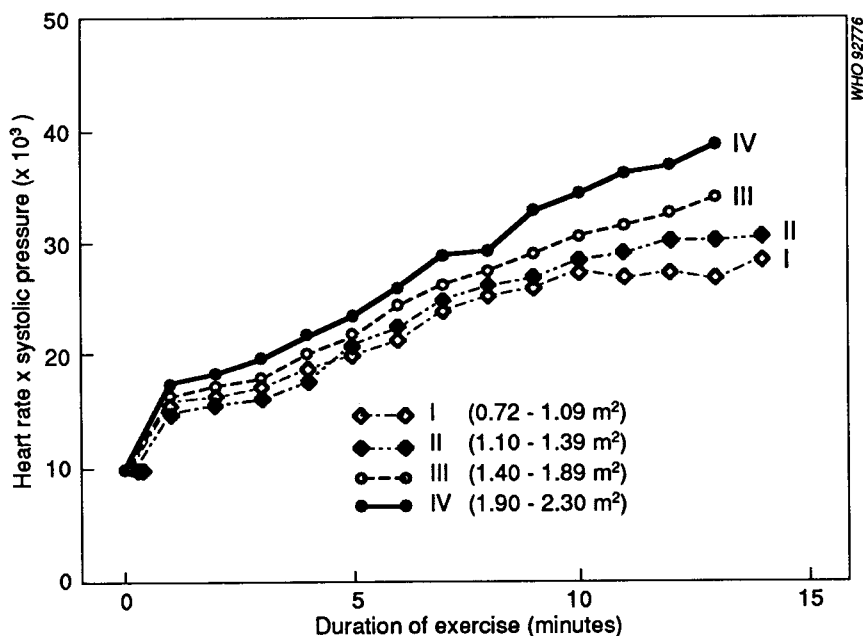
Figure 9  
**Continuous graded exercise test for treadmill (Bruce protocol): Cumming, Everatt, Hastman, 1978 (30).**  
**Relationship between heart rate and stage of exercise<sup>a</sup>**



<sup>a</sup> Source: reference 21.

Figure 10

**Continuous graded exercise test for treadmill (modified Balke): Riopel, Taylor, Hohn, 1979 (32). Relationship of the product of heart rate and systolic blood pressure and the duration of exercise, at various body surface areas<sup>a</sup>**



<sup>a</sup> Source: reference 21.

#### 4. **Rehabilitation of the severely disabled, medically complex cardiac patient**

Recent advances in cardiac care have contributed to improved survival of patients with advanced heart disease (48). The purpose of cardiac rehabilitation is to improve the functional status of these patients, to help them maintain independence, and to enhance the quality of their lives (49-55).

##### 4.1 **Severely disabled cardiac patients: description of the population**

A major proportion of the target population in developing countries will include patients with cardiomyopathies and valvular heart disease, rather than mainly coronary heart disease. However, the epidemiological trend suggests that coronary heart disease is likely to increase in prevalence.

Patients in New York Heart Association (NYHA) functional classes III and IV, and Canadian Cardiovascular Society classifications III and IV (for angina pectoris) are included in the group of severely disabled cardiac

patients. They are subject to moderate to severe limitations in daily living activities, such as bathing and dressing, in performing household tasks, in standing for long periods of time, and even in slow walking. The caloric expenditure for such activities is less than  $3 \text{ cal}_{\text{th}}/\text{minute}^1$  (1-2 METs; see section 2.6.1). Patients in class IV are unable to carry out even minimal physical activity without discomfort. (See Annex 4.)

A suitable and feasible rehabilitation programme is needed for these severely disabled patients (56): even modest improvements in physical working capacity can substantially improve their independence and quality of life. It is important to assess both the functional capacity and the risk status of these patients before considering them as candidates for exercise rehabilitation (49, 57-59).

## 4.2 **The roles of exercise testing** (4, 55, 60)

When feasible, exercise testing is useful before exercise rehabilitation is undertaken. It allows the identification of adverse responses to exercise, risk stratification, and assessment of functional capacity.

### 4.2.1 **Identification of adverse responses to exercise and risk stratification** (61)

In the severely disabled cardiac patient, exercise testing can provide information about the risk of myocardial ischaemia (62), the inability of the heart to meet the needs of muscular effort, the occurrence of exercise-induced arrhythmias and their characteristics, or combinations of these problems.

Ischaemia must be quantified (63): time of onset, amplitude, and delay in recovery of S-T segment displacement in relation to the intensity of the exercise and the associated increase in heart rate are therefore recorded. Once appropriate anti-ischaemic drugs have been administered, a second exercise test helps in the design of a safe and effective exercise programme.

An inadequate increase or a fall in systolic blood pressure, a low exercise capacity, and, in many cases, an inappropriate or exaggerated acceleration of heart rate, dyspnoea, pallor, and cold sweat are common markers of exercise-induced pump failure.

Exercise-induced high-risk ventricular arrhythmias contraindicate unsupervised exercise training. In patients with cardiomyopathies and rheumatic heart disease, atrial fibrillation is common. Atrial fibrillation with a ventricular response that is controlled at rest may become very rapid with exercise and induce pulmonary oedema. When triggered by exercise, rapid atrial fibrillation may induce severe ischaemia in a coronary patient. Control of the rapid ventricular response by medication can improve exercise capacity.

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<sup>1</sup>  $1 \text{ cal}_{\text{th}} = 4.184 \text{ J}$ .

#### 4.2.2 **Evaluation of functional capacity** (64)

Besides identifying the risks of exercise, exercise testing provides information about exercise capacity, which depends on a complex metabolic process in which cardiac output is a major factor. Pulmonary function, muscular strength and fitness, joint flexibility, coordination, body weight, level of haemoglobin, and nutritional status are also important. The contributions made by all these factors to the limitation of exercise capacity must be assessed by clinical examination combined with knowledge of patients' previous physical activity levels and fitness. Any remediable features should be addressed before exercise testing is undertaken: lack of fitness of other origin can exaggerate the apparent severity of cardiac impairment at exercise testing.

Generally, however, there is good correlation between NYHA functional classification and exercise capacity expressed as duration and workload sustained at exercise testing, oxygen consumption, and MET levels (see Annex 7).

Performing an exercise test before rehabilitation is undertaken provides assessment of cardiovascular fitness and thus a basis for appropriate exercise prescription. In this regard, workload and heart rate at peak exercise are particularly important (65-67). For individuals receiving medication on a regular basis, the exercise test should be performed while they are receiving these drugs. In some cases, it may be necessary to perform exercise testing using an arm ergometer because of orthopaedic problems or leg claudication.

### 4.3 **Methodology of rehabilitation**

#### 4.3.1 **Overview**

The rehabilitation of patients severely disabled by cardiovascular disease includes optimal medical therapy and, when appropriate, surgical intervention. Treatment should be reassessed before rehabilitation begins because an optimal regimen of drugs may substantially improve functional capacity. Patients with compensated chronic heart failure due to rheumatic or other valvular disease, to coronary heart disease, or to cardiomyopathy can often be included in a training programme of low to moderate intensity. Such patients, and others with depressed left ventricular ejection fractions can participate in long-term exercise rehabilitation programmes without further deterioration of ventricular function and with their improved functional capacity maintained (12).

#### 4.3.2 **Energy requirements of work** (see Annexes 9 and 10)

The caloric requirements of various activities can serve as a guide for restoring an acceptable quality of life to many severely disabled cardiac patients. The patient who can look forward to a productive and creative daily life will benefit from an improved mental state, and reduced anxiety, fear, and depression (68). The need for structured psychological support



can be reduced in patients who are able to return to productive work in occupations with low caloric requirements or in sheltered workshops (12). For success, rehabilitation must be flexible enough to take account of the social and cultural background of the patient and of local conditions (59).

#### 4.3.3 ***Class IV patients***

Class IV patients have only a minimal ability to engage in physical activity requiring greater energy expenditure than  $1.5\text{--}2.5 \text{ cal}_{\text{th}}/\text{min}^1$ , even for short periods of time. Exercise rehabilitation should therefore not involve traditional aerobic training. Short walks on level ground for up to 10-15 minutes once or twice a day should be tried. Breathing and relaxation exercises and passive exercise may be helpful initially. Occupational therapy up to  $1.5 \text{ cal}_{\text{th}}/\text{min}$  is well tolerated by most patients, and light sedentary activities can also gradually be undertaken (see Annex 10). Patients should be told to cease immediately any activity that causes symptoms such as increasing breathlessness, resting anginal pain, and/or severe palpitations. The programme should be revised and new recommendations made if necessary. Symptomatic complications of this nature can be anticipated in Class IV patients.

#### 4.3.4 ***Exercise rehabilitation of Class III and Class IV patients***

##### *Supervised programmes*

Typically, patients of Classes III and IV are admitted for 6-8 weeks to a facility where close medical supervision is provided and a systematic increase in physical activity is monitored. It is rare for complications to occur in the circumstances (see Annex 2).

In order to obtain a training effect, work intensity in the range of 65-75% of peak work capacity has to be achieved for approximately 30 minutes each session at least three times a week. There is good correlation between heart rate and work capacity, with a heart rate of 70-85% of peak corresponding to 65-75% of peak work capacity. Exercise training intensity can be conveniently monitored where the exercise prescription is based on a target heart rate range, particularly in a supervised setting.

##### *Unsupervised programmes*

Exercise of lower intensity but of longer duration and greater frequency can provide the same benefit (6). The lesser risk of lower intensity exercise is important in unsupervised programmes. Self-monitoring in the absence of supervision should include checking the pulse rate, using the Borg scale of perceived exertion (11), or being able to continue talking to a companion during exercise.

In developing countries where the prevalence of coronary heart disease is increasing, comprehensive cardiac rehabilitation programmes are indicated for Class III and IV patients after myocardial infarction or

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<sup>1</sup>  $1 \text{ cal}_{\text{th}} = 4.184 \text{ J}$ .

coronary bypass surgery (69). Since supervision by physicians may be minimal in many non-urban areas, approaches that involve non-physician health professionals should be considered (see section 2.3.1)

#### 4.3.5 ***Non-exercise recommendations for Class III and Class IV patients***

Class III and IV patients should receive information that will help them achieve positive modification of lifestyle (e.g. cessation of smoking, diet modification) and precise information relating to their specific diseases.

#### 4.4 **Exercise recommendations for Class III and Class IV patients by disease category**

Specific exercise training recommendations for patients with coronary heart disease, cardiomyopathy, or valvular heart disease should be followed.

##### 4.4.1 ***Coronary heart disease***

Patients with coronary heart disease should undergo clinical evaluation and exercise testing for risk stratification when possible (see Annex 3) to determine the potential risks of exercise. Scores for quantification of the severity of disease may be useful, although they are based on specific test protocols (70-73).

High-risk patients (see Annex 3) should participate in *supervised* exercise training programmes.

Patients who are impaired by effort angina during exercise training should take sublingual nitroglycerine before beginning exercise.

In rural areas, with basic equipment and facilities, the first priority should be to establish a comprehensive education programme focusing on the patient's cardiovascular problem. If possible, an exercise test should be performed and a low-intensity programme prescribed (see Annex 1).

##### 4.4.2 ***Hypertrophic cardiomyopathy***

*Note:* Dilated cardiomyopathy is discussed in section 4.5.

Only low-intensity exercise should be undertaken by patients with hypertrophic cardiomyopathy because of the increased risk of sudden death if they have:

- significant outflow gradient (identified by echocardiography or catheterization);
- severe left ventricular hypertrophy;
- history of syncope;
- history of sudden death in relatives;
- exercise-induced complex ventricular arrhythmias.

#### 4.4.3 **Valvular heart disease** (67, 74)

##### *Mitral valve disease*

Mitral valve disease is the most common problem among patients with rheumatic heart disease. In dominant mitral stenosis, closed valvular mitral commissurotomy reduces the symptoms, improves function, and provides cost-effective rehabilitation. The benefit of physical training in patients with mild to moderately severe mitral valve disease has not been systematically examined.

Patients in Classes III and IV with mitral valve disease are candidates for surgery and subsequent exercise training programmes. Such patients usually have a long history of disability and severely limited activity (49). Cessation of smoking, correction of overweight, and control of atrial fibrillation may temporarily reduce the severity of symptoms. Valvular surgery is a planned intervention, and preparation of the patient should include dental care to prevent infective endocarditis. Patients should also learn incentive spirometry.

##### *Exercise after heart valve replacement*

When exercise is prescribed after heart valve replacement (49), four major factors must be considered:

- the type of valve prosthesis used or reconstructive procedure undertaken, as it affects valve gradient;
- the anticoagulant treatment;
- the extent of myocardial dysfunction;
- prior physical deconditioning.

*Aortic valve replacement.* After aortic valve replacement for aortic stenosis, exercise testing is a useful guide to prescribing appropriate exercise. Long-term prognosis for valve replacement for aortic stenosis differs from that for aortic regurgitation: the more favourable prognosis in aortic stenosis relates to preserved ventricular function. The recommendation for exercise after aortic valve replacement for aortic regurgitation depends on residual left ventricular dysfunction and on residual aortic regurgitation. In all patients with a valve prosthesis, the mandatory anticoagulation will substantially increase the risk of complications from exercise- or activity-related trauma.

*Mitral valve replacement or repair.* After surgery for the repair or replacement of the mitral valve, the following haemodynamic abnormalities remain:

- An average gradient of 7–10 mmHg (0.933–1.33 kPa) persists across the valve at rest. This gradient is substantially increased by exercise-induced tachycardia.
- Atrial fibrillation is frequently present and superimposes its adverse effects on cardiac output, giving rise to rapid heart rate and loss of atrial contribution to ventricular filling. (Administration of appropriate drugs to slow atrioventricular conduction is beneficial, and cardioversion should also be considered.)

The extent of postoperative ventricular dysfunction determines whether or not exercise recommendations should be as for left ventricular dysfunction (see section 4.5). Early mobilization and progressive ambulation reduce the likelihood of postoperative venous thromboembolism, but careful clinical evaluation is mandatory. Radiographic monitoring of heart size may be required.

There are few systematic studies dealing with physical rehabilitation of patients who have had valvular surgery. Postoperative physical activity involves low-intensity muscular conditioning that does not impose an undue load on the heart. This includes walking, calisthenics (with due care taken of the sternal incision), and supervised treadmill or bicycle exercise. A symptom-limited exercise test is useful in assessing ability to return to work and for recommending levels of occupational and recreational activities.

Soon after surgery patients should receive advice and counselling about anticoagulant treatment (and keeping records of this), other medical therapy, the type of valve prosthesis, prophylaxis against infectious endocarditis, and response to recurrence of symptoms.

Return to work and appropriate social reintegration depend on many variables, including the patient's motivation, cardiac status, prognosis and risk, competent vocational counselling, and – very importantly – the opinion and influence of the treating physician. The longer a patient has been out of work, the less likely it is that he or she will resume a remunerative occupation.

#### **4.5 Patients with severe cardiac failure (Classes III and IV)**

##### **4.5.1 Overview**

Heart failure is not a disease entity but a manifestation of many causes of heart disease, including dilated cardiomyopathy, hypertensive cardiac failure, valvular heart disease, endomyocardial fibrosis, and ischaemic ventricular dysfunction. The last is a major cause of heart failure in developed countries and an increasing cause in developing countries.

##### **4.5.2 *Comprehensive rehabilitation programmes for patients with compensated heart failure and severely impaired left ventricular function***

Medical and surgical therapy have significantly decreased morbidity and mortality in patients with compensated heart failure and severely impaired left ventricular function (48, 75-77). Patients with chronic stable heart failure are disabled by breathlessness and fatigue. There is no constant correlation between these symptoms, which limit exercise tolerance, and the degree of left ventricular dysfunction (78, 79). The decreased muscular function (80) may be due either to hypoperfusion during exercise (81) or to prolonged deconditioning. Respiratory discomfort is caused both by hyperventilation, which provokes premature fatigue of the respiratory

muscles, and to some extent by an increase in pulmonary vascular pressures, which gives rise to a sensation of suffocation.

Thus, to improve exercise tolerance, maximal blood flow should be increased, muscle vasodilation improved, and deconditioning avoided. The drugs normally used to compensate heart failure result in improved exercise tolerance. Studies on the effects of exercise training in patients with heart failure are limited, but preliminary results have been encouraging (82-85). A training-induced decrease in lactate accumulation, a consequent delay in onset of anaerobic threshold, and an increase in exercise endurance favourably affect the submaximal exercise level involved in patients' day-to-day activities.

In addition to the exercise programme, cardiac rehabilitation in these patients includes dietary advice and long-term control of medical therapy. Malnutrition is common in patients with heart failure because of decreased food intake and poor intestinal absorption. For those patients with heart failure who are significantly overweight, weight loss is important: excess weight increases cardiac work. Restriction of sodium intake is important in both groups. Teaching these patients work techniques that will simplify their usual daily activities improves their ability to maintain independence.

#### *Rehabilitation after large myocardial infarction*

After large myocardial infarction, even patients of NYHA functional class III or IV may achieve some relative benefit from an exercise programme. Clinical studies have shown that, although patients with left ventricular dysfunction, especially those with ischaemic heart disease, are at potentially high risk of exercise-related arrhythmias, the actual risk is relatively small when compared with the high incidence of non-exercise-related sudden death. One report (86) describes adverse effects of early high-intensity exercise training on ventricular function in some patients with large anterior Q-wave myocardial infarction; several other studies have failed to confirm this (51, 56, 87). None the less, patients with large infarction should be considered with caution for long-term exercise therapy. Serial clinical evaluation of heart size and left ventricular function should be carried out; in case of worsening, physical training should be reduced or stopped.

#### **4.5.3 Exercise therapy and guidelines for patients with compensated heart failure and reduced left ventricular ejection fraction**

Exercise training helps to improve the functional capacity, and hence the quality of life, of patients with compensated heart failure and reduced left ventricular ejection fraction (88, 89). The ability to increase low level activity by even 1-2 METs may mean the difference between an independent existence and living in a chronic care facility.

Patients with severe left ventricular dysfunction can improve their exercise capacity by increasing their target heart rates gradually, by small increments, during the exercise programme. With time, skeletal muscles

extract more oxygen from the blood during exercise (90), thus widening the arteriovenous oxygen difference. Exercise tolerance improves, as demonstrated by lower heart rates during submaximal exercise and increased peak workloads.

Patients must be evaluated carefully by a physician before starting the exercise programme (58). They should be free of unstable angina, decompensated heart failure, or arrhythmias that compromise haemodynamic stability before exercise.

Patients should be told to use subjective indicators such as the Borg scale of rate of perceived exertion (see Annex 8) to guide the intensity of their activity during exercise sessions and in day-to-day tasks.

Patients with left ventricular dysfunction can tolerate only limited workloads, but most can gradually increase the duration of their exercise. Rest intervals during exercise (interval training) may allow more activity during a training session. Warm-up and cool-down periods should be prolonged. Dynamic resistance exercise can produce muscle strengthening; when comfortably seated in an armchair a patient with heart failure may accomplish substantial muscular work with the arms or the legs using light dumb-bells or, when possible, pulleys and counterweights, without adverse effects. Interval training is also advised for muscle-strengthening exercises.

Ideally, there should be ECG monitoring of patients with severe left ventricular dysfunction throughout warm-up, exercise, and cool-down, at least during the initial sessions.

#### **4.6 Exercise training in patients with implanted pacemakers (91)**

##### **4.6.1 *Fixed-rate pacemakers***

Many patients who are pacemaker-dependent at rest show a reappearance of atrioventricular conduction when they exercise, although many others remain pacemaker-dependent. It is not possible to consider the heart rate as a parameter for exercise prescription in patients of this group.

In a pilot study, a cardiovascular training response of this type was obtained in patients with fixed-rate pacemakers (92).

##### **4.6.2 *Variable-rate pacemakers***

In patients with pacemakers that are atrioventricular-synchronized and/or rate-responsive, exercise testing can be used both to set the pacing rate of the pacemakers and to prescribe exercise training based on heart rate (93, 94).

#### **4.7 Rehabilitation of patients with serious arrhythmias**

Rehabilitation of patients with serious arrhythmias poses complex problems. Currently there is concern about prescribing certain antiarrhythmic drugs because of their proarrhythmic effects. Beta-

blocking agents seem to reduce the incidence of sudden death after myocardial infarction among patients for whom their use is suitable; in many patients, unfortunately, the negative inotropic effect of these drugs reduces exercise capacity. Ideally, an evaluation of the effect of antiarrhythmic drugs by an exercise test and/or ambulatory ECG monitoring should be conducted.

Atrial fibrillation is one of the most common supraventricular arrhythmias, and makes a heart rate parameter during exercise unreliable. In patients with atrial fibrillation, the Borg scale of rate of perceived exertion (see Annex 8) may be a valuable guide to exercise training.

Implanted cardioverter defibrillators are increasingly used for management of life-threatening arrhythmias. Although the number of patients with these devices who will undergo exercise training is limited, the following points should be emphasized (97):

- Exercise testing can identify the patients with exercise-induced arrhythmias who should not undergo exercise training.
- Exercise testing can be a guide to heart rate settings, ensuring that a device responds to life-threatening arrhythmias but is not triggered by heart rates achieved during exercise.
- Other patients who share the same exercise sessions should be reassured that no harm will result from touching patients with cardioverter defibrillators during discharge of the devices.

#### 4.8 **Rehabilitation of elderly cardiac patients (53, 55)**

As populations age in both developed and developing countries, more elderly patients with cardiac disease will be enrolled in rehabilitation programmes. Coronary heart disease is the most common problem in developed countries. Elderly coronary patients are medically complex because of the frequent complications of coronary disease and concomitant problems of diabetes, cerebral and peripheral vascular disease, hypertension, and chronic obstructive pulmonary disease.

The exercise capacity of elderly cardiac patients reflects the nature of their disease, other concomitant diseases, and, frequently, the deconditioning resulting from a sedentary lifestyle, all superimposed on the physiological effects of aging. Exercise training may help reduce the consequent limitations of activity and provide the sense of well-being and self-esteem necessary to prolong active and independent life.

Important considerations for exercise training of elderly cardiac patients include the following:

- high-impact activities should be avoided;
- prolonged warm-up and cool-down periods are necessary;
- training should begin at low intensity and progress gradually;
- repeated short periods of activity may be as beneficial as a single, more prolonged session;

- exercise intensity should be reduced in hot and humid environments because of patients' impaired thermoregulation;
- exercise-related orthostatic hypotension resulting from delayed baroreceptor responsiveness should be assessed;
- specific muscle-strengthening activities can aid in self-care.

#### 4.9 **Rehabilitation in cardiac transplantation** (54, 95–98)

##### 4.9.1 ***Pre-transplantation patients***

Patients awaiting transplantation are often deconditioned and exhibit severe cardiac impairment, breathlessness on exertion, and cardiac cachexia; they are also at increased risk of sudden cardiac death. The goal of exercise is to prevent further deconditioning and, in some patients, to improve skeletal muscle status. Standard exercise testing or cardiopulmonary exercise testing is valuable in formulating recommendations for physical activity. These patients are at high to intermediate risk for exercise rehabilitation.

Education and counselling can introduce the concept of reducing coronary risk factors after transplantation, improve patients' motivation, and encourage family support.

##### 4.9.2 ***Post-transplantation patients***

After transplantation, patients receive immunosuppressive medication including ciclosporin. They are at high risk of infection, and exhibit predisposition to atherosclerosis, susceptibility to transplant rejection, diastolic dysfunction of the transplanted heart, chronic effects of medication-related hypertension on cardiac function and exercise, wasting of skeletal muscle, weakness resulting from corticosteroid therapy, and a blunted heart-rate response and lower cardiac output with exercise because of cardiac denervation.

Once these patients are stabilized postoperatively, exercise training carries intermediate or low risk. They generally remain in a supervised rehabilitation programme at the transplant centre, participating in exercise training 2–4 times a week for 4–6 weeks as a component of intensive early postoperative treatment and rehabilitation.

Subsequent rehabilitation services will vary according to where the patient receives primary long-term care. Rehabilitative exercise training may take place in a community-based facility or be undertaken without supervision at home. Patients are typically followed by their referring community physician for risk factor modification and most other routine treatments, based on recommendations from the transplantation centre. Periodic visits to the transplant centre are scheduled.

#### 4.10 **Patient education and counselling**

One of the most important features of a rehabilitation programme, especially for those who are severely ill, is a well prepared and thorough



educational programme for patients and their families (see section 5.1). To be successful, comprehensive rehabilitation needs both the dedicated assistance of the medical profession and the willingness of patients and families to cooperate.

#### 4.11 **Summary**

Rehabilitation is an essential part of the management of the severely disabled, medically complex cardiac patient, and leads to an increase in physical capacity and improved quality of life. It demands great expertise on the part of the patient's physician and other health professionals because of the potential hazards involved; available medical and surgical services should be fully utilized, with cost-effectiveness a consideration at every level of care. The result of a successful, continuing rehabilitation programme is greater self-confidence and self-reliance for the patient, and lowered demands on health services, particularly for in-patient care. If the patient's capacity for self-sufficiency and independent living can be maintained or restored, the need for institutional care is also reduced.

### 5. **Current and future approaches to education in the rehabilitation of patients with cardiovascular disease**

#### 5.1 **Importance of education and counselling in cardiac rehabilitative care**

##### 5.1.1 ***Definition and goals***

Education of patients and their families involves the provision of carefully constructed opportunities for learning. It is designed to facilitate patients' ability to initiate and sustain changes in health behaviour and to achieve predetermined goals (99). Health information is a strategic resource in the educational process.

Educating a patient's family and/or spouse is as important as educating the patient in achieving active and informed participation; all should learn about the disease, the process of recovery, and the benefits of rehabilitation. The family is an important source of social support for the patient.

##### 5.1.2 ***Benefits to patients*** (100)

Acute or episodic care alone is inadequate for most chronic diseases, and patients themselves and their families must therefore assume greater responsibility for care (101). They must be trained to become active partners in the rehabilitation process. Through education, the cardiac patient's feelings of hopelessness and helplessness can be reduced, self-esteem restored, confidence in a successful outcome increased, and ability to cope with problems of illness enhanced. Understanding the disease can also increase the patient's compliance with recommendations

for care. Some of the educational goals are thus short-term and some long-term, but the ultimate aim of education is to improve cardiovascular “health” and quality of life (102).

Education and counselling also improve the patient’s perception of health status and aid in resumption – at an appropriate level – of family, occupational, and community roles (103-106).

### 5.1.3 **Benefits to society**

Initially, education may entail an increase in health care costs because of greater use of services, but patients will subsequently manifest fewer recurrences or complications or less progression of disease; costs of hospital care, use of emergency facilities, etc. will thus ultimately be reduced.

## 5.2 **Educational concepts and principles**

Physicians and health professionals should be caring, compassionate, and dedicated to patients, to keeping them well, and to helping them during illness. For each patient it is important that they devise a plan of action for transmitting the knowledge, values, skills, and attitudes that are essential to improved prognosis and social reintegration.

In some countries there is a legal requirement for patients to be instructed in self-care, as an integral part of planning for their discharge from hospital. Health professionals bear responsibility for the content and presentation of the appropriate information, and for ascertaining that patients have fully comprehended it. It is a significant challenge to integrate all aspects of cardiac rehabilitation – including the educational component – into existing health care systems in a cost-effective manner (100).

### 5.2.1 **Overview**

Although the aims of education programmes have universal relevance, their content may require modification to take account of local languages, culture, educational levels, available communication media, and disease patterns. Ideally, programmes should be relatively inexpensive, informative, accurate, and attractive. If patients are to be correctly informed about their disease, the subsequent need for care, and the importance of modifying health-related behaviour, a systematic approach and consistent presentation of material are essential (103). Patients must be motivated to continue in an educational programme because the skills and knowledge acquired are important to health and to the prolongation of life.

Factors that should influence the choice of educational methods are:

- literacy and educational level of patients;
- linguistic settings: language may constitute an obstacle to communication in print or by radio or television in societies with many tribal/population language groups;

- communication medium: use of printed material requires a reasonable level of literacy, but drawings and photographs can be used where illiteracy is common; radio and television can transcend illiteracy levels, but must take account of local language requirements;
- culture: education must relate to the environment in which a patient lives; any recommended changes in lifestyle should be achievable within local cultural norms.

The main principles of patient education may thus be outlined as follows:

- Information should be presented in a language and style appropriate to the subject and patient. Short words and sentences should be used for better understanding. Important ideas should be repeated. Specific, detailed recommendations should be given.
- Information should relate to the individual, and a patient's questions should be fully answered.
- Learning should be reinforced and corrective feedback provided.
- Patients' knowledge should be assessed before and after education, to evaluate the extent of learning.
- Education should take advantage of the "teachable" moment, when the patient actively seeks information.

Learning theory (Tables 28, 29) emphasizes three important serial components in effecting change:

- consciousness or awareness of need for information;
- provision of information, which can generate changes in attitude; and
- implementation of behavioural change based on personal value of the information, with long-term adherence requiring feedback and reinforcement (5, 105, 106).

### 5.2.2 **Education of adults** (107)

In contrast to children, who generally learn whatever information is presented to them, adults learn in order to solve problems. Adults therefore tend to be concerned with the immediacy of application of new knowledge.

An individual learns effectively those things perceived as relating directly to his or her own problems. The atmosphere that best promotes learning is one in which (a) the learner's perception of the disease as a threat can be reduced to a minimum, and (b) the material is seen by the learner as individualized and appropriate to adult needs.

Changes in self-concept are reflected in the change from dependence to increasing self-efficacy as an adult learns. Success promotes learning: that is, mastering one aspect of a problem facilitates mastery of others. Readiness to learn is likely to be prompted by personal need – in this case, the need to cope with recovery at home.

Table 28

**Relationship between behaviour domains and teaching and learning actions<sup>a</sup>**

Domain	Teaching method	Learning outcome
	The teacher will:	The learner will:
Cognitive Information, knowledge	<ul style="list-style-type: none"> <li>– inform</li> <li>– instruct</li> <li>– lecture</li> <li>– provide</li> </ul>	<ul style="list-style-type: none"> <li>– explain</li> <li>– describe</li> <li>– discuss</li> <li>– define</li> </ul>
Affective Attitudes, emotions	<ul style="list-style-type: none"> <li>– counsel</li> <li>– model</li> <li>– reinforce</li> <li>– provide peer exchange</li> </ul>	<ul style="list-style-type: none"> <li>– express</li> <li>– affirm</li> <li>– choose</li> <li>– share</li> </ul>
Psychomotor Skills, performance	<ul style="list-style-type: none"> <li>– demonstrate</li> <li>– coach</li> <li>– guide</li> <li>– provide practice</li> </ul>	<ul style="list-style-type: none"> <li>– perform</li> <li>– do</li> <li>– produce</li> <li>– use</li> </ul>

<sup>a</sup> Source: reference 106.

Table 29

**Checklist for assessing patient readiness to learn<sup>a</sup>**

Is the patient ready to learn at this time?	
Physical ability checkpoints	Psychological willingness checkpoints
<ul style="list-style-type: none"> <li>• Stable physical condition (free of pain and complications)</li> <li>• Adequate energy level (not too exhausted or sedated)</li> </ul>	<ul style="list-style-type: none"> <li>• Appropriate emotional state (not too anxious or depressed)</li> <li>• Awareness of actual problems (not in total denial)</li> </ul>

<sup>a</sup> Source: reference 106.**5.2.3 The behavioural approach (105)**

Behavioural changes made gradually are more likely than sudden changes to be successful in maintaining a healthy lifestyle. A successful education programme to change health-related behaviour should:

- build positive, realistic, and accurate expectation of the results of learning;
- precisely define the health-related behaviour to be changed;
- set realistic goals;
- enhance commitment by “contracting” (providing participants with incentives);
- prepare participants for the possibility of lapses and relapses, if appropriate;
- provide a model for the desired behaviour;
- prompt the practice of the desired behaviour;

- provide feedback regarding progress in behavioural change;
- identify difficulties and provide guidance in problem-solving;
- reward patients' achievements; and
- enlist social support as needed and as appropriate.

#### 5.2.4 ***Education of children with cardiac disease***

For paediatric patients, the educational objective is to make optimal intellectual, physical, emotional, and social development possible. This necessitates long-term adherence to a recommended lifestyle, and involves informed decisions on career options. Education of girls with cardiac disease about their condition is as important as that of boys, even in societies where the general education of girls may be limited.

Although the setting for rehabilitative education and the communication medium can vary considerably, the most important influences on paediatric patients remain their parents, their teachers and schools, their peers, and local role models.

Children respond well to visual, auditory, tactile, and kinaesthetic stimuli, and special characteristics therefore apply to educating those with cardiac disease about exercise training for rehabilitation. A variety of activities should be provided, each lasting for a short time and allowing for spontaneous movements, in a group rather than an individual setting. Groups should be separated according to age: up to 8 years, 8-12 years, 13-15 years, 15 years and over. Parents should be encouraged to become involved: their participation presents a child with a role model. Further motivation can involve a system of incentives or rewards.

#### 5.2.5 ***Education of elderly cardiac patients (108)***

Educational programmes for elderly cardiac patients must be designed to overcome medical and social as well as cultural barriers to communication. Impaired vision or hearing are examples of such physical barriers; other likely obstacles include declining cognitive function and memory, and emotional instability. In general, education of elderly patients must take account of the fact that many individuals may be fragile and may suffer from other coexisting conditions or diseases. It is also important that educational programmes should acknowledge the cultural traditions of the patients, for example the position of the elders in a particular society. Requirements for education of elderly cardiac patients include the following:

- lifestyle interventions made in moderation and at levels compatible with the patients' age and experience;
- development of social support networks, and simplification of daily work and other activities;
- clear written instructions to help avoid confusion, especially when several drugs are prescribed or multiple recommendations made.

Education of the elderly can take place in the doctor's office or in a clinic.

Community centres and retirement homes offer a tremendous potential both for educational programmes and for lifestyle interventions. These group settings offer “captive” audiences, interested in health issues and supportive of health-related programmes.

Home visits by medical, health care, or social workers provide important contacts with individual elderly patients in many countries, and in many societies, the home and family can facilitate home-based education. Monitoring of the patient’s general health, ECG, etc. by means of telephone links or comparable technology in developed societies can promote self-care and facilitate surveillance of elderly patients living independently.

### **5.3 Facilities for educational programmes at different levels of care**

#### **5.3.1 *Basic, intermediate, and advanced***

Educational programmes must be provided at all three levels of care: basic, intermediate, and advanced. As already noted in section 2.3, the availability of trained personnel and appropriate resources will vary widely between the three levels.

For a variety of reasons, patients who live in rural areas of developing countries often have extremely limited access to hospital programmes. Of necessity, therefore, the home and other non-medical sites may be the focus for many of the educational efforts. In these circumstances, patient education must meet a number of challenges if it is to be effective, including:

- implementation in sites other than the hospital or clinic, e.g. the home, community centres, schools, and worksites;
- greater reliance on non-physician health professionals to implement education; and
- more effective and creative use of existing basic communication channels and of advanced technology where available.

#### **5.3.2 *Use of technology***

Appropriate use of available technology can both reduce the workload and increase the effectiveness of education; it can also help to initiate behavioural changes throughout a wide spectrum of educational levels.

Printed educational materials should be tailored to a patient’s needs and abilities. Many materials in current use require literacy levels above those of the target population, in both developed and developing countries. If printed material is to be effective, its language and illustrations, the skills it demands, and the examples it uses must be appropriate to the intended audience. Moreover, many of the printed sources of information are unavailable in patients’ homes and communities in developing countries: books, newspapers, and magazines are in short supply, even among literate populations. Where high levels of illiteracy exist, the impact of print media is less than that of radio or television (109).

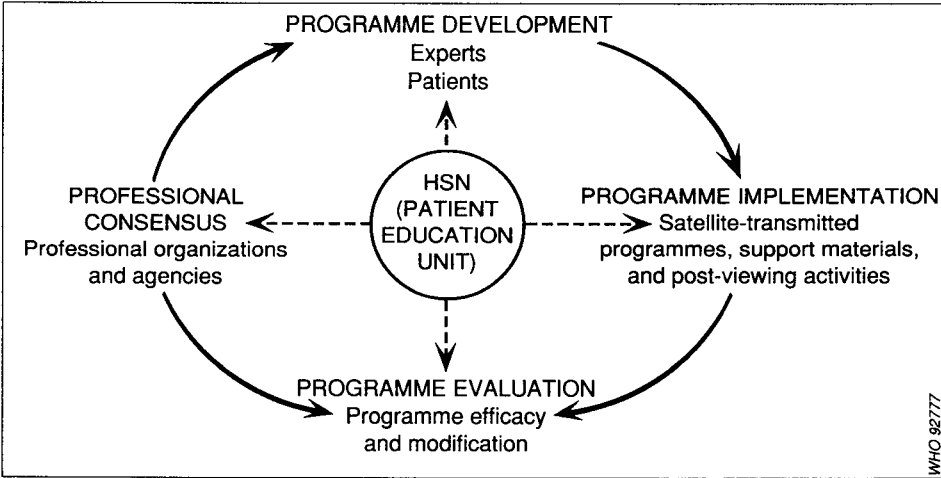
The availability of radio, television, and even video cassette recorders is increasing, even among rural communities. These media can inform, educate, and entertain over great distances, but the cost of batteries and the lack of other power sources are important limitations to their use.

Lack of availability and frequently prohibitive costs limit the potential usefulness of the telephone as an educational medium in developing countries. In developed societies, however, health care professionals can use the telephone to institute and maintain behaviour change. Linked to databases, integrated systems digital networks, and home computers, the telephone may ultimately become a critical tool for education in behavioural change. Interactive telephone education systems have enormous potential for application in health care settings.

The development of satellite technology (Fig. 11) has made information available instantly and globally through television, telephone, and fax, and by teleconferences (110). As satellite dishes become smaller and more widely available, use of this technology will become more cost-effective. Information can be communicated by voice over the telephone; pictures, data, text, and graphics can be transmitted through microcomputers, printed material through fax machines, and notes, charts and diagrams through teleprinters.

Figure 11  
**Distance patient education system<sup>a</sup>**

Hospital-based programmes may require modification to suit local needs. The systems for patient programmes can also be used for professional education systems.



HSN = hospital satellite network

<sup>a</sup> Adapted from reference 110.

The potential disadvantages of international educational programmes designed for use with this technology are the differences that exist in cultural characteristics, family values, consumer behaviour, copyright laws, political issues, etc. between countries.

In developed societies increasingly complex medical information will be available in the home through cable television, videotext, and optical disc storage. In many countries, hospitals have cable television for entertainment purposes as well as for education of patients and medical personnel. The advent of telephone-linked computers in the home will allow more and better exchange of information, such as ECGs transmitted to physicians and appropriate instructions relayed to patients. Educational subscription television with health education components is currently available in many countries.

Computers can help patients to assess their knowledge, attitudes, behaviour, and skills in relation to a particular risk factor, and then to establish specific goals for change. Many computer programs with these characteristics have been developed. Interactive video, as well as videophones and special computer formats, offers even greater potential for more interesting, yet personal, instruction.

Financial considerations are likely to be the limiting factor in realizing the potential of new technology. Sophisticated computer programs require expensive hardware and are unlikely to achieve wide distribution in the foreseeable future. Other, cheaper, communication media, such as audio tapes that supplement simple printed material, may be more useful in developing countries.

Indeed, computers are used relatively little in most medical practice settings, and there are many reasons for this. Physicians and other health care professionals generally have limited knowledge or experience of computers as educational media; both hardware and software are expensive; and there is a widespread belief that patients react negatively to the use of computers for education designed to promote behavioural change, despite a number of recent reports to the contrary.

However, computers are becoming more “user-friendly”, better software programs are being developed at lower cost, and many studies have now shown that patients’ reactions to computer education are increasingly favourable. For instance, interactive computer systems that function entirely on the basis of symbols could be used to educate many hospitalized patients and their families inexpensively and effectively. As people become better educated, computer-literacy will increase.

Education of the cardiac patient in the future will be characterized by the growing availability of basic communication technology (radio, television) in developing countries, the instant and worldwide availability of information by newer and better direct-broadcasting satellites, and increasingly sophisticated home information systems (cable television, screen-based information systems such as videotext and teletext) and



advances in mass storage of data (e.g. optical discs). The advantages and disadvantages of each technology in each setting must be evaluated for cost-effectiveness and potential for integration into existing patient education systems.

### 5.3.3 ***Use and availability of personnel***

Education can be provided by both physicians and non-physician health professionals. Non-physician health professionals will play an increasingly important role in cost-effective education at community level, since they are in close and regular contact with patients and their families.

The following factors should be considered at educational facilities of all levels:

- Who is already available to teach?
- Who can be trained to teach?
- How should teachers be trained? (The content of educational programmes will depend to a large extent on the educational level of teachers.)

The training for teachers should include instruction on methods of teaching, interaction with learners, and appropriate content of educational programmes (*III, II2*).

In rural communities and village settings those who can fulfil the role of teacher of health information include:

- *Schoolteachers* who have the advantage of regular contact over a period of years with schoolchildren and their parents, and who are also influential members of their communities. With guidance from teachers, schoolchildren can also become health messengers to families and communities.
- *Religious leaders*, who play central, integrating roles in the social and cultural life of most developing countries. Religious leaders are respected community leaders; many are closely allied with nongovernmental agencies, hospitals, and clinics. Religious-based health institutions can be valuable resources for patient education.
- “*Model patients*”, i.e. patients who have successfully followed similar programmes.

Patients’ education programmes at *basic levels of care* may involve community health workers, health visitors, and community nurses, who can be trained in this work during their basic schooling or subsequently. Nurses frequently demonstrate effectiveness in encouraging behavioural change among patients with cardiovascular disease, through both individual and group teaching.

The training curriculum for community health workers, health visitors, etc. should include the following elements:

- structure and function of the cardiovascular system;

- cardiovascular changes in disease (coronary heart disease, hypertension, rheumatic heart disease, congenital heart disease, cardiomyopathy);
- characteristics of acute cardiovascular illnesses (which occur with myocardial infarction, unstable angina pectoris, acute rheumatic fever, rheumatic heart disease, heart failure, arrhythmias, and particularly atrial fibrillation), and the surgical interventions commonly undertaken;
- management of acute illnesses, general aspects (hospital treatment, medication, surgery);
- psychological responses to illness (denial, anxiety, depression);
- rehabilitation needs (physical activity, education);
- residual symptoms of heart disease; simple assessment of physical capacity;
- content and methods of patient education; group leadership, family education and support; community structure and support;
- networks for community (basic level) education.

These personnel must develop communication skills, particularly to answer or refer patients' problems. To achieve maximal support and cohesion of activity, it is also important that they learn how to establish cooperative networks with neighbouring community health workers.

A comparable training programme can be established in professional schools, or on a "pyramid" basis for established practitioners (i.e. one experienced individual teaches a group of people, each of whom can then pass on knowledge to others).

At *intermediate levels of care*, community health workers and similar personnel can be trained in community hospitals. They should learn the requirements for cardiac education appropriate to the rural or village setting where little or no equipment will be available and facilities will be limited. Physicians can serve as teachers at this level.

At the *advanced level of care*, the number and areas of expertise of teaching staff will be influenced by the size and complexity of the population to be taught. Teachers may include primary care physicians, cardiologists, medical specialists, paediatric cardiologists, paediatricians, cardiac surgeons, physicians specializing in rehabilitative medicine, sports medicine and occupational health, and general practitioners. These who learn must acquire teaching and communication skills and be provided with supporting materials for use in teaching patients.

Nurses, occupational and physical therapists, dietitians, psychologists, health educators, and exercise physiologists can also act as trainers of health personnel working at intermediate and basic levels of care, in addition to carrying out their own patient education activities.

Most education programmes in public health, nursing, nutrition, exercise, etc. need to add to or improve curricula in respect of patient education for behavioural change.

At the advanced level, educational specialists and experts in the use of mass media for educational purposes can contribute their skills to programme development, addressing learning strategies, “testing points” in teaching, and optimal modes of presentation for specific patient populations.

To maximize the cost-effectiveness of training health professionals in developing countries, where one person may be assigned several tasks, extensive collaboration is essential. A potential advantage of using whatever modern technology is available for training health professionals is the consistency, quality control, and replicability that can be imposed on training programmes. This approach may be considered at an intermediate level.

Training by an individual teacher or lecturer might generate considerable variation in the content and emphasis of training and in its efficacy. Use of videotape or computer-assisted or computer-interactive educational material ensures uniformity and standardizes the means of assessment of efficacy. This approach may be useful in implementing health curricula in professional schools.

#### 5.4 **Educational components for particular disease categories**

(Table 30)

Patients and their families need basic information if they are to comply with long-term requirements of care programmes designed to reduce disability and improve outcome (100). Information should cover the nature, progress, control, and possible complications of their disease(s), and the names, purposes, doses, effects, and side-effects of medications.

Learning how to lead a healthy lifestyle is of utmost importance to the cardiac patient. Wise eating habits for correct nutrition, cessation of smoking, the physical activities that are recommended and those that should be restricted or avoided (including work limitations) should all be discussed individually with the patient, who should also understand the value of a healthy lifestyle and the possible adverse implications of resuming an earlier unhealthy lifestyle. Family and social support can help in implementing these beneficial changes and in preventing relapses.

The patient should also understand the significance of symptoms such as shortness of breath, chest pain, palpitations, swollen legs, and the appropriate responses to them. Psychological (i.e. mood) changes are secondary to the physical symptoms of the disease, and full psychosocial recovery over a period of time is the norm.

##### 5.4.1 **Coronary heart disease**

The patient with coronary heart disease should be taught about normal cardiac structure and function, the development of atherosclerosis – progression and regression, the changes that occur with myocardial infarction, and the ability of the heart to heal and recover its functions.

Table 30

**Education of cardiac patients and their families<sup>a</sup>**

Education component	Coronary heart disease	Systemic arterial hypertension	Rheumatic heart disease	Congenital heart disease	Cardiomyopathy/ congestive heart failure
Medical follow-up	++	++	++	++	++
Taking medication	++	++	++	++	++
Rheumatic fever prophylaxis			++		
Endocarditis prophylaxis			++	++	—/+
Anticoagulant treatment	—/+		++	—/+	—/+
Response to symptoms of severity	++		++	++	++
Advice about pregnancy	—/+	++	++	++	—/+
Career counselling/ choice			++	++	+
Return to work	++	++	++	+	++
General nutrition	+	+	++	++	++
Weight/obesity control	++	++	++	++	++
Fat/cholesterol intake	++	++	+	+	+
Sodium intake	++	++	+	+	++
Blood pressure control	++	++	—/+	—/+	++
Smoking cessation	++	++	++	++	++
Diabetes control and education	+	++	—/+	—/+	+
Physical activity/ exercise	++	++	++	++	++

—/+ = if applicable, + = routine, ++ = high priority

<sup>a</sup> Basic educational components, stable phase of disease.

Guidance should be provided on resumption of general and sexual activity, return to work, the specific medications prescribed (with reasons for each), and appropriate responses to new or recurring symptoms. It is also important to give advice on problems the patient may face upon returning home and the community resources that may aid rehabilitation. Basic information on risk factors, tailored to the patient's individual needs, will support behavioural changes.

The goal of “reducing progression and inducing regression” of atherosclerosis can be attained by following a vegetarian or low-fat diet, ceasing to smoke, taking regular, moderate exercise, understanding why lipid-lowering medication should be taken if prescribed, controlling hypertension, and practising stress management and relaxation techniques (113).

*Diet change* is a complicated process involving alterations in patterns that have been firmly established by culture, family, and personal factors, but is often prompted by a coronary event (an “opportune time” for the patient). Most successful dietary interventions involve relatively frequent, long-term contact with health professionals. Appropriate selection and preparation of foods should be emphasized.

Essential *weight reduction* in obese patients is obviously strongly related to changes in diet and exercise habits.

When physicians and medical teams are committed to *smoking cessation*, success rates of 50% or more have been reported among cardiac patients. Most smokers manage to stop on their own, but the greatest problem is relapse; preparation for this must be included in the smoking cessation plan. Role-play, cigarette refusal, and enlisting the social support of family, friends, and colleagues reinforces the non-smoking behaviour.

*Physical activity and exercise* are important parts of cardiac rehabilitation. Patients should be taught about their target heart rate and how to count their pulse, especially in programmes without supervision. They should understand the importance of warming-up and cooling-down periods when exercising. The Borg scale of rate of perceived exertion (see Annex 8) is a valuable guide, with the desired level being between 13 and 15.

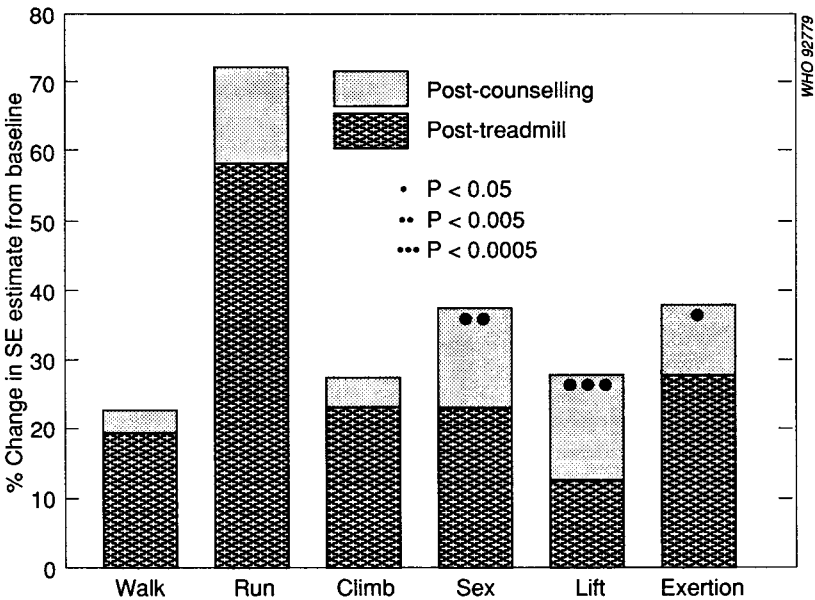
Different methods of *coping with stress* should be taught.

*Sexual activity* can be continued and this should be discussed with patients and their partners. The effects of medication on sexuality should also be explained.

The names, dosages, and potential side-effects of each *medication* prescribed should be discussed with the patient (114). It is also important to review the proper use of drugs – when to take them, how much to take, and how long to continue. The better the patient’s understanding of the actions of prescribed drugs and the reasons for taking them, the better will be compliance with drug schedules.

Training members of the patient’s family in *cardiopulmonary resuscitation* is an important part of rehabilitative education. The patient also has a crucial role to play in the early phase of treatment, and must be given guidance on recognizing symptoms, and confidence in ease of access to the health care system. After percutaneous transluminal coronary angioplasty, for example, patients must be aware of early restenosis symptoms and appropriate responses. After a stay in hospital, it should be clearly explained to patients when they can resume home activities such as

Figure 12  
**Increases in self-efficacy (SE) after treadmill and counselling compared with the values obtained before treadmill exercise and before counselling, respectively<sup>a</sup>**



<sup>a</sup> Source: reference 105.

climbing stairs, lifting, driving, socializing with visitors, shopping, walking outdoors. Specific information from test procedures (e.g. treadmill and appropriate exercise testing) should be related to daily or occupational activities (Fig.12).

Treatment of *hypertension* in coronary patients should focus on weight reduction and essential dietary changes, and on adherence to medication. Management of *diabetes mellitus* associated with coronary heart disease should also focus on weight reduction and, if applicable, dietary changes, exercise, foot care, and adherence to any prescribed medication.

Return to work is discussed in section 2.6. Reducing cardiovascular risk factors involves alterations in several of those risk factors simultaneously, using both behavioural and pharmacological interventions.

### 5.4.2 Hypertension

Hypertension is not only a risk factor for coronary heart disease but it is also the most prevalent of the cardiovascular diseases. The components of appropriate patient education have already been described in section 5.4.1. (See also Table 30.)

#### 5.4.3 ***Rheumatic heart disease***

The basic information that should be given to patients with rheumatic heart disease, to the parents, guardians, and schoolteachers of affected children, and to local health volunteers should include the following:

- the importance of treating a streptococcal sore throat;
- the need to comply with regular antibiotic prophylaxis to prevent recurrence of rheumatic fever;
- anticoagulant control of embolism in atrial fibrillation;
- the importance of dental hygiene;
- general nutritional guidelines; and
- the importance of prophylaxis of endocarditis.

#### 5.4.4 ***Congenital heart disease (Table 31)***

If congenital heart disease is diagnosed in a child, the parents or guardians should be informed and the child should receive medical follow-up as needed. Basic health education should be given to parents or guardians, teachers, and local health volunteers, and should cover the following:

- awareness of the signs and symptoms of the disease;
- the importance of dental hygiene;
- future career/job counselling;
- advice on the health implications of a future pregnancy; and
- the prevention of infective endocarditis.

#### 5.4.5 ***Cardiomyopathies, congestive heart failure, Kawasaki disease, and pacemakers***

Basic health education should be given to patients with cardiomyopathies, congestive heart disease, or Kawasaki disease, to those who are fitted with permanent pacemakers, to the parents or guardians and teachers of paediatric patients, and to local health volunteers. The information given should cover:

- avoidance of tobacco products;
- appropriate nutrition;
- recognition of signs and symptoms; and
- the possibilities and potential advantages of medical and surgical treatment, if appropriate.

#### 5.5 **The role of governments, voluntary health organizations, and international agencies**

Governments can support and facilitate cardiac rehabilitation through suitable legislation or government-sponsored insurance, where applicable within existing health systems. Effective rehabilitative services can reduce the burden on the health services of cardiovascular disability. Government support may also extend to the provision of guidelines for, and implementation of, training of health professionals.

Professional medical associations should become strong advocates of cardiac rehabilitation services, including patient education, for which they should develop their own local standards.

Voluntary organizations should support cardiac rehabilitation services, develop training systems for professional health education and for patients' education, and initiate research to evaluate the efficacy of cardiac rehabilitation programmes. In addition, such organizations can foster self-help programmes for patients and family support during the recovery period from acute cardiac illness. Governments and voluntary organizations should work together to create the appropriate environment, legislation, infrastructure, and workforce required for the education of the cardiac patient and for the training of teachers for such patients.

Tobacco advertising in all mass media and smoking in public places should be curtailed by legislation. Creating a social climate that is not conducive to smoking is effective in reducing smoking rates.

National campaigns (e.g. "heart weeks") that create awareness of healthy lifestyles can be organized or sponsored by governments and by professional associations such as the International Society and Federation of Cardiology. In focusing on the promotion of non-smoking, the labelling of heart-healthy foods, etc., national campaigns can be complemented at the local level by health "fairs" in community centres.

It is a challenge and a responsibility for health professionals to persuade governments to adopt a positive role in areas of health promotion such as patient education, fitness in schools, and nutritional guidance.

Governments and private sector educational institutions should collaborate with universities and colleges to integrate these aspects of health education into the training curricula for health care professionals in medical and nursing schools, health sciences, and other medical areas, and for specialists, to promote the skills and information required for education of cardiac patients. Curriculum guidelines for non-physician health professionals are available from such bodies as the American College of Sports Medicine and the American Association of Cardiovascular and Pulmonary Rehabilitation, and could be incorporated into existing professional education systems (55, 115).

Training in basic or advanced cardiopulmonary resuscitation should be provided at the appropriate level of care.

It is particularly important for general practitioners and primary care physicians to understand the need to educate their patients, and to acquire the teaching skills to do so. Incorporation of patient education into the training of medical doctors is essential but will require long-term planning.

Depending on a country's system for delivering and financing health care, it might be appropriate to involve medical insurance companies in patient education.



Agencies such as the World Health Organization, the International Society and Federation of Cardiology, the International Telecommunication Union, the World Federation for Medical Education, broadcasting organizations, and international development agencies may support pilot studies to assess the cost-effectiveness of specific new educational interventions in improving the health of cardiac patients.

Pilot programmes for health and education in developing countries – for example Project SHARE, co-sponsored by INTELSAT (International Telecommunications Satellite Organization) and the International Institute of Communications – may be able to benefit from having free satellite time made available (116).

## 6. **Conclusions and recommendations**

### 6.1 **Conclusions**

1. Cardiac rehabilitation is part of the long-term comprehensive care of cardiac patients.
2. Cardiac rehabilitation should include both an individualized regimen of physical activity and health education and counselling as appropriate for the individual patient's needs and specific cardiac problem.
3. Cardiovascular disease is an increasing problem in developing countries. In children and young adults it is likely to be a lifelong problem; in adults, the cardiovascular diseases of industrialized societies are becoming more prevalent. The growing numbers of elderly people in most developing nations warrant attention being given to cardiovascular disease in this section of the population as well.
4. The benefits of total rehabilitative services, which make well organized programmes cost-effective, include:
  - improved physical function and health status;
  - improved quality of life;
  - greater social independence and a more satisfactory place in society;
  - improved chances of resuming and continuing remunerative work.
5. Governments and nongovernmental organizations can use training facilities available through international and regional agencies.
6. Cardiac rehabilitation services and regimens can improve recovery from chronic cardiac illness in a number of ways, including:
  - improving the capacity for physical activity and thus speeding physical recovery;
  - preventing invalidism;
  - improving patients' compliance with treatment recommendations and suggestions for behaviour modification;
  - reducing hospital readmissions and recurrences of cardiovascular events;

- speeding psychological recovery;
  - facilitating social reintegration;
  - hastening return to work and resumption and maintenance of recreational activities;
  - increasing the degree of independence possible for elderly patients;
  - improving quality of life and sense of well-being;
  - maintaining physical and social capacity for self-care and independence.
7. Although cardiovascular disease is likely to become a growing problem in the workplace, most patients with cardiovascular diseases are capable of returning to work. Rehabilitative care helps to make their return more rapid and effective; for paediatric patients, it can provide guidance in appropriate choice of and preparation for future occupation.
  8. The benefits to employers of rehabilitative care for their employees include:
    - earlier return to work;
    - less disability;
    - less absenteeism;
    - reduced financial commitment to sickness and disability payments;
    - reduced training costs for replacement of personnel;
    - greater productivity.
  9. Both paediatric patients and their families benefit from rehabilitative care that includes physical activity, education, and counselling, and that is designed to promote a long-term healthy lifestyle. The benefits include:
    - increased self-esteem in the child;
    - lesser risk of over-protective attitudes and behaviours in the parents;
    - healthy physical and psychological development;
    - lesser risk of habitual and unwarranted invalidism persisting into adult life;
    - fewer recurrences and/or complications of cardiovascular disease;
    - better guidance for later married and family life.
  10. Most children with cardiac disease are capable of participating in a variety of physical activities, even at high-intensity levels. This participation facilitates their social integration with healthy peers and contributes to a healthy lifestyle and improved quality of life.

## 6.2 Recommendations

1. Cardiac rehabilitation should be an integral component of the long-term, comprehensive care of cardiac patients.
2. Cardiac rehabilitation programmes or services should be available to all patients with cardiovascular disease, both children and adults.

3. Rehabilitation services should be provided by any trained health professional caring for cardiac patients, since no sophisticated equipment or facilities are required. Both patients and their families should participate.
4. Rehabilitation programmes should be integrated into the existing health care system; this can be done at modest cost. The major requirement is for health professionals to be trained in prescribing appropriate exercise and providing health education and vocational guidance.
5. Responsibility for the implementation of cardiac rehabilitation should be given to a designated health professional at the local level, trained as a coordinator. This individual should, in turn, be responsible to an appropriate physician or to a department, hospital, or other health care facility, which may operate under the auspices of the government or a nongovernmental organization or other agency.
6. All plans for the implementation of rehabilitative programmes should include provision for evaluating the efficacy of the programmes.
7. School officials should consult responsible medical personnel regarding the physical activities appropriate for individual children with cardiac disease.
8. Because of the increase in prevalence of cardiovascular disease and the importance and value of cardiac rehabilitation services, WHO should, in collaboration with the International Society and Federation of Cardiology and other interested bodies, seek to facilitate:
  - transmission of recommendations for cardiac rehabilitation to Member States;
  - provision of international or regional training courses;
  - provision to governments and professional associations of guidelines on the implementation of rehabilitative care (within existing health care systems).
9. Relevant international agencies that might appropriately be contacted to help with training of personnel and implementation of cardiovascular rehabilitation include:
  - International Commission on Occupational Health
  - International Council of Nurses
  - International Federation of Sports Medicine
  - International Labour Organisation
  - International Telecommunication Union
  - International Union of School and University Health and Medicine
  - Rehabilitation International
  - United Nations Educational, Scientific and Cultural Organization
  - World Bank
  - World Hypertension League
  - World Rehabilitation Fund.

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## Annex 1

### Light exercise programme (6 weeks)

Classes for groups of 10-20 patients should be held twice weekly. Each class should last for 1 hour.

#### Allocation of class time

- 5-10 minutes *Opening session*, greetings, discussion, determination of resting heart rate
- 10-15 minutes *Calisthenics*, following exercise sheets<sup>1</sup>
- 30 minutes *Circuit exercises*, with rest and determination of pulse rate between successive exercises. Activity levels should be restricted to keep the increment in heart rate to < 20 beats/minute over the resting level, i.e. exercise should be observation- and symptom-limited.
- 5-15 minutes *Closing session*, final discussion and determination of heart rate, advice on home exercise programmes.

#### Calisthenics

Patients should progress through 12 levels, increasing the number of repetitions of each exercise by 2-3 at each class. The exercises should also be done twice daily at home.

#### Circuit exercises

##### *Stationary cycle*

Starting at 200 kg-m/min (33 W) for 2 minutes, workload and duration of exercise should increase progressively.

##### *Rowing*

This exercise should be undertaken only by patients with no history of back pain or injury. Starting with 1 minute of low-resistance rowing, duration of exercise should increase by 1-2 minutes per class.

##### *Pulley*

The patient sits on a chair, back to the wall, with a 2.5 kg (5 lb) weight on both left and right pulleys, and pulls down repeatedly with both arms for 1 minute. Duration of the exercise is increased progressively to 4 minutes; weights are then increased to 5 kg (or 10 lb).

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<sup>1</sup> Similar to those in Annex 2.

**Weights**

Weights of 1, 2, 3, 5 or 7 kg (or 2, 5, 7, 10, or 15 lb) are lifted anteriorly from thigh level to above the head. Each of the following exercises is performed initially for 1 minute:

- unilateral (left arm) lift
- unilateral (right arm) lift
- bilateral lift
- rising from sitting to standing position, arms extended laterally, returning to sitting position.

Duration of exercise is increased progressively, followed by an increase in the weights used.

**Steps**

Using a set of steps each 15 cm (6 inches) high, patients take six steps up then six down (using handrails if necessary). The exercise is repeated three times initially, increasing to 15 times at a comfortable pace.

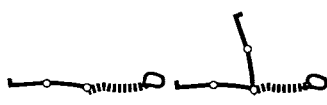
**Home walking**

Patients should walk at home, at a comfortable place, for a daily minimum of 30 minutes (which may be split into a series of shorter periods). They should start on level ground or by walking slowly uphill. Duration and speed of walking should be increased progressively, but should always remain within the limits of comfort. Walking with a companion increases the pleasure of the exercise; the pace should always be such that talking with ease is possible.

## Annex 2



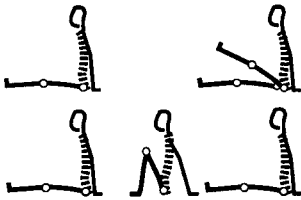
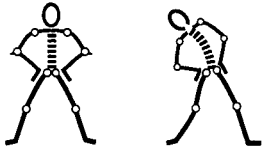
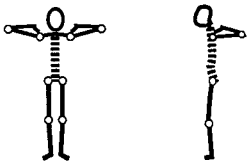
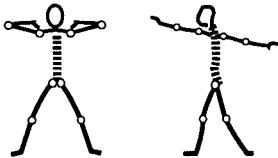
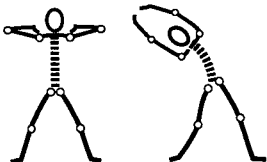
### Energy expenditure in various exercises<sup>a</sup>

Exercise description	Frequency (per min)	Energy consumption		Heart rate beats/min
		kcal <sub>th</sub> /min	kJ/min	
Patient lies supine, hands behind head. Crosses right elbow to left knee, and then vice versa.	20	2.7	11.3	93
Patient lies supine, with knees bent. Holding both knees with hands, lifts torso by bending elbows.	12	2.8	11.7	97
Patient lies supine with one knee bent. Holding one knee with both hands, lifts torso by bending elbows.	14	3.2	13.4	101
Patient lies supine. Lifts right leg, straight, fingers of right hand touching toes. Lifts head. Return slowly to supine position, sliding hand along body.	25	3.3	13.8	102
Patient sits, fingers touching toes. Moves upper body backwards, increasing angle with each repetition, until lying flat.	5	3.7	15.5	105
Lying on side, patient performs half push-ups, eight times each side.	24	3.6	15.1	110

Exercise	Description	Frequency (per min)	Energy consumption kcal <sub>th</sub> /min (kJ/min)	Heart rate beats/min
	Patient lies supine, arms by the sides. Lifts one straight leg vertically, then repeats with the other.	40	3.2 (13.4)	100

<sup>a</sup> Adapted and translated from:

Kellerman JJ. Riabilitazione dei pazienti coronaropatici. In: Puddu V, Anguissola AB, eds. *Cardiologia d'oggi*, Vol. III. Turin, Edizioni Medico Scientifiche, 1976: 259-292.

Exercise	Description	Frequency (per min)	Energy consumption kcal <sub>m</sub> /min (kJ/min)	Heart rate beats/min
	Patient lies supine, arms by the sides. Pulls both knees up towards chest, then straightens legs again.	40	3.2 (13.4)	105
	Patient sits. Touches toes of right foot with left hand, then vice versa.	66	4.3 (18.0)	117
	Patient sits, hands behind back. Lifts first one straight leg, then the other. Bends both knees, straightens legs again.	66	4.7 (19.7)	116
	Patient stands, legs apart, hands on hips. Bends body first left then right.	66	3.2 (13.4)	101
	Patient stands, hands on shoulders. Pulls elbows back repeatedly.	112	3.2 (13.4)	113
	Patient stands, legs apart, hands on shoulders. Straightens arms sideways while turning body left and right.	80	3.9 (16.3)	111
	Patient stands, legs apart, hands on shoulders. Straightens arms upwards while bending body left and right.	66	4.2 (17.6)	119

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## Annex 3

# Exercise therapy guidelines using risk stratification definitions<sup>1</sup>

### Guidelines for low risk patients

This category includes asymptomatic patients with uncomplicated coronary history. Functional capacity: 8 METs<sup>2</sup>

- Heart rate guidelines should be based on the results of a treadmill exercise test.
- Perceived exertion should be consistent with moderate exercise.
- Symptom guidelines should be based on a patient's self-reported history and on the results of cardiovascular examination.
- There should be continuous self-monitoring.
- ECG monitoring is necessary only as indicated.
- Exercise guidelines should be consistent with a patient's functional capacity.
- Recreational guidelines should be consistent with a patient's functional capacity and appropriate goals.

### Guidelines for intermediate risk patients

This category includes patients who are at risk of a recurrent coronary event: patients who have experienced shock, congestive heart failure, or abnormal exercise ECG, and those who are unable to self-monitor. Functional capacity < 8 METs<sup>2</sup>

- Heart rate guidelines should be based on the results of a treadmill exercise test.
- Perceived exertion should be consistent with moderately low-level exercise.
- Symptom guidelines should be based on a patient's self-reported history and on the results of cardiovascular examination.
- There should be continuous self-monitoring.
- There should be intermittent monitoring of ECG in order to establish cardiovascular response to therapeutic exercise.
- Guidelines for moderate exercise should be consistent with functional capacity and symptoms. Exercise sessions should be more frequent, with a slower progression of exercise intensity.
- Recreational guidelines should be consistent with functional capacity and with the estimated energy costs of activities; other variables such as the weather, and the competitiveness of the activity should be taken into consideration.

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<sup>1</sup> Adapted from: Berra K, Fry G. Community resources for rehabilitation. In: Wenger NK, Hellerstein HK, eds. *Rehabilitation of the coronary patient*, 3rd ed. New York, Churchill Livingstone, 1992: 561.

<sup>2</sup> See section 2.6.1.

### Guidelines for high risk patients

This category includes patients with severely depressed left ventricular function (ejection fraction < 30%); resting complex arrhythmias; arrhythmias that increase with exercise; demonstrable exercise-induced fall in systolic blood pressure; marked exercise-induced ischaemia (> 2 mm S-T depression); and survivors of sudden cardiac death.

- Heart rate guidelines should be based on the results of a treadmill exercise test.
- Perceived exertion should be consistent with low-level exercise.
- Symptom guidelines should be based on a patient's self-reported history and on the results of cardiovascular examination.
- There should be continuous self-monitoring.
- There should be continuous or intermittent monitoring of ECG according to the cardiovascular signs, symptoms, and history; continuous monitoring can be reduced to intermittent monitoring as soon as usual cardiovascular responses are documented.
- Guidelines for low-level exercise should be consistent with functional capacity and symptoms; exercise type, intensity, frequency, and duration should be modified to provide low-level stimulus.
- Recreational activities should not be resumed until cardiovascular responses to exercise are established and functional capacity has reached a level consistent with the desired activity.

### Annex 4

#### Oxygen uptake during two-step exercise<sup>a</sup>

Note: Height of step is 21 cm;  $n = 12$ .

Number of trips/3 min	Oxygen uptake ( $\pm$ std deviation) ml/min per kg	Energy cost METs <sup>b</sup>
10	10.2 $\pm$ 1.3	3
20	13.0 $\pm$ 1.5	4
30	16.1 $\pm$ 1.8	5
40	20.0 $\pm$ 1.9	6
50	22.4 $\pm$ 2.3	7
60	26.6 $\pm$ 2.7	8

<sup>a</sup> Source: Toshima H, personal communication to Guzman SV.

<sup>b</sup> See section 2.6.1.

## Annex 5

### Comparison of modified Naughton and Bruce protocols for treadmill exercise testing<sup>a</sup>

Note: Duration of test = 3 minutes.

Energy cost  METs <sup>b</sup>	Modified Naughton protocol				Bruce protocol			
	Stage	Speed miles/h   km/h		Slope %	Stage	Speed miles/h   km/h		Slope %
3	1	2.0	3.2	3.5	—	—	—	—
4	2	2.0	3.2	7.0	—	—	—	—
5	3	2.0	3.2	10.5	1	1.7	2.7	10.0
6	4	2.0	3.2	14.0	—	—	—	—
7	5	2.0	3.2	17.5	2	2.5	4.0	12.0
8	6	3.0	4.8	12.5	—	—	—	—
9	7	3.0	4.8	15.0	—	—	—	—
10	8	3.0	4.8	17.0	3	3.4	5.4	14.0

<sup>a</sup> Source: reference 9.

<sup>b</sup> See section 2.6.1.

## Annex 6

### Approximate energy requirements during bicycle ergometry for different body weights<sup>a</sup>

Note: Bicycle ergometry is usually performed against a brake set at a predetermined load. Most protocols start at a workload of 25 W (150 kg-m/min) and increase by 25 W (150 kg-m/min) every 2 or 3 minutes.

Workload										
W kg-m/min	25 150	50 300	75 450	100 600	125 750	150 900	175 1050	200 1200	250 1550	300 1800
Body weight lb      kg	Energy requirements, METs <sup>b</sup>									
88      40	4.3	6.4	8.6	10.7	12.9	15.0	17.1	19.3	23.5	27.9
110     50	3.4	5.1	6.9	8.6	10.3	12.0	13.7	15.4	18.9	22.3
132     60	2.9	4.3	5.7	7.1	8.6	10.0	11.4	13.2	15.7	18.6
154     70	2.4	3.7	4.9	6.1	7.3	8.6	9.9	11.0	13.4	15.9
176     80	2.1	3.1	4.3	5.4	6.4	7.4	8.6	9.7	11.7	14.0
198     90	1.9	2.9	3.8	4.8	5.7	6.7	7.6	8.6	10.5	12.4
220     100	1.7	2.6	3.4	4.3	5.1	6.0	6.9	7.7	9.4	11.1
242     110	1.6	2.3	3.1	3.9	4.7	5.4	6.3	7.0	8.6	10.1
264     120	1.4	2.1	2.9	3.6	4.3	5.0	5.7	6.4	7.9	9.3

<sup>a</sup> Source: reference 9.

<sup>b</sup> See section 2.6.1.

# Annex 7 **Relationship between functional class, clinical status, and maximal oxygen consumption<sup>a</sup>**

METs <sup>b</sup>	1.6	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
ml O <sub>2</sub> /kg per min	5.6	7		14		21		28		35		42		49		56
Clinical status	Symptomatic patients															
	Diseased, recovered															
							Sedentary, healthy									
							Physically active subjects									
Functional class	IV	III			II		I and normal									

<sup>a</sup> Source: reference 10.

<sup>b</sup> See section 2.6.1.

# Annex 8 **Borg scale of rate of perceived exertion<sup>a</sup>**

Perceived exertion	Rating
Very, very, light	6
	7
	8
Very light	9
	10
Light	11
	12
Somewhat hard	13
	14
Hard	15
	16
Very hard	17
	18
Very, very hard	19
	20

<sup>a</sup> Adapted from reference 11.

## Annex 9

### Energy requirements of various occupations<sup>a</sup>

Occupation or activity	Energy requirement		
	kJ/min	kcal <sub>th</sub> /min	METs <sup>b</sup>
Bakery, general	11.7	2.8	2.3
Bookbinding	11.7	2.8	2.3
Carpentry, general	15.9	3.8	3.2
Carrying heavy loads, e.g. bricks	36.8	8.8	7.3
Carrying moderate loads (16–40 kg, 35–88 lb) upstairs	35.3	8.5	7.1
Chambermaid	11.7	2.8	2.3
Coal mining, drilling	29.7	7.1	5.9
Coal mining, general	27.6	6.6	5.5
Coal mining, shovelling coal	32.2	7.7	6.4
Construction work, outdoor	25.1	6.0	5.0
Electrical work, plumbing	15.9	3.8	3.2
Farming, baling hay, cleaning barn	36.8	8.8	7.3
Farming, chasing cattle	15.9	3.8	3.2
Farming, driving harvester/tractor	11.7	2.8	2.3
Farming, feeding animals	18.4	4.4	3.7
Farming, hand-milking	14.6	3.5	2.9
Farming, machine-milking	7.1	1.7	1.4
Farming, shovelling grain	25.1	6.0	5.0
Fire-fighter	20.9	5.0	4.2
Forestry, chopping with axe, fast	79.5	19.0	15.8
Forestry, barking trees	23.0	5.5	4.6
Forestry, carrying logs	50.2	12.0	10.0
Forestry, felling trees	36.8	8.8	7.3
Forestry, hoeing	23.0	5.5	4.6
Forestry, planting by hand	27.6	6.6	5.5
Forestry, sawing by hand	32.2	7.7	6.4
Forestry, sawing, power	20.9	5.0	4.2
Forestry, trimming trees	41.4	9.9	8.3
Forestry, weeding	18.4	4.4	3.7
Horse-grooming	27.6	6.6	5.5
Horse-racing, galloping	36.8	8.8	7.3
Horse-riding, walking	11.7	2.8	2.3

<sup>a</sup> Source: reference 9.

<sup>b</sup> See section 2.6.1.

Occupation or activity	Energy requirement		
	kJ/min	kcal <sub>th</sub> /min	METs
Locksmith	16.3	3.9	3.3
Machine tooling, machining, working sheet metal	11.7	2.8	2.3
Machine tooling, operating lathe	14.6	3.5	2.9
Machine tooling, operating punch press	23.0	5.5	4.6
Machine tooling, tapping and drilling	18.4	4.4	3.7
Machine tooling, welding	14.6	3.5	2.9
Masonry, concrete work	32.2	7.7	6.4
Moving, pushing heavy object, > 75 kg (165 lb)	32.2	7.7	6.4
Operating heavy-duty equipment	11.7	2.8	2.3
Orchard work	20.9	5.0	4.2
Printing (standing)	10.5	2.5	2.1
Road-building	27.6	6.6	5.5
Shoe repair work	11.7	2.8	2.3
Shovelling, ditch-digging	39.3	9.4	7.8
Shovelling, heavy, > 16 kg/min (35 lb/min)	41.4	9.9	8.3
Shovelling, light, < 10 kg/min (22 lb/min)	27.6	6.6	5.5
Shovelling, moderate, 10–15 kg/min (22–33 lb/min)	32.2	7.7	6.4
Sitting, light work (assembly/repair, desk/phone work, driving car)	7.1	1.7	1.4
Sitting, moderate work (operating heavy levers, forklift, crane)	11.7	2.8	2.3
Standing, light work (store work, bartender, assembly work, filing)	11.7	2.8	2.3
Standing, moderate work (fast assembly work, lifting 50 kg/110 lb)	16.3	3.9	3.3
Standing, moderate/heavy work (masonry, lifting > 50 kg/110 lb)	18.4	4.4	3.7
Steel mill work, forging	25.1	6.0	5.0
Steel mill work, hand rolling	36.8	8.8	7.3
Steel mill work, removing slag	50.2	12.0	10.0
Steel mill work, tending furnace	34.3	8.2	6.8
Steel mill work, tapping moulds	25.1	6.0	5.0
Tailoring, general	11.7	2.8	2.3
Tailoring, pressing	18.4	4.4	3.7
Typing	7.1	1.7	1.4
Using heavy power tools (pneumatic drills, packhammers, etc.)	27.6	6.6	5.5

Occupation or activity	Energy requirement		
	kJ/min	kcal <sub>th</sub> /min	METs
Using heavy tools (shovel, pick, spade, tunnel bar, etc.)	36.8	8.8	7.3
Walking, 5 km/h (3 miles/h)	16.3	3.9	3.3
Walking briskly, or standing, carrying < 25 kg (55 lb)	20.9	5.0	4.2
Walking or standing, carrying 29–49 kg (55 to 108 lb)	23.0	5.5	4.6
Walking or standing, carrying 50–74 kg (110–163 lb)	29.7	7.1	5.9
Watch repairing	7.1	1.7	1.4

## Annex 10

### Energy requirements of common daily activities, including housework<sup>a</sup>

Activities	Mean energy requirement		
	kJ/min	kcal <sub>th</sub> /min	METs <sup>b</sup>
<i>Household chores</i>			
Making beds	17.2	4.1	3.4
Showering	8.8	2.1	1.8
Dressing	8.8	2.1	1.8
Simple house-cleaning	11.3	1.8	2.3
<i>Occupational therapy activities</i>			
Light carpentry, sanding, polishing, basket-weaving	12.6	3.0	2.5
Light mechanics	11.7	2.8	2.3
<i>Walking</i>			
Walking 2 km/h (1.3 miles/h), 3 km (2 miles) daily	9.6	2.3	1.9
Excursions at 3.5 km/h (2.2 miles/h)	11.7	2.8	2.3
Excursions at 5 km/h (3 miles/h)	15.9	3.8	3.2
<i>Gardening</i>			
Watering with hose	7.5	1.8	1.5
Watering with can	10.0	2.4	2.0
Digging	7.5	1.8	1.5
Raking	8.8	2.1	1.8
Sowing flowers and vegetables	10.5	2.5	2.1
Picking flowers and vegetables	11.7	2.8	2.3
Hoeing with 2.5 kg (5.5 lb) hoe, light to medium soil	13.8	3.3	2.8
Pruning	13.8	3.3	2.8

<sup>a</sup> Source: reference 12.

<sup>b</sup> See section 2.6.1.



## Annex 11

### **Indications to terminate an exercise test**

Exercise testing should be terminated if serious dysrhythmia, e.g. ventricular tachycardia or supraventricular tachycardia, is observed or detected by ECG monitoring. It should also be terminated if any of the following potentially hazardous signs, symptoms, or situations arise:

- pain, headache, dizziness, syncope, excessive dyspnoea, and fatigue precipitated by exercise;
- pallor, clamminess of the skin, inappropriate affect;
- excessive rise in blood pressure, with systolic pressure exceeding 240 mmHg (32 kPa) and diastolic pressure exceeding 120 mmHg (16 kPa);
- progressive fall in blood pressure;
- failure of ECG monitoring system;
- S-T segment depression or elevation greater than 3 mm during exercise;
- dysrhythmia precipitated or aggravated by exercise, e.g. premature ventricular contractions with increasing frequency, supraventricular tachycardia;
- ventricular tachycardia (three or more consecutive beats);
- recognized types of intracardiac block precipitated by exercise.

## Annex 12

### **Contraindications and special considerations for exercise testing**

Exercise testing is contraindicated in patients with the following conditions:

- acute inflammatory cardiac disease
- uncontrolled congestive heart failure
- acute myocardial infarction
- acute pulmonary disease (acute asthma, pneumonia)
- blood pressure greater than 200/110 mmHg (26.7/14.7 kPa)
- acute renal disease (acute glomerulonephritis)
- acute hepatitis
- drug overdose affecting cardiorespiratory response to exercise (digitalis toxicity).

Special consideration must be given to the increased risks of and the benefits to be derived from exercise testing in patients with the following conditions:

- severe aortic stenosis
- severe pulmonary stenosis
- serious ventricular dysrhythmia, especially in association with significant cardiac disease
- coronary artery disease
- severe pulmonary vascular disease
- metabolic disorders (glycogenolysis types I and V)
- haemorrhagic diseases
- orthostatic hypotension.

The risk of exercise testing in patients with these diseases and conditions is greater than normal. If testing is performed, experienced personnel and proper monitoring equipment are essential to minimize risks.

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