REVIEW ARTICLE

Sports Med 2000 Sep; 30 (3): 207-219
0112-1642/00/0009-0207/$20.00/0

Physical Activity for the Chronically Ill and Disabled

J. Larry Durstine,[1] *Patricia Painter,*[2] *Barry A. Franklin,*[3] *Don Morgan,*[4] *Kenneth H. Pitetti*[5] and *Scott O. Roberts*[6]

1 Department of Exercise Science, University of South Carolina, Columbia, South Carolina, USA
2 Department of Physiologic Nursing, University of California, San Francisco, California, USA
3 Cardiac Rehabilitation and Exercise Laboratories, William Beaumont Hospital and Department of Physiology, School of Medicine, Wayne State University, Detroit, Michigan, USA
4 Department of Exercise and Sport Sciences, University of North Carolina - Greensboro, Greensboro, North Carolina, USA
5 Department of Public Health Sciences, College of Health Professions, Witchita State University, Wichita, Kansas, USA
6 Department of Physical Education, Health, and Leisure Services, Central Washington University, Ellensburg, Washington, USA

Contents

Abstract

Exercise prescription principles for persons without chronic disease and/or disability are based on well developed scientific information. While there are varied objectives for being physically active, including enhancing physical fitness, promoting health by reducing the risk for chronic disease and ensuring safety during exercise participation, the essence of the exercise prescription is based on individual interests, health needs and clinical status, and therefore the aforementioned goals do not always carry equal weight. In the same manner, the principles of exercise prescription for persons with chronic disease and/or disability should place more emphasis on the patient's clinical status and, as a result, the exercise mode, intensity, frequency and duration are usually modified according to their clinical condition. Presently, these exercise prescription principles have been scientifically defined for clients with coronary heart disease. However, other diseases and/or disabilities have been studied less (e.g. renal failure, cancer, chronic fatigue syndrome, cerebral palsy). This article reviews these issues with specific reference to persons with chronic diseases and disabilities.

Much is known about the health and fitness benefits that result from increased physical activity (table I and II) as well as the mechanisms responsible for the favourable adaptations and improvements. The US Surgeon General's report on physical activity and health[1] states the following conclusions concerning regular physical activity participation:

- People of all ages, both male and female, benefit from regular physical activity.
- Significant health benefits can be obtained by including a moderate amount of physical activity (e.g. 30 minutes of brisk walking) on most days if not all days of the week.
- Through a modest increase in daily activity, most Americans can improve their health and quality of life.

This report also presents evidence for the effects of physical activity on health and disease, specifically:

- Regular physical activity decreases the risk of cardiovascular disease mortality in general and of coronary artery disease (CAD) mortality in particular.
- Regular physical activity prevents or delays the development of high blood pressure and exercise reduces blood pressure in people with hypertension.
- Regular physical activity is necessary for maintaining normal muscle strength, joint structure and joint function.
- Weightbearing activity is essential for normal skeletal development during childhood and adolescence and for achieving and maintaining peak bone mass in young adults.
- There is promising evidence that strength training and other forms of exercise in older adults preserves the ability to maintain independent living status and reduce the risk of falling.
- Physical activity appears to relieve symptoms of depression and anxiety and improve mood.
- Physical activity appears to improve health-related quality of life by enhancing psychological well-being and by improving physical functioning in persons compromised by poor health.

Although not specifically mentioned by the US Surgeon General's report on physical activity and health,[1] many persons with chronic diseases and disabilities (table III) can benefit from increased physical activity in similar ways. The overall primary benefit is improved physical functioning. However,

Table I. Functional and health benefits of exercise

Functional capacity
Increase in maximal oxygen consumption
Increase in ventilatory (anaerobic) threshold
Decrease in heart rate, blood pressure and perceived exertion during submaximal exercise
Improved ability to tolerate physical stress
Reduced risk of diseases/medical conditions
Reduced risk of heart disease
Reduced risk of developing diabetes mellitus
Reduced risk of developing high blood pressure
Reduced risk of developing colon cancer
Reduced risk of developing obesity
Improved blood lipid and lipoprotein profile
Musculoskeletal
Helps maintain and enhance healthy bone density, muscles and joints
Increases muscular strength and endurance
Improves ability for locomotion
Increases flexibility
Psychological
Promotes psychological well-being
Improved self image
Improved sleep quality
Improved stress management
Increases self-efficacy

health benefits are also important because many chronic conditions have secondary concomitant medical conditions such as hypertension, diabetes mellitus and CAD, and all are favourably influenced by regular physical activity.

1. Consequences of Inactivity

Considerable data are available on the detrimental physiological effects of bed rest and restricted physical activity on health and physical functioning. Most individuals with a chronic disease or disability become less physically active. This, in turn, leads to a cycle of deconditioning that results in the impairment of multiple physiological systems (fig. 1). The result is physical deterioration and a subsequent further reduction in physical activity. The known effects of bed rest and inactivity on physiological systems may be worsened in certain conditions in which there may be increased protein degradation (renal failure) or neurogenic causes of bone loss (spinal cord injury). Unless patients are counselled regarding ways to safely and effectively increase physical activity, consequences may include poor long term health and suboptimal quality of life. Specific consequences of an inactive lifestyle for persons with a chronic disease or disability can include:

- reduced cardiorespiratory fitness
- osteoporosis
- impaired circulation to the lower extremities leading to eventual thrombus
- diminished self-concept
- greater dependence upon others for daily living
- reduced ability for normal societal interactions.

In recent times much attention has been directed towards developing the role of physical activity for improving health, physical fitness, and the rehabilitation potential of persons with chronic diseases and disabilities. The primary goals for increasing physical activity in these individuals are to:

- reverse the physical deconditioning resulting from bed rest and/or restricted physical activity
- optimise physical functioning
- enhance overall health and well-being.

Table II. Biological mechanisms whereby exercise may contribute to the primary or secondary prevention of coronary artery disease

Maintain or increase myocardial oxygen supply
Delay coronary atherosclerosis
Improves high-density lipoprotein cholesterol to low-density lipoprotein cholesterol ratio
Decreases triglycerides
Increases insulin sensitivity (improve carbohydrate metabolism)
Decreases platelet aggregation and increases fibrinolysis
Decreases somatic adiposity
Increase epicardial artery diameter
Increase coronary blood flow and/or distribution
Increase electrical stability of myocardium
Decrease myocardial ischemia at rest and during submaximal exercise
Decrease catecholamine in myocardium at rest and at submaximal exercise
Increase ventricular fibrillation threshold due to reduction of cyclic AMP
Decrease myocardial work and oxygen demand
Decrease heart rate at rest and during submaximal exercise
Decrease systolic and mean systemic arterial pressure at rest and during submaximal exercise
Decrease circulating plasma catecholamine levels at rest and during submaximal exercise
Increase myocardial function
Increase stroke volume at rest and during submaximal and maximal exercise
Increase ejection fraction at rest and during exercise
Increase intrinsic myocardial contractility
Increase myocardial function due to a decrease in ‘afterload’
Increase myocardial hypertrophy

Within any diseased and/or disabled population, there is a wide range of physical abilities and varied ways to respond to exercise. These diverse physical abilities and physical activity responses are largely determined by 1 or more of the following:

- the severity and/or progression of the disease or medical condition
- the response to treatments
- the presence of concomitant illnesses.

Thus, medical outcomes for physical activity programming are not always known and may range from arresting or attenuating the deterioration in functional capacity to markedly improving physical status. Expected health benefits resulting from increased physical activity are, for the most part, unknown for individuals with many different chronic diseases and/or disabilities. Presently, there is a need to study the safety, effectiveness and medical outcomes of increasing physical activity in a variety of special medical conditions presented by a given disease pathology, treatment or nature of the disabling condition.

Table III. List of diseases and disabilities

Cardiovascular and pulmonary
Myocardial infarction
Coronary artery bypass graft and angioplasty
Angina and silent ischaemia
Valvular heart disease
Congestive heart failure
Hypertension
Peripheral arterial disease
Aneurysms and Marfan syndrome
Pulmonary disease
Cystic fibrosis
Metabolic
Renal failure
Diabetes mellitus
Hyperlipidaemia
Obesity
Frailty
Immunological/haematological disorders
Cancer
Anaemia
Bleeding disorders
Acquired immune deficiency syndrome
Organ transplant
Chronic fatigue syndrome
Orthopedic diseases and disabilities
Arthritis
Low back pain syndrome
Osteoporosis
Neuromuscular disorders
Stroke and head injury
Spinal cord injury
Muscular dystrophy
Epilepsy
Multiple sclerosis
Polio and post polio syndrome
Amyotrophic lateral sclerosis
Cerebral palsy
Parkinson's disease
Cognitive, emotional and sensory disorders
Mental retardation
Alzheimer's disease
Mental illness
Deaf and hard of hearing
Visual impairment

Development of a model for comprehensive physical activity management for individuals with chronic diseases and disabilities requires the integration of knowledge, experience and scientific research of the multiple medical and allied health professions devoted to the rehabilitation/management process. These professionals include physicians, physical therapists, kinesiotherapists, adapted physical educators, therapeutic recreation specialists, wheelchair/adapted sports coaches, clinical exercise physiologists, nurses and physicians. A move toward active support from the medical community in recommending management that includes exercise programming and routine referral to rehabilitation professionals is critical in changing the attitudes and expectations of individuals and families of individuals with chronic disease and disabilities. Such increased interest, support and encouragement from the medical team as well as an increase in well designed and controlled scientific research studies are positive steps toward the goals of optimising physical functioning, health and well-being for persons with chronic diseases and disabilities.

2. Mobility

An important consideration for individuals with diseases or disabilities is the ability to maintain mobility. The extent to which limitations to movement exist in physically-challenged individuals determines the ease with which they can perform daily living tasks. Disability conditions such as CAD, cancer, pulmonary disease, stroke, arthritis, traumatic injuries (e.g. traumatic brain injury, spinal cord injury, amputation), visual impairments and developmental disabilities (e.g. cerebral palsy, spina bifida) can limit mobility. Based on statistics from the National Institutes of Health,[2] 35 to 43 million Americans have chronic diseases and/or disabilities that restrict the performance of 1 or more daily activities; of these, about 38% exhibit some difficulty with ambulation. The costs to the individual as well as

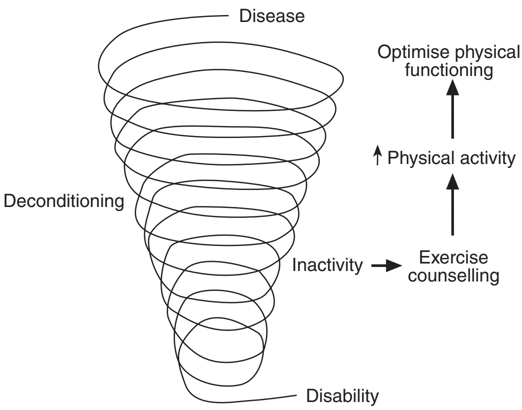

Fig. 1. Cycle of deconditioning with physical inactivity. Disease can lead to inactivity and deconditioning. Deconditioning can lead to further inactivity and increase the potential for disability. Exercise counselling can increase physical activity and optimise physical functioning, and reduce the deconditioning associated with a disease process (from Painter[37] with permission).

to society for locomotor-related disabilities are substantial.[2] Thus, interventions to address ambulation and mobility issues are warranted.

The cause of mobility limitations differs depending on the specific diagnosis. Likewise, evaluation and intervention protocols also vary among diagnoses. The National Center for Medical Rehabilitation Research suggests that identification of variables most relevant to ambulatory status in mobility-restricted individuals take into account the pathophysiology, impairment and functional limitations associated with a particular disease or disabling condition.[2] For example, ambulatory limitations for a child with cerebral palsy are the result of a disease pathophysiology which is characterised by a static and nonprogressive brain lesion occurring before, during or after birth. Impairments in these children are demonstrated by excess muscle contraction and reflex activity, poor balance and posture control, and muscle weakness and imbalance. Functional limitations arising from these impairments are slow and inefficient locomotor patterns. Thus, the most appropriate assessment of mobility limitations and changes resulting from therapeutic interventions would include some combination of testing that would measure submaximal energy demand, walking speed, step length and frequency, electromyographic activity, lower extremity muscle strength and gross motor ability. These assessments are appropriate since the primary factors influencing mobility in this patient population are muscle function and gait efficiency.

Metabolic consequences of disabled locomotion include higher oxygen consumption, heart rate and rating of perceived exertion at a standard walking speed compared to ablebodied individuals.[3-9] Likewise, from a biomechanical perspective, individuals with mobility limitations exhibit slower walking velocities, shorter stride lengths, reduced step frequencies, gait timing asymmetries and absence of normal flexion and extension patterns in the lower limb and hip, greater coactivity of agonist and antagonist muscles, earlier and more prolonged electromyogram (EMG) activity, and less power generation by ankle plantar flexors.[5,10-15]

Intervention programmes for patients that have ambulation limitations characterised by impaired muscle function and gait efficiency have featured the use of lower extremity strength training, gait training, electrical stimulation, bodyweight support, pharmacological and surgical treatment, assistive devices and prostheses, and exercise training. However, when mobility is limited in patients with cardiovascular or pulmonary disease, intervention programmes should emphasise dynamic exercise activities that stress the cardiovascular and pulmonary systems as well as the neuromuscular system. Regardless of the diagnosis, exercise programming provides beneficial effects to patients with a neuromuscular disorder, cardiorespiratory disease or both. In any case, the evaluation process is critical for any chronic disease and disability, since it aids in developing appropriately-targeted therapeutic interventions and postintervention assessments. The evaluation process may include measurement of peak oxygen consumption ($\dot{V}O_{2peak}$), haemodynamic responses to exercise, ratings of perceived exertion, and other variables that reflect metabolic responses, such as the ventilatory (anaerobic) threshold or lactate response to exercise.

3. Research Limitations

In recent years there have been a greater number of reports in the literature regarding physical activity for various diseases and disabilities, but few specific studies regarding appropriate exercise programming guidelines for these individuals are available. Table IV summarises the purposes for physical activity programming and recommended activities for several chronic diseases and disabilities. Although there are an increased number, few data regarding the benefits of such programmes in establishing realistic outcomes are available. The present research is limited for the following reasons:

- Many studies are designed for reasons of interest regarding a medical specialty and not necessarily to assess exercise outcomes. Thus, methodology is variable and may result in the inability to translate the data into practical recommendations.
- Most studies only include the most ‘stable’ patients, excluding individuals with multiple pathologies or subgroups of a given condition, thereby limiting the generalisability of the results.
- Standardised testing and training procedures are often not incorporated into research study designs.

There are additional confounding variables that are disease- or treatment-related which can also contribute to the interpretation of existing information for exercise programming for individuals with chronic diseases and disabilities:

- Because there are varying etiologies and progression rates of a disease and disability, there are a wide variety of conditions within a specific diagnosis.
- There are ongoing changes in medical treatments which may affect results and render conclusions of previous studies irrelevant. Such changes include progress in medical and surgical therapies (e.g. erythropoietin in renal disease) as well as development of contemporary prosthetic devices for amputees which decrease biomechanical stresses, reduce energy requirements and enhance overall ability to ambulate.
- There are various responses to treatments and often many factors that determine a given patient’s specific response.
- Our ability to predict patient responses to pharmacological and/or surgical treatments remains imperfect.
- Many conditions have concomitant secondary medical concerns that confound interpretation (e.g. corticosteroid-induced diabetes mellitus after organ transplant, development of CAD in amputees).

These factors make the development of specific guidelines for exercise programming difficult for

Table IV. Exercise in the management of specific chronic diseases and disabilities[16]

Disease	Purposes of programme	Recommended activities
Bronchial asthma	Conditioning; possible reduction of exercise-induced bronchospasm; instill confidence	Aquatic, intermittent, long warm-up
Cerebral palsy	Increase maximal aerobic power, range of motion, ambulation; control of body mass	Depends on residual ability
Cystic fibrosis	Improve mucus clearance, training of respiratory muscles	Jogging, swimming, walking, selected games
Diabetes mellitus	Help in metabolic control; control of body mass	Various; attempt equal daily energy output
Mental retardation	Socialisation; increase self-esteem; prevent detraining	Recreational, intermittent, large variety
Muscular dystrophies	Increase muscle strength and endurance; prolong ambulatory phase	Swimming, calisthenics, wheelchair sports
Neurocirculatory disease	Increase effort tolerance; improve orthostatic response	Various; emphasise endurance-type activities
Obesity	Reduction of body mass and fat; conditioning; socialisation and improved self-esteem	High in caloric expenditure but feasible for child; walking, recreational games, swimming
Rheumatoid arthritis	Prevent contractures and muscle atrophy; increase daily function	Swimming, calisthenics, cycling

individuals with any given condition. Further, since little exercise research has been completed on specific medical conditions, expected exercise outcomes are not known for given interventions.

Although an improvement in physical functioning would be desirable, this may not always be realistic. For example, in a condition that is progressive in nature, attenuation of physical functioning deterioration is a positive outcome, as is maintenance of current levels of physical functioning. For many, the ability to remain independent in their current environment is critically important and is a positive outcome, even if 'objective' evidence of improvement cannot be documented. Factors that determine which outcome should be expected in a given condition need to be identified. Thus, individualised goals must be developed and reassessed regularly.

4. Exercise Programming Considerations

Recently, increased attention has been directed towards the role of regular physical activity for improving the health, aerobic capacity and rehabilitation potential of persons with disabilities.[17,18] Common medical conditions such as stroke, multiple sclerosis, muscular dystrophy and traumatic injury to the central nervous system can result in a variety of debilitating sequelae. However, an inactive lifestyle may cause these individuals to experience secondary complications such as reduced maximal oxygen uptake ($\dot{V}O_{2max}$), muscle atrophy, osteoporosis, orthostatic intolerance, and impaired circulation to the lower extremities leading to eventual thrombus formation or decubitus ulcers. In addition, a diminished self-efficacy, increased depression and hypochondriasis levels, greater dependence upon others for daily living and reduced ability for normal societal interactions can have a negative psychological impact.

Properly designed and implemented physical activity programmes should include developing and maintaining cardiovascular endurance, flexibility and muscular strength. Such programmes are as important for older persons as they are for younger populations.[19-21] There is a paucity of data concerning the exercise adaptations in noncardiovascular disease populations. Thus, expected adaptations to training observed in the general population (and those with cardiovascular disease) may or may not apply to other populations. However, there is enough data on the general population to suggest that similar exercise programming may benefit individuals with chronic disease and disabilities. Thus, basic exercise programming guidelines can be used as a starting point, with adjustment where indicated to accommodate the special considerations for a given disease or disability. Physical activity programmes should also maximise accessibility, safety and effectiveness, and be enjoyable.

4.1 Accessibility

Recent studies have explored new approaches to delivering physical activity programmes to persons with disabilities, with the goals of increasing availability and decreasing costs while preserving efficacy and safety. Home-based exercise training programmes not only increase functional capacity but enable coronary risk factor modification, which enhances prognosis.[22] This model, if broadly implemented, may substantially increase the number of physically challenged individuals who are participating in activity/exercise programmes. Community-based programmes may also be conducted in a variety of settings, including schools, work sites, places of worship, residential housing facilities and other local recreation centres. Nevertheless, these efforts should be complemented with regular, multiple strategies (e.g. contests, incentives, self-help programmes, media announcements, screenings, environmental changes) to educate and motivate adults to exercise. The success of these strategies may be largely dependent on the person's stage of readiness for change,[23] as well as their social support systems.

4.2 Safety

To be noninjurious to the patient and effective for the purposes intended, physical activity must be prescribed according to age, gender, physical characteristics, related medical conditions, habit-

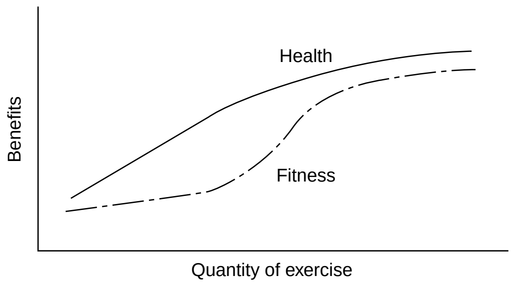

Fig. 2. Theoretical relationship between health and fitness benefits and the amount or intensity of exercise.

ual physical activity and functional status (musculoskeletal and cardiorespiratory). Special deficits or defects resulting from congenital deformities, injury or chronic disease, and the needs and contraindications imposed by these conditions must also be considered. The prescribed exercise dosage (i.e. intensity, frequency, duration) should be above the minimum level required to induce a 'training effect', yet below the metabolic rate or intensity that evokes abnormal clinical signs, symptoms and/or injury.

4.3 Effectiveness

Levels of physical activity lower than previously recommended for cardiorespiratory conditioning (e.g. below 50% $\dot{V}O_{2max}$) have been shown to reduce the risk of certain chronic diseases and promote a variety of health benefits (fig. 2), including increased bone density, enhanced glucose tolerance, an improved coronary risk factor profile and reduced cardiovascular-related mortality.[24] Moreover, it appears that the lower the baseline physical activity status, the greater will be the health benefit associated with a given increase in physical activity.[25] However, such programmes are associated with longer and/or more frequent exercise sessions.

Simple exposure to orthostatic or gravitational stress after injury or an acute cardiac event can obviate much of the deterioration in exercise performance that normally accompanies prolonged inactivity (e.g. during convalescence).[26] For most deconditioned persons with chronic diseases and disabilities, the threshold intensity for aerobic exercise training probably lies between 40 and 60% of $\dot{V}O_{2max}$ (fig 3). Improvement in aerobic fitness with low to moderate intensities suggests that the inter-relation among the training intensity, frequency and duration may permit a decrease in the intensity to be partially or totally compensated for by increases in the exercise duration or frequency, or both.[24] Recent studies have also shown similar cardiorespiratory training effects in individuals who completed 10-minute sessions of moderate intensity exercise 3 times per day versus those who performed 1 'long' 30-minute exercise session (table V).[27] Thus, relative increases in functional capacity appear to depend more on the individual's initial fitness and the total amount of exercise accomplished or calories expended than on the specific exercise frequency, intensity or duration.

Dynamic arm exercise or resistance training provides a reasonable alternative to leg exercise in patients with neurological, vascular or orthopedic impairment of the lower extremities.[28] In addition, arm exercise training appears to be the conditioning method of choice for persons whose occupational and recreational activities are dominated by upper extremity efforts. Recent studies also suggest that the arms respond in a similar qualitative and quantitative manner as the legs (fig. 4).[29]

The exercise programme should generally address cardiovascular endurance, muscular strength and range of motion. Each individual's limitations should be the focus of the exercise programming. For example, exercise management for the child with cerebral palsy should include a combination of interventions that are designed to improve inefficient locomotor patterns, whereas exercise management for individuals with pulmonary disease should focus on interventions to reduce symptoms of breathlessness or dyspnoea. Their exercise programming would incorporate cardiovascular endurance exercise and respiratory muscle training. Some patients (e.g. persons with arthritis) may need to initiate range of motion activities prior to moderate-to-vigorous exercise. This form of intervention may reduce pain and, as a result, help the person tolerate increased intensities of cardiovascular ex-

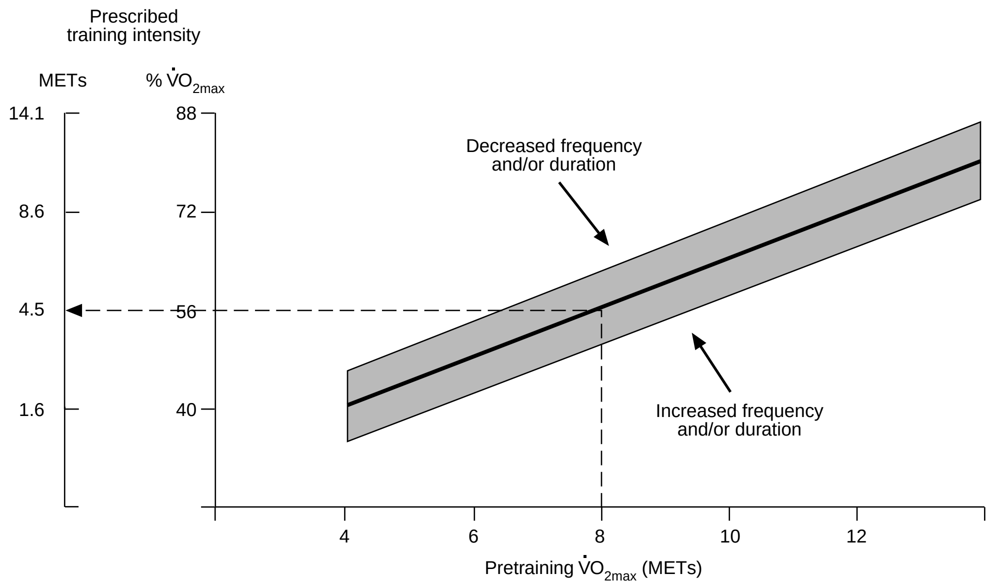

Fig. 3. Theoretical relation between aerobic capacity (metabolic equivalents; METs; 1 MET = 3.5 ml/kg/min) and the minimal intensity for exercise training, expressed as a percentage of the maximal oxygen uptake ($\dot{V}O_{2max}$). The threshold intensity for training increases in direct proportion to $\dot{V}O_{2max}$ before training; however, it can be modulated by altering the exercise duration or frequency, or both. For example, a patient with an aerobic capacity of 8 metabolic equivalents would exercise at approximately 56% of his/her $\dot{V}O_{2max}$, or 4.5 ± 0.5 METs, to further increase his/her functional capacity.

ercise. Muscle strengthening should be emphasised initially in patients who have significant muscle weakness due to severe activity restriction during their disease course. Muscle weakness may limit ambulation, making weightbearing cardiovascular exercise difficult to sustain. On the other hand, non-weightbearing cardiovascular exercise will increase both lower extremity strength and cardiovascular endurance and may be preferable to weightbearing activity initially.

4.4 Enjoyment

While many persons with disabilities can be encouraged to initiate a physical conditioning programme, motivating them to continue is critical to promote favourable adaptation and improvement. Unfortunately, negative variables often outweigh the positive variable contributing to sustained participant interest and enthusiasm. Such imbalance leads to a decline in adherence while programme effectiveness diminishes.

Research and empirical experience suggest that certain programme modifications and motivational strategies may enhance participant interest and enjoyment.[30] These include:

- establishing short term goals
- emphasising variety and enjoyment
- providing positive reinforcement through periodical testing

Table V. Training effects of long versus short periods of exercise in healthy individuals[27]

Variable/programme	Long (30 min) [% change]	Short (3-10 min) [% change]
$\dot{V}O_{2max}$ (ml/min/kg)	+ 13.0[a]	+ 7.6
Treadmill time (min)	+ 12	+ 12
Submaximal exercise heart rate	–6	–6

a p = 0.03 versus short periods.

min = minutes; **$\dot{V}O_{2max}$** = maximal oxygen uptake.

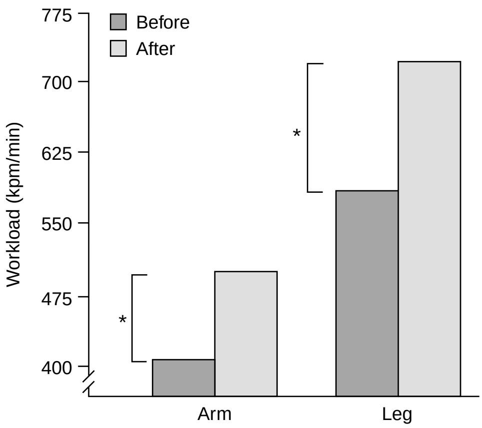

Fig. 4. Average work loads (kpm/min) during maximum arm and leg exercise testing before and after a programme of combined upper and lower extremity training in men with previous myocardial infarction. Peak power output during arm and leg ergometry increased 24 and 23%, respectively. ***** indicates $p < 0.01$.[30]

- recruiting spouse support of the exercise programme
- including a modified recreational game to the conditioning programme format that minimises skill and competition and maximises participant success
- using progress charts to record exercise achievements
- recognising individual accomplishments.

5. Exercise Prescription Principles

Exercise prescription should consider not only the exercise mode, intensity, duration, frequency and progression, but should also integrate programming that would accommodate functional limitations, the presence of CAD risk factors, other concomitant medical conditions, pathophysiology and the impairments associated with the disease or disability. Appropriate exercise management will address all of these variables while meeting the individual's personal goals for exercise and, simultaneously, making physical activity enjoyable.

There are resources to use as guides for exercise programming for individuals with chronic diseases and/or disabilities.[31-33] Much of what is known about exercise prescription (table VI) comes from the *American College of Sports Medicine's (ACSM's) Guidelines for Exercise Testing and Prescription*,[34] which deals with considerations for healthy individuals and those with cardiovascular and/or pulmonary disease. Information in this book is supplemented by the *ACSM's Resource Manual for Guidelines for Exercise Testing and Prescription*.[35] These resources are invaluable for clinical teams working in exercise management by providing the basics for designing safe, effective and enjoyable physical activity programmes.

A major point to remember when developing an exercise programme for a person with a chronic disease or disability is that the prescribed exercise intensity should be above a minimal level required to induce an exercise training effect, yet below the metabolic work rate that evokes abnormal clinical signs or symptoms (e.g. severe muscular pain/discomfort, angina, ischaemic ST-segment depression, threatening ventricular dysrhythmias). For most deconditioned patients, the threshold intensity for exercise training probably lies between 40 to 60% $\dot{V}O_{2max}$ (or the corresponding heart rates); moreover, considerable evidence suggests that this

Table VI. Criteria for developing the exercise prescription in healthy individuals[34]

Mode: any form of physical activity using large muscle groups. This includes walking jogging, running, biking, stepping, rowing and many other rhythmic activities
Intensity: 50 to 85% of heart rate reserve or $\dot{V}O_{2max}$
Duration: accumulate 30 minutes or more each session
Frequency: at least 3 sessions, but preferably 5 sessions per week
Progression: depends on each person's specific abilities, goals, and preferences
Special considerations
The prescribed activity depends on each individual's short and long term goals
The activity of choice should be enjoyable and performed with minimal difficulty
The progression should provide a challenge to the functional capacities of each individual without causing excessive fatigue and/or muscle soreness
Progression should occur at a rate that is unlikely to promote musculoskeletal injury or trauma

$\dot{V}O_{2max}$ = maximal oxygen uptake.

threshold increases in direct proportion to the pretraining $\dot{V}O_{2max}$ or level of habitual physical activity.

The information contained in table VII shows how traditional criteria for developing an exercise prescription (table VI) can be modified for persons with CAD and other medical conditions. Generally, the initial exercise intensity for these individuals is lower than that recommended for healthy persons. The recommended exercise duration is usually longer, the frequency or number of physical conditioning sessions per week is greater, and the progression toward achieving these goals may be longer.[31] In addition, special considerations (e.g. medications, meal schedules, potential foot problems such as blisters, and visual impairment) should be factored into the exercise prescription.

Table VII. Criteria for developing the exercise prescription for persons with coronary artery disease (CAD) and/or diabetes mellitus[31]

Mode: any form of physical activity using large muscle groups. This includes walking, jogging, running, biking, stepping, rowing and many other rhythmic activities
Intensity: 40 to 85% of heart rate reserve or $\dot{V}O_{2max}$
Duration: 20 to 60 minutes of continuous or accumulated exercise each session
Frequency: at least 4 sessions per week are desirable, and preferably daily physical activity
Progression: depends on each person's specific abilities, goals and preferences. A specific goal should be to increase aerobic capacity and reduce submaximal myocardial oxygen demands
Special considerations
Same considerations as those recommended for healthy persons (table VI)
Persons with CAD and/or diabetes mellitus may be taking medications. The health care professional should consider the cardiovascular and metabolic effects of these medications when formulating the exercise prescription
Low fit clients often start exercise programming at lower intensities (40 to 50% heart rate reserve)
Monitor for abnormal signs and symptoms (e.g. chest pain, lightheadedness, arrhythmias)
Increasing muscular strength is an important complement to an aerobic training programme
Many clients with CAD and/or diabetes mellitus have concomitant peripheral vascular disease. Thus, conditions such as intermittent claudication and autonomic neuropathy (this condition is associated with silent myocardial ischaemia, postural hypotension and/or blunted heart rate exercise responses) are common and should be considered when developing the exercise prescription
Because of diabetes mellitus and an impaired ability for healing, care should be given to decreasing lower extremity trauma and injury. In addition, because of the potential for autonomic neuropathy, the likelihood for visual impairment is greatly increased
Insulin and meal schedule should be considered
Hypoglycaemia may occur several hours after exercise

$\dot{V}O_{2max}$ = maximal oxygen uptake.

6. Incorporation of Physical Activity and Physical Functioning into the Overall Health Care Plan

Unwavering support from the individual's health care team for physical activity programming is essential. Their support is critical for assuring the patient and their family that physical activity is an important component in enhancing their overall health and well-being, and that exercise is safe for them. If there is resistance to exercise among the health care team, there may be hesitation on the part of the patient and/or family. Therefore, the health care team should be provided with as much information on the benefits of physical activity as possible before starting to work with their patients. Incorporation of physical activity into the short and long term patient care plan is important in order to monitor exercise adaptations or the lack thereof. Impaired exercise adaptations may be a signal that other medical conditions need attention, that alternative medical treatment is warranted, or both. One example is the need for a reduction in antihypertensive medication if blood pressure decreases with exercise. Physical activity may also provide the health care team with advance 'warning' of medical problems. Because a supervised exercise programme provides a serial surveillance opportunity, a deterioration in clinical status may be identified sooner (e.g. an increase in symptoms with exercise or a reduced exercise tolerance). When an individual remains physically inactive, the medical team has greater difficulty in differentiating what limitations in physical function (and symptoms) are due to the disease or disability, and what symptoms are attributed to physical deconditioning. Attention to the responses to exercise and increased physical activity may assist in this regard.

7. Call for Action and Conclusion

Greater emphasis is needed in determining the risks and benefits of increased physical activity programming for persons with chronic diseases and disabilities. A recent consensus statement has identified 5 areas as focal points for future research work:[36]

- epidemiological studies
- effects of nutrition on health and ability to exercise
- cardiovascular and pulmonary health
- children and disabilities
- accessibility and safety of exercise programmes.

Because there are few specific exercise guidelines for individuals with many chronic diseases and disabilities, innovative exercise research studies that develop and evaluate programmes for accessibility, safety and effectiveness are needed. These types of studies will enable the exercise professional to develop an exercise programme that is individually tailored to meet each patient's need. Further, such studies will assist in developing guidelines for optimal exercise programming for a wide variety of medical conditions, treatments, and the various stages of disease development. Publication of case study experiences for various populations can also assist in increasing the awareness of health care providers, family members, and patients. Finally, these case studies can also be used to direct future research designs. As we gain experience with many different patient populations, we will gradually be able to move beyond routine medical care issues to meeting the goals of optimising physical functioning and overall health and well-being for a wide variety of individuals with chronic disease and\or disabilities.

References

1. US Department of Health and Human Services. Physical activity and health: a report of the Surgeon General. Atlanta (GA): US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, 1996
2. Department of Health and Human Services. Research plan for the national center for medical rehabilitation research. Washington, DC: US Government Printing Office; 1993. NIH publication no. 93-3509
3. Evans EP, Tew B. The energy expenditure of spina bifida children during walking and wheelchair ambulation. Z Kinderchir 1981; 34: 425-7
4. Hoffman MD, Sheldahl LM, Buley KJ, et al. Physiological comparison of walking among bilateral above-knee amputee and able-bodied subjects, and a model to account for the differences in metabolic cost. Arch Phys Med Rehabil 1997; 78: 385-92
5. Nowroozi F, Salvanelli ML, Gerber LH. Energy expenditure in hip disarticulation and hemipelvectomy amputees. Arch Phys Med Rehabil 1983; 64: 300-3
6. Rose J, Gamble JG, Burgos A, et al. Energy expenditure index of walking for normal children and for children with cerebral palsy. Dev Med Child Neurol 1990; 32: 333-40
7. Rose J, Gamble JG, Medeiros J, et al. Energy cost of walking in normal children and in those with cerebral palsy: comparison of heart rate and oxygen uptake. J Pediatr Orthop 1989; 9: 276-9
8. Stein RB, Belanger M, Wheeler G, et al. Electrical systems for improving locomotion after incomplete spinal cord injury: an assessment. Arch Phys Med Rehabil 1993; 74: 954-9
9. Unnithan VB, Drowling JJ, Frost G, et al. Role of cocontraction in the 0_2 cost of walking in children with cerebral palsy. Med Sci Sports Exerc 1996; 28: 1498-504
10. Barth DG, Schumacher L, Sienko SS. Gait analysis and energy cost of below-knee amputees wearing six different prosthetic feet. J Prosthet Orthotics 1989; 4: 63-74
11. Brandstater ME, de Bruin H, Gowland C, et al. Hemiplegic gait: analysis of temporal variables. Arch Phys Med Rehabil 1983; 64: 583-7
12. Krawetz P, Nance P. Gait analysis of spinal cord injured subjects: effects of injury level and spasticity. Arch Phys Med Rehabil 1996; 77: 635-8
13. Lechner DF, McCarthy C, Holden MK. Gait deviations in patients with juvenile rheumatoid arthritis. Phys Ther 1987; 67: 1335-41
14. Olney SJ, MacPhail H, Hedden DM, et al. Work and power in hemiplegic cerebral palsy gait. Phys Ther 1990; 70: 431-8
15. Skrotzky K. Gait analysis in cerebral palsied and nonhandicapped children. Arch Phys Med Rehabil 1983; 64: 291-5
16. Bar-Or O. Exercise in childhood. In: Walsh RP, Shephard RJ, editors. Current therapy in sports medicine. Toronto: CV Mosby, 1985: 1985-6
17. Jackson R, Davis G. The value of sports and recreation for the physically disabled. Orthop Clin North Am 1983; 14: 301-15
18. Santiago MC, Coyle CP, Kinney WB. Aerobic exercise effect on individuals with physical disability. Arch Phys Med Rehabil 1993; 74: 1192-8
19. Ades PA, Hanson JS, Gunther PG, et al. Exercise conditioning in the elderly coronary patient. J Am Geriatr Soc 1987; 35: 121-4
20. Ades PA, Grunvald MH. Cardiopulmonary exercise testing before and after conditioning in older coronary patients. Am Heart J 1990; 120: 585-94
21. Ades PA, Waldmann ML, Gillespie C. A controlled trial of exercise training in older coronary patients. J Gerontol A Biol Sci Med Sci 1995; 50A: M7-11
22. King AC, Haskell WL, Taylor CB, et al. Group vs. home-based exercise training in healthy older men and women. JAMA 1991; 266: 1535-42

23. Prochaska J, DiClemente C. Transtheoretical therapy: toward a more integrative model of change. Psychother Theory Res Pract 1982; 19 (3): 276-88
24. Franklin BA, Gordon S, Timmis GC. Amount of exercise necessary for the patient with coronary artery disease. Am J Cardiol 1992; 69: 1426-32
25. Pate RR, Pratt M, Blair SN, et al. Physical activity and public health: a recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. JAMA 1995; 273: 402-7
26. Convertino VA. Effect of orthostatic stress on exercise performance after bed rest: relation to in hospital rehabilitation. J Cardiac Rehabil 1983; 3: 660-3
27. DeBusk RF, Stenestrand U, Sheehan M, et al. Training effects of long versus short bouts of exercise in healthy subjects. Am J Cardiol 1990; 65: 1010-3
28. Franklin BA. Aerobic exercise training programs for the upper body. Med Sci Sports Exerc 1989; 21: S141-8
29. Franklin BA, Vander L, Wrisley D, et al. Training ability of arms versus legs in men with previous myocardial infarction. Chest 1994; 105: 262-4
30. Franklin BA. Motivating patients to exercise: strategies to increase compliance. Sports Med Digest 1994; 16: 1-3
31. American College of Sports Medicine. ACSM's exercise management for persons with chronic disease and disabilities. 1st ed. In: Durstine JL, Bloomquist LE, Figoni SF, et al., editors. Champaign (IL): Human Kinetics, 1997
32. Burgess EM, Rappoport A. Physical fitness: a guide for individuals with limb loss. Baltimore (MD): Department of Veterans Affairs, Rehabilitation Research and Development Service, 1993
33. Painter P, Blagg C, Moore GE. Exercise for the dialysis patient: a comprehensive program. Madison (WI): Medical Education Institute, 1995
34. Kenney WL, Humphrey RH, Bryant CX, et al., editors. American College of Sports Medicine's guidelines for exercise testing and prescription. 5th ed. Baltimore (MD): Williams and Wilkins, 1995
35. Roitman JL, Kelsey M, LaFontaine TP, et al., editors. American College of Sports Medicine's resource manual for guidelines for exercise testing and prescription. 3rd ed. Baltimore (MD): Williams and Wilkins, 1998
36. Cooper RA, Quatrano LA, Axelson PW, et al. Research on physical activity and health among people with disabilities: a consensus statement. J Rehabil Res Dev 1999; 36: 142-54
37. Painter P. The importance of exercise training in rehabilitation of patients with end stage renal disease. Am J Kidney Dis 1994; 24 (1 Suppl. 1): S2-S9

Correspondence and offprints: Professor *J. Larry Durstine*, Department of Exercise Science, The University of South Carolina, Columbia, SC 29208, USA.
E-mail: ldurstine@sophe.sph.sc.edu

