Exercise Therapy in the Management of Musculoskeletal Disorders

Edited by

Fiona Wilson

John Gormley

Juliette Hussey

Discipline of Physiotherapy
School of Medicine
Trinity College, Dublin
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Contributors

Leanne Bisset PhD, MPhty (Sports and Musculoskeletal), BPhty
Research Fellow, Physiotherapy Department, Royal Brisbane & Women's Hospital, Herston, Queensland; School of Physiotherapy and Exercise Science, Griffith University, Gold Coast, Queensland, Australia

Thomas J. Gill IV, MD
Chief, Sports Medicine Service, Massachusetts General Hospital; Associate Professor of Orthopedic Surgery, Harvard Medical School; Medical Director, Boston Red Sox Baseball Club, Boston, Massachusetts, USA

John Gormley BSc (Hons), DPhil
Senior Lecturer, Discipline of Physiotherapy, School of Medicine, Trinity College Dublin, Ireland

Juliette Hussey MA, MSc, PhD, Dip Phys, Dip Advanced Physiotherapy Studies
Senior Lecturer and Head of Discipline, Discipline of Physiotherapy, School of Medicine, Trinity College Dublin, Ireland

Mandy Johnson PhD, MPhil, Grad Dip Phys, MCSP
Senior Academy Physiotherapist, Manchester United Football Club, Sir Matt Busby Way, Old Trafford, Manchester, UK

Ruth Magee MPHty, BA (Hons), BSc, MISCP, MCSP
Physiotherapist in private practice, Enniskerry Physiotherapy Clinic, Enniskerry Medical Centre, Enniskerry, County Wicklow, Ireland

Nicholas J. Mahony BA, MB, MSc, FFSEM, MICGP
Lecturer, Department of Anatomy, School of Medicine, Trinity College Dublin, Ireland

Alison H. McGregor PhD, MSc, MCSP
Reader in Biodynamics, Human Performance Group, Biosurgery & Surgical Technology, Division of Surgery, Oncology, Reproductive Biology & Anaesthetics (SORA), Faculty of Medicine, Imperial College London, Charing Cross Hospital, London, UK

Grace O'Malley BSc, MSc, MISCP
Senior Paediatric Physiotherapist, The Children's University Hospital, Dublin, Ireland

Kirsty Peacock BSc, MSc (Sports Med), MISCP
Formerly Physiotherapist to Munster Rugby and Irish Rowing Team; Currently Physiotherapist in Private Practice, Munster Sports Physiotherapy, Limerick, Ireland

Michael M. Reinold PT, DPT, ATC, CSCS
Rehabilitation Coordinator/Assistant Athletic Trainer, Boston Red Sox Baseball Club; Coordinator of Rehabilitation Research and Education, Department of Orthopedic Surgery, Division of Sports Medicine, Massachusetts General Hospital, Boston, Massachusetts, USA

Kyle J. Rodenhi MS, PT
Physical Therapist, Massachusetts General Hospital Sports Physical Therapy, Boston, MA, USA

Dr Kevin Sims MPhty St, PhD, FACP
Clinical Supervisor/Casual Lecturer, University of Queensland; Physiotherapist, Cricket Australia, Centre of Excellence, Australia

Michelle Smith PhD, MPhty (Sports Phty), BMR (Phty), BPhysEd
Lecturer, Division of Physiotherapy, School of Health and Rehabilitation Sciences, The University of Queensland, Queensland, Australia

Professor Bill Vicenzino PhD, MSc, Grad Dip Sports Phty, BPhty
Chair in Sports Physiotherapy and Head of Division of Physiotherapy, School of Health and Rehabilitation Sciences, The University of Queensland, Queensland, Australia

Anne S. Viser PT, DPT, ATC
Physical Therapist, Massachusetts General Hospital Sports Physical Therapy, Boston, Massachusetts, USA

Fiona Wilson BSc, MSc (Sports Med), MA, MISCP
Lecturer/Chartered Physiotherapist, Discipline of Physiotherapy, School of Medicine, Trinity College Dublin, Ireland

Preface

In recent years, the balance of evidence has led to exercise as the treatment of choice in musculoskeletal dysfunction. This has seen a shift in focus in both undergraduate and postgraduate training towards exercise therapy with an accompanying demand for appropriate texts. This book addresses this need and covers the fundamentals of using exercise as a treatment modality in the broad range of pathologies including osteoarthritis, inflammatory arthropathies and osteoporosis. It is anticipated that this book will provide a good progression from the fundamental principles described in this text and would specifically relate these principles to specific areas and pathologies.

The specific aims of this book are to:

- Provide the student with a comprehensive overview of the role of exercise therapy in the management of musculoskeletal disorders
- Evaluate the evidence for use of exercise therapy as a treatment modality
- Educate the student in the potential of exercise as a treatment modality
- Provide practical ideas for use of exercise therapy in the management of musculoskeletal disorders in different areas of the body and for differing pathologies
- Promote the use of exercise among physiotherapists.

This book is primarily aimed at undergraduate physiotherapy students and postgraduate physiotherapists and other clinicians who are starting to design rehabilitation programmes for patients. An emphasis of the book is the relevance of evidence but there is also a practical bias with ideas of rehabilitation programmes and specific exercises.

To
Olly and Daisy,
Sean,
Robert and Gavin

1

The Principles of the Use of Exercise in Musculoskeletal Disorders

1 Introduction

John Gormley

Historical perspectives

In many countries physiotherapy or physical therapy is the one of the largest health care professions after medicine and nursing. One of the major modalities of treatment at a physiotherapist's disposal is exercise. Examining the history of the profession demonstrates that exercise is a fundamental component of treatment. Indeed many would argue that exercise is the most important treatment available to physiotherapists. The use of exercise in both the prevention and treatment of disease and disorders pre-dates the formation of the physiotherapy profession. This chapter examines the history of exercise and its role in disease management.

History of exercise

The use of exercise to promote health was recognised in China in approximately 2500BC, when Hua T'o, a Chinese surgeon, promoted exercise based on the movement of animals (MacAuley, 1994). The ancient Greeks encouraged physical wellbeing and the greatest exponent of exercise was Galen. In his work, De Sanitate Tuenda dealt with the beneficial effects of exercise. In explaining how exercise worked, the amount of exercise and the types of exercise, he used numerous case studies to illustrate his ideas (Bakewell, 1997). What is clear is that not only was the importance of exercise recognised by the Greeks, but also the need for a prescription, encompassing not only the type of exercise, but also the dose or amount necessary for wellbeing. Galen believed that exercise in a moderate form was beneficial but that excess was dangerous as it worked by balancing the effects of eating and drinking, and therefore it was important to avoid excess of either.

In the seventeenth century, the Italian mathematician Giovanni Borelli (1608–1679) first described the body as a machine and used mathematics to describe the functioning of the body. This was the first attempt to apply scientific principles to human movement and Borelli would be regarded as the father of biomechanics. As the body was described as a machine with moving parts, it could be concluded that it needed movement for optimum effectiveness (Bakewell, 1997). In 1740, a French doctor, Nicolas Andry (1658–1742) wrote a book entitled *L'Orthopedie*, in which he described the need for

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correct posture to prevent and treat deformities of the spine and also the need for active exercise rather than passive movement.

The idea that exercise was beneficial for the human body was hampered in the eighteenth century by a number of renowned British physicians including John Hunter (1728–1793), who promoted rest for the treatment of 'disablements' (Buckwalter, 1995). One of the greatest exponents of the use of rest was the Liverpool physician Hugh Owen Thomas (1834–1878), who is regarded as the father of British orthopaedics and during his career invented the Thomas splint for a fractured femur. He advocated that healing was enhanced by rest and that early mobilisation only caused adhesions. It is interesting that this philosophy is contrary to modern-day treatments for musculoskeletal disorders.

Contrary views to this pervading opinion were put forward by Julius Wolff (1836–1902) and Just Lucas-Championniere (1843–1913). Wolff proposed Wolff's Law: that mechanical stress altered bone and that bone was laid down at sites of stress and reabsorbed at sites where there was little stress. Lucas-Championniere, a French physician, argued that rest was detrimental to the musculoskeletal system and that fractures (especially those near joints) were best treated by early mobilisation and by massage. Although Wolff and Lucas-Championniere's theories have been subsequently proved to be correct, it was not until the mid 1950s that early exercise and mobilisation in the treatment of fractures started to become accepted.

Exercise and physiotherapy

The major changes in the use of exercise came about in the twentieth century, with an increase in knowledge and with the formation of the physiotherapy profession. The origins of the physiotherapy profession can be traced back to 1894 as the Society of Trained Masseuses, which became a legal and professional organisation in 1900 as the Incorporated Society of Trained Masseuses. In 1920, exercise was incorporated as part of the profession when the Incorporated Society of Trained Masseuses amalgamated with the Institute of Massage and Remedial Gymnastics. In 1944 the society was renamed the Chartered Society of Physiotherapists. Treatment at this time primarily consisted of exercise, electrotherapy and massage. Gymnasiums were a common sight in physiotherapy schools and exercise was a major component of the physiotherapy curriculum, which required students to undertake physical education classes.

Physiotherapists at this time, however, were not autonomous professionals as they had their treatments prescribed by doctors. In 1977, physiotherapists gained professional autonomy, therefore allowing them to treat patients as they felt appropriate. The fact that up to 1977 physiotherapists were unable to carry out treatment as they thought appropriate was not conducive to either innovation or to research. Despite physiotherapists using exercise on a daily basis, most of the advances in exercise therapy came from the fields of exercise physiology, biomechanics and medicine. This research led to a greater understanding of how the body works and how exercise can benefit all the major systems in the body.

The changes in 1977 and the movement of physiotherapy education into universities provided an opportunity for increased innovation and research in exercise therapy. Furthermore, in 1986 the Remedial Gymnasts Board was disbanded and remedial gymnasts became members of the physiotherapy profession. It is therefore surprising that interest in exercise as a treatment appeared to decrease in the 1990s. The reasons for this are unclear but are probably multifaceted, spanning changes in undergraduate curricula, increased specialisation and new technology. In recent years there has been a renewed interest in exercise and its beneficial effects not only among physiotherapists but also in health care in general.

The benefits of exercise

Exercise has beneficial effects on the cardiovascular system and the musculoskeletal system and indeed other body systems, but it is in the cardiovascular and musculoskeletal systems that the effects are most obvious. Aerobic exercise leads to a decreased demand on the heart at any particular workload with decreased blood pressure and decreased heart rate, increased stroke volume and consequently at a given heart rate, an increased cardiac output. Muscles become more efficient in extracting oxygen from the circulating blood through an increase in the number and size of mitochondria. In bone, there is an increase in the density of weight-bearing bones and therefore is recommended for the prevention of osteoporosis in at-risk groups, e.g. post-menopausal women. Exercise also has beneficial effects on the density of bone in non-weight-bearing bones. Upper limb athletes, e.g. tennis players, have greater bone density in their dominant arm compared with their non-dominant arm (Kontulainen *et al.*, 1999).

Strength training in itself will not necessarily lead to the changes in blood pressure, heart rate and stroke volume as seen with aerobic exercise. At the level of muscle there will be an increase in the size of fast twitch muscle fibres, which accounts for the hypertrophy of muscles and also neuromuscular adaptations, leading to a more efficient muscle contraction. Strength training increases the strength of ligaments and tendons and can lead to increased bone density. The increase in bone density seen in resistance training is greater compared with the changes seen in aerobic training. Cumulatively exercise has effects throughout the body.

Exercise is an active treatment which needs the co-operation and assent of the individual to be treated. Exercise programmes and exercise prescriptions therefore rely on the participation of the individual, and will not be successful if an individual is not compliant with their prescription. The lack of compliance or adherence to exercise programmes is one of the greatest reasons for poor results. Individuals often want a 'quick fix', i.e. a painkiller or a manipulation, so exercise may not be popular with many patients. It is therefore important that physiotherapists explain and educate people about their condition and their exercise programme in order to achieve high levels of adherence.

This chapter reviewed how the use of exercise has developed over the centuries. The following chapter examines the practical application of exercise in the management of musculoskeletal disorders.

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2 The Role of Exercise in Managing Musculoskeletal Disorders

Fiona Wilson

SECTION 1: INTRODUCTION AND BACKGROUND

Chapter 1 reviewed how the use of exercise has developed over the centuries. This chapter will examine the practical application of exercise in the management of musculoskeletal disorders. The intention is not to be too condition- or joint-specific as these areas will be examined in detail later in the book. The aims of this chapter are to:

- Review current evidence and emerging bias towards exercise as a modality of choice over the past 10 years
- Discuss different areas of exercise: aerobic training; strength training; range of movement and flexibility exercise; proprioceptive and balance training
- Examine modalities and techniques employed when prescribing exercise.

Evidence for the role of exercise in managing musculoskeletal disorders

A search of the literature was conducted using the keywords musculoskeletal ± disorder, disease, injury, dysfunction and exercise. The search engines that were employed were: Medline, PubMed, Cinahl, Science Direct, PEDro, *Cochrane Database of Systematic Reviews* and Google Scholar. A number of trials have focused on the efficacy of therapeutic exercise in specific areas of disorder such as low back pain and whiplash. Other trials are less specific and have examined the influence of exercise on pain or disability associated with musculoskeletal disorders.

A small number of trials have examined the role of exercise on long-term musculoskeletal health in a large cohort. These trials are both prospective and longitudinal in design. Bruce *et al*. (2005) studied the long-term impact of running and other aerobic

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exercises on musculoskeletal pain in a cohort of healthy ageing male and female seniors. The prospective study was carried out over 14 years. The cohort of 866 individuals was stratified into runners and community-based controls. Pain was the primary outcome measure and was assessed in annual surveys. The subjects were further stratified into 'ever-runners' and 'never-runners' to include runners who had stopped running. It was found that runners had a lower body mass index (BMI) and less arthritis than community controls, and although they reported slightly more fractures, this result was not significant. Likewise, the ever-runners had lower BMI and less arthritis than controls. Exercise was associated with significantly lower pain scores in both the runners and ever-runners when compared with controls. The authors concluded that consistent exercise patterns over the long term in physically active seniors are associated with about 25% less musculoskeletal pain than reported by sedentary controls.

Berk *et al.* (2006) concluded that exercise can have a beneficial effect on postponement of disability due to musculoskeletal disease, even if introduced at a later stage in life. A prospective cohort of 549 patients was studied annually for 16 years using a Health Assessment Disability Index as the outcome measure. All patients were given a rating to describe their levels of general activity at baseline and at the end of the study. While active exercisers performed well at the end of the study in comparison with the cohort that had remained sedentary, it was found that participants who were initially inactive but increased their activity levels as the study progressed achieved excellent end-of-study values, which were similar to the values in those who were active throughout. The authors concluded that exercise has benefits for the musculoskeletal system even if introduced later in life. The implications for the clinician of the above studies relate to the importance of education for all patients and that exercise can be introduced at any time for any patient to provide benefit to the musculoskeletal system. The studies also clearly point to the fact that lack of activity is a risk factor for musculoskeletal disease.

Establishment of risk factors for any disorder or disease is one of the first lines of long-term management for any clinician. A small number of studies have specifically addressed exercise/activity and its relationship to the onset of musculoskeletal disorders. Heesch *et al.* (2006) examined this relationship between levels of physical activity and stiff or painful joints in a 3-year prospective study. In a cohort of 8770 women (mid-age and older) it was found that both mid-age and older women who were active at low, moderate or high levels had significantly lower odds of reporting stiff or painful joints than their sedentary counterparts. This was particularly noted in the older age group and the authors suggested that this study was the first to show a dose–response relationship between physical activity and arthritis symptoms. While the previous study focused on older women, Pihl *et al.* (2002) examined whether the physically active lifestyle of physical education teachers reduced their risk of musculoskeletal disorders when compared with sedentary controls. The researchers established that the lifestyle of physical education teachers led them to have significantly lower adjusted risk of all musculoskeletal disorders as well as improved body composition in comparison with the control group.

The evidence reviewed above and that which will follow in the book, on balance, supports therapeutic exercise in the management of musculoskeletal disorders. However, it is pertinent to examine the role of exercise or activity in itself as a risk factor for musculoskeletal disease. There are two main areas where exercise or activity has been established as increasing the risk of developing musculoskeletal disorders, that is, in sport and in certain occupations. Increasing evidence from the past decade has strengthened the relationship between occupational activities and the risk of developing and accelerating osteoarthritis (Conaghan, 2002). McLindon *et al.* (1999) established that the number of hours of heavy physical activity was linked to the risk of radiographic knee osteoarthritis with the risk increasing in obese people. However, the injuries were associated with heavy lifting and high levels of squatting and kneeling. Kujala *et al.* (1994) demonstrated an increased risk of developing osteoarthritis in the lower limbs in former male elite athletes in a retrospective study of 2049 subjects. However, the evidence is still biased towards moderate levels of activity having beneficial effects on the musculoskeletal system for both management and prevention of musculoskeletal disorders. Studies which highlight exercise as a risk factor for disorders consistently identify high levels of loading as being the causative element, and clinicians who prescribe exercise must be aware of this.

In conclusion, exercise has been shown in a number of high-quality trials to have benefits both in the management and prevention of musculoskeletal disorders. While there is some evidence that exercise may have harmful effects on the musculoskeletal system in the form of disease or injury, this is almost exclusively associated with abnormal or high levels of loading.

SECTION 2: PRACTICAL APPLICATION OF EXERCISE

Components of fitness

The components of fitness may be described as the following: aerobic or cardio-respiratory fitness; muscle strength and endurance; flexibility or range of motion (ROM); and body composition (American College of Sports Medicine (ACSM), 2000). However, a frequent inclusion in recent years is balance, co-ordination and proprioception (Shankar, 1999). Body composition depends on many factors including genetics, activity levels and diet, and for the purposes of this text will be addressed primarily in Chapter 15, which deals with obesity. Therefore, the components of fitness which will be referred to throughout this text may be summarised as:

- Aerobic or cardio-respiratory fitness
- Muscle strength and endurance
- Flexibility or ROM
- Balance, co-ordination and proprioception.

Exercise prescription

Prescription of exercise requires a clear understanding of the components of fitness and knowledge of appropriate levels of intensity, frequency and duration of each element that will be suitable for each patient. Beyond prescribing specific exercise, the health benefits of general exercise should be considered, particularly at initial assessment. In 2007, the ACSM revised its guidelines for levels of physical activity that are required to see health benefits. For healthy adults under age 65, it is now recommended that they (ACSM, 2008):

Do moderately intense cardio 30 minutes a day, 5 days a week
Or
Do vigorously intense cardio 20 minutes a day, 3 days a week
And
Do 8–10 strength-training exercises, 8–12 repetitions of each exercise twice a week.

The clinician who is prescribing exercise must consider the two main principles of training, which are overload and specificity. When considering the components of fitness, these principles can be most effectively applied to aerobic fitness, muscle strength, and endurance and flexibility. The principle of overload states that for an organ or tissue to improve its function, it must be exposed to loading at a level to which it is not accustomed (ACSM, 2000). The principle of specificity states that training effects form an exercise modality are specific to the exercise performed and the muscles involved. This is seen when high-repetition, low-load exercise produces an increase in muscular endurance but little increase in strength. Conversely, high-load and low-repetition exercise will increase strength but will have little effect on endurance (ACSM, 2000).

Components of an exercise session

Designing an exercise programme requires consideration of the distinct phases of a session, which are defined in sequence as:

- Warm-up
- Endurance phase
- Recreational activities
- Cool-down.

Traditional clinical treatment sessions would frequently introduce exercise to include one or more components at the end of a modality, such as manipulation. However, best practice is to structure a programme and to ensure that all components are covered. It is common to focus on one area such as strength training and neglect to include other areas in the patient's treatment plan, which demonstrates a lack of consideration for the patient's general health. Focusing on one area such as strength training does not consider the overall benefits of all components of fitness to the musculoskeletal system, as outlined in the previous chapter. A programme that is designed into the phases listed above is more likely to cover all components of fitness in a more structured way.

Warm-up

The warm-up facilitates a transition for the body to move from a state of rest to exercise. It allows the heart rate to achieve a steady increase to exercising levels, facilitates increased blood flow to muscles and may increase soft tissue extensibility and thus enhance performance and reduce injury. The warm-up should consist of around 10 minutes of low-intensity exercise which facilitates activity in large joints such as the hips, knees and shoulders and uses large muscle groups. A good example of such exercise would be deep knee bends with arm swinging or step-ups.

Stretches should follow this activity with specific joint and muscle groups targeted individually for the patient. Consideration should also be given to the level of loading which specific muscle groups will experience during the activity which will follow. A generic stretching programme should be avoided as this may fail to target important areas for individual patients and may lead to lengthy stretching programmes that interrupt the flow of the warm-up. Stretching and flexibility are discussed later in this chapter.

The final stage of the warm-up will allow the heart rate to reach the target exercise levels and thus will include more high-level aerobic activity, which may start to replicate that used during the endurance phase.

Endurance phase

The endurance phase develops cardio-respiratory fitness and should comprise about 10–60 minutes of continuous or intermittent aerobic activity. This should be set at a level that is appropriate for the patients and is based on previous assessment of levels of fitness. Activities which use large muscle groups should be employed for optimal effect. The duration of this phase should be inversely related to the intensity of the activity. Resistance training and specific exercise in a rehabilitation programme may be included in this phase (ACSM, 2000).

Recreational activities

Inclusion of games, skills or challenges following the endurance phase may make the programme more interesting and encourage the patient to adhere to the programme. This may be particularly important in the rehabilitation of an athlete or an individual with an occupational injury.

Cool-down

The purpose of the cool-down is to facilitate a graduated return to the pre-exercise state. It allows heart rate and blood pressure to return to normal and enhances lactate removal. The format should be very similar to the warm-up and should include exercise of diminishing intensity. In practical terms, it presents an opportunity for the clinician to further assess the patient's response to the programme.

Prescription of aerobic exercise

The benefits of aerobic exercise for the musculoskeletal system were outlined in the previous chapter. The aim of prescription of aerobic exercise is to generate an improvement in maximal oxygen consumption (VO_{2max}). The VO_{2max} of an individual defines their aerobic capacity and is a measure of their maximal oxygen uptake. Endurance training has the effect of making the cardio-respiratory system more efficient when the training is performed regularly, and consequent improvements will be seen in the VO_{2max}. As the VO_{2max} and heart rate of an individual are related in a linear fashion, measurement of heart rate during exercise is a good reflection of the individual's VO_{2max} or aerobic capacity. It must be remembered that changes not only take place in the cardiac and pulmonary systems but also at a localised muscular level. Changes in VO_{2max} are directly related to the intensity, frequency and duration of the prescribed exercise and these elements should be given primary consideration in exercise prescription.

Type of exercise

There are many factors to consider when prescribing aerobic exercise for the patient with a

Figure 2.1 Power walking.

musculoskeletal disorder. The usual recommendation is to prescribe exercise which uses as many large muscle groups as possible in a repeated, aerobic pattern – clear examples are running and swimming. However, prescribing exercise in a patient with a musculoskeletal disorder can present a challenge as their condition may limit their function. The clinician needs to have a good understanding of the limitations of the disorder and prescribe a mode of exercise accordingly. One of the most challenging aspects of designing an aerobic exercise programme is to plan one to which the patient will adhere in the long term. Short-term adherence is frequently managed by asking the patient to attend for supervision on a regular basis, however, long-term benefits to the patient's health will only be seen when the mode of exercise is maintained. Therefore it is important that very careful consideration is given to the mode of exercise that is selected. Most ambulant patients with a musculoskeletal disorder, provided it is not severe and in the lower limbs, will be able to commence a walking programme. The benefits of walking are that patients are familiar with the exercise and that they are often easily able to fit it into their lifestyle as no equipment is needed. However, there is a risk that walking would be performed at a level which is too low and therefore insufficient to challenge the cardiovascular system, particularly as it may be performed with minimal movement of the trunk and upper limbs. Some simple and safe adaptations can make the exercise more challenging such as adding in definite arm movements with weights in the hands, as seen in power walking (Fig. 2.1), which encourages the recruitment of more muscle groups and enhances the aerobic effect. Nordic walking uses poles in the hands, which not only encourages greater use of the trunk and upper limbs but also enhances stability for those who may be challenged by balance (Fig. 2.2).

Figure 2.2 Nordic walking.

Figure 2.3 Bicycle on ‘rollers’.

Swimming is an excellent exercise as it does not load the joints and recruits most of the major muscle groups. However, many adults are poor swimmers or may not have easy access to a pool as public leisure centres become scarcer. However, if it is enjoyed by the patient, a good swimming programme can be very beneficial. Hydrotherapy which involves exercise in heated water has been shown to present numerous benefits in patients with musculoskeletal disease. Many hospital physiotherapy departments would have such a pool and this should be considered if it is available. However, this is frequently only offered as a short course of treatment and consideration needs to be given to a mode of exercise which will be used in the long term.

Cycling is a good source of challenge to the cardio-respiratory system and has the advantage that it may be used as a mode of transport for some patients and therefore can be a lifestyle change. Exercise of the trunk and upper limbs is minimal but it may be suitable for patients who have a lower limb disorder. An exercise bike can be used by those who are nervous of cycling in traffic; patients can purchase cycling ‘rollers’ from any bicycle shop to convert a normal bike into one that is stationary (Fig. 2.3).

Prescription of exercise when rehabilitating an athlete requires specific consideration. The aim should be to return the athlete to their sport as quickly as possible. Loss of aerobic fitness during rehabilitation of an injury will prevent a rapid return to a competitive environment, which is the primary concern for most athletes. The type of aerobic exercise should be as close to their sport as possible, with adaptations if necessary. For example, a runner with a lower limb injury may commence aqua jogging using a flotation vest, which will ensure that similar muscle groups and kinematics will be employed during rehabilitation. It should also be remembered that an athlete will have a much higher starting point in terms of fitness and may need to be prescribed higher intensity exercise as their goal is to maintain fitness rather than achieve it.

Exercise intensity

There are a number of different methods of setting the exercise intensity but the mode which may be most practical and simple for the musculoskeletal clinician involves prescribing as a percentage of maximum heart rate (HR_{max}). The ACSM (2008) recommends between 55/65% up to 90% of HR_{max} to achieve benefit. While those individuals whose are very unfit at the start of the programme would require prescription at the lower end of intensity, those who are fit would be working at the upper end of intensity. For the average individual, prescription at 70–80% of HR_{max} would be suitable to see improvement. Best practice requires establishment of the patient’s HR_{max} by means of a progressive physiological or ‘step’ test. However, the equation which estimates the HR_{max} (below) may be used when this is not available, i.e.

$$\text{Estimated } HR_{max} = 220 - \text{age}.$$

Exercise duration

The duration of exercise is governed by the intensity as high intensity exercise will require shorter duration periods than low intensity to achieve the same benefits. The ACSM guidelines outlined earlier in the chapter should be reviewed to establish minimum requirements for each patient. In general, for the average individual who is exercising at 70–80% of HR_{max}, a duration of 20–30 minutes excluding warm-up and cool-down will be sufficient to benefit the patient. As mentioned previously, this should be adapted accordingly for the very unfit or conversely, the very fit patient.

Exercise frequency

Exercise frequency for the musculoskeletal patient may be governed by clinical visits which may be limited to once or twice per week. However, optimal benefits will be achieved with three to five sessions per week. This demands adherence by the patient that may be achieved in a number of ways, the most successful of which requires that the patient is supervised in a clinic or gym. However, this is both costly and not practical, particularly as long-term benefits are only achieved by maintenance of the programme following discharge. Training diaries may be useful as are classes at a local gym, and the aim should be to educate the patient regarding the importance of maintaining the exercise frequency. Of course, for the Olympic athlete who is already doing two aerobic training sessions daily, this should be replicated in rehabilitation to maintain fitness. The patient who is starting from a very low fitness level may achieve benefits by starting at two sessions per week. Although the frequency must be adjusted for each patient, the ultimate goal for the average individual should be to at least meet the minimum requirements as recommended by the ACSM and outlined earlier in the chapter.

Progression of the programme

The rate of progression of the programme will depend on the patient and their goals, which will have been established at the original assessment. As this text is concerned with rehabilitation of musculoskeletal injury, it will also depend on the rate of resolution of the injury. The intensity, duration and frequency of exercise may be low (40–50% HR_{max}), short (15 minutes) and limited to three times per week for the patient who is commencing the programme. The ultimate aim would be that this patient will have progressed to moderately intense exercise for 30 minutes, five times a week, or vigorously intense exercise for 20 minutes, three times a week. The programme should be commenced with caution, and assessment should always be ongoing and the patient's response to the programme should be constantly monitored. As the patient finds that the programme becomes less challenging, which may be demonstrated when the established exercise intensity is no longer enough to reach heart rate goals, then intensity, frequency and duration may be increased gradually and with caution. Maintenance of improvement should be considered at discharge and a programme should be planned which the patient may adapt to their lifestyle to facilitate long-term benefits.

Prescription of muscle strength and endurance exercise

Strength is regarded as the maximum force that a muscle can exert and endurance refers to the ability to maintain the force over time. Both are required for normal function of muscles and different muscles have different functions. Some muscles have a greater proportion of slow twitch or type I fibres and thus demonstrate greater endurance, such muscles are associated with functions such as postural control. Other muscles have a greater proportion of fast twitch or type II fibres and are associated with rapid generation of force. Resistance training improves the capacity of a muscle to generate and/or maintain force. When prescribing resistance training, the overload principle should be applied. This may be achieved by increasing the load, the number of repetitions or the number of weight-training sessions above levels normally experienced. Muscle strength is developed by using low repetitions, typically 8–12 repetitions, with a resistance or weight which is close to the maximum that may be lifted or moved. To improve muscle endurance, high repetitions with low load are employed.

Types of resistance

Huber and Wells (2006) define the modes of resistance exercise as *isometric* (constant length), *isotonic* (constant tension), *isokinetic* (constant velocity) and *plyometric* (increased length). The most commonly used resistance exercise is isotonic muscle work in the form of free or machine-based weights. Resistance may be manual, given by the clinician, or mechanical, in the form of resistance from machine, free, pulley or elastic-based weights.

Isometric exercise

Isometric resistance may be given by the therapist, gravity or by a constant weight. Isometric exercise