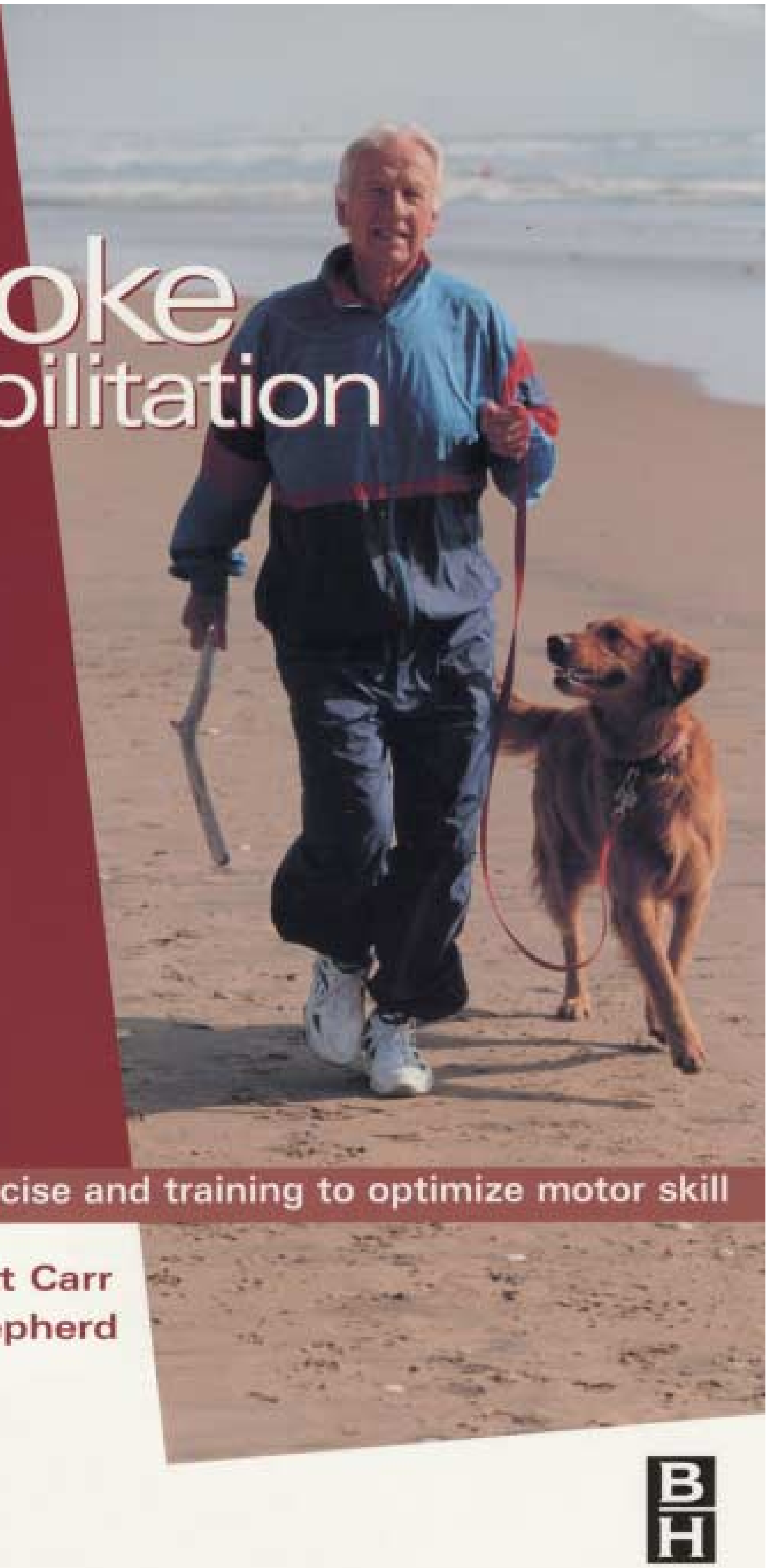
stroke rehabilitation



guidelines for exercise and training to optimize motor skill

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BH

Stroke Rehabilitation

Guidelines for Exercise and Training to Optimize Motor Skill

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enrichment may affect a general factor or a host of specific factors that relate to the general adaptive capacity of the organism, i.e. its ability to cope with a variety of situations and problems of a general nature (Finger 1978).

Animal experiments have shown that exposure to a particular type of environment may either enhance or restrict opportunity for general experience. Rats housed in an enriched environment, with the opportunity for physical activities and interaction with other rats, performed significantly better on motor tasks than rats housed in a standard laboratory environment, alone and with no opportunities for interesting activities (Held et al. 1985, Ohlsson and Johansson 1995).

In animal research, the aspects of the enriched environment which appear to be critical as enhancers of behaviour are social stimulation, interaction with objects that enable physical activity (Bennett 1976) and an increased level of arousal (Walsh and Cummins 1975). It is of interest, therefore, to consider what effects a typical rehabilitation environment may have on the behaviour of humans, and observational studies of rehabilitation settings provide some insights. They suggest the environment may not be sufficiently geared to facilitating physical and mental activity or social interaction, and that the rehabilitation setting may not function as a learning environment (Ada et al. 1999).

Several studies investigating how stroke patients spend their time have shown that a large percentage of the day was spent in passive pursuits rather than in physical activity. Even less physical activity occurred on weekends compared with weekdays and there was little evidence of independent exercise. Patients were noted to remain solitary and inactive for long periods, watching others or looking out of the window. Although what physical activity occurred was in the therapy area, therapy was noted to occur for only a small percentage of the day (Keith 1980, Keith and Cowell 1987, Lincoln et al. 1989, Tinson 1989, Mackey et al. 1996, Esmonde et al. 1997). It is disappointing to see that over the nearly two decades spanned by these studies there was little change in the amount of time spent in physical activities.

Structuring a practice environment

The goals of physiotherapy are to provide opportunities for an individual to regain optimal skilled performance of functional actions and to increase levels of strength, endurance and physical fitness. For the able-bodied and the disabled, it is recognized that practice is the way to achieve these aims.

Skill in performing a motor task increases as a function of the *amount* and *type of practice* as does strength, endurance and fitness. Although the amount of practice is critical and more practice is better than less, recent research into motor learning and strength training suggests that the amount of practice may not be the only variable influencing any improvements in performance. There is some clinical evidence (e.g. Parry et al. 1999a) that merely increasing the time spent in therapy may not necessarily improve outcome. It is probably the *type of practice* rather than simply its occurrence that reshapes the cortex following a brain lesion (Small and Solodkin 1998).

learner and the therapist as teacher or coach. Increasing numbers of clinical studies are supporting the use of more varied methods of delivery and more active methods of intervention.

Optimizing skill

Skill has been defined as 'any activity that has become better organized and more effective as a result of practice' (Annett 1971) and also as 'the ability to consistently attain a goal with some economy of effort' (Gentile 1987). Everyday activities, even such apparently simple ones as standing up from a seat, constitute motor skills. They are complex actions, made up of segmental movements linked together in the appropriate spatial and temporal sequence. The person with motor impairments following a neural lesion needs to learn again how to control segmental movement so that the spatial configuration and temporal sequencing of body movements brings about an effective action, thereby achieving the individual's goal with minimum energy expenditure. Task-oriented training is critical to gaining the necessary control. In attempting to regain movement control, however, the degree of muscle weakness may be such that initially the patient also has to practise exercises for activating and sustaining activity in specific muscle groups.

An important characteristic of acquiring skill is that learning seems to take place in overlapping stages. Two models that have been proposed give insights useful to the clinic. An early study described three stages of learning: an early or cognitive stage, an intermediate or associative stage and a final or autonomous stage (Fitts and Posner 1967). The learning stages have also been described as first getting the idea of the movement, then developing the ability to adapt the movement pattern to the demands of the environment (Gentile 1987). In both cases the initial stage is cognitive.

Early after stroke, patients with a lesioned system are struggling to learn again how to perform even simple movements as well as everyday actions. They need to practise repetitively in order to get the idea of the action they are (re)learning and to train the neural coordination necessary for effective performance. As they gain more strength and control, less attention can be directed toward performing the action and more attention to the goal and relevant environmental cues.

As motor control and skill develop, changes occur at different levels. For example, with more intersegmental control there is less tendency to 'freeze' the degrees of freedom. There is also a decrease in energy expenditure. The focus of attention shifts. In walking, the focus of visual attention shifts from the feet to the surrounding environment; 'star billing' for sit-to-stand changes from foot placement and speed of trunk rotation to steadying a glass of water while standing up. Being aware of the characteristics of each stage enables the therapist to provide the appropriate practice conditions to optimize performance.

For movement to become more automatic, intensive practice is required in order to increase endurance as well as the opportunity to practise adapting the

3 Walking

CHAPTER CONTENTS

INTRODUCTION

The ability to walk independently is a prerequisite for most daily activities. The capacity to walk in a community setting requires the ability to walk at speeds that enable an individual to cross the street in the time allotted by pedestrian lights, to step on and off a moving walkway, in and out of automatic doors, walk around furniture, under and over objects and negotiate kerbs. A walking velocity of 1.1–1.5 m/s is considered to be fast enough to function as a pedestrian in different environmental and social contexts. It has been reported that only 7% of patients discharged from rehabilitation met the criteria for community walking which included the ability to walk 500 m continuously at a speed that would enable them to cross a road safely (Hill et al. 1997).

Walking is a complex, whole-body action that requires the cooperation of both legs and coordination of a large number of muscles and joints to function together. An important question in the study of motor control is how the many structural and physiological elements or components cooperate to produce coordinated walking in a changing physical and social environment. Bernstein (1967) proposed that to perform a coordinated movement the nervous system had to solve what he termed the 'degrees of freedom problem'. The degrees of freedom of any system reflect the number of independent elements to be constrained. Given the large number of joints and muscles and the mechanical complexity inherent in the multisegmental linkage, Bernstein questioned how these elements can be organized to produce effective and efficient walking.

The coordination of a movement, Bernstein wrote, 'is a process of mastering redundant degrees of freedom of the moving organism, that is, its conversion to a controllable system'. Degrees of freedom can be reduced by linking muscles and joints so that they act together as a single unit or synergy, thus simplifying the coordination of movement. Such a linkage is illustrated in gait by the cooperation between muscle forces at hip, knee and ankle to produce an overall support moment of force to ensure the limb does not collapse.

Sensory inputs in general and visual inputs in particular provide information that makes it possible for us to walk in varied, cluttered environments and uneven terrains. Vision provides information almost instantaneously about both static and dynamic features of the near and far environment. This information is used to plan adjustments to the basic walking pattern (Patla 1997).

Avoidance of falls depends to a large extent on the ability to identify, predict and act quickly enough upon potential threats to stability based on past experience. The visual system plays an important role in identifying and avoiding potential threats to balance. Avoidance strategies include adaptation of step length, width and height, increasing ground clearance to avoid hitting an object on the ground, increasing head clearance to avoid hitting an obstacle above ground, changing direction and stopping (Patla 1997). These strategies are adaptive and are implemented to ensure stability of the moving body. Kinesthetic, tactile and vestibular inputs also play an important role, particularly in the reactive control of balance during walking. Reactive control by definition is a last resort or backup in regaining balance and relies upon triggering of reflexive responses (Patla 1993, 1997).

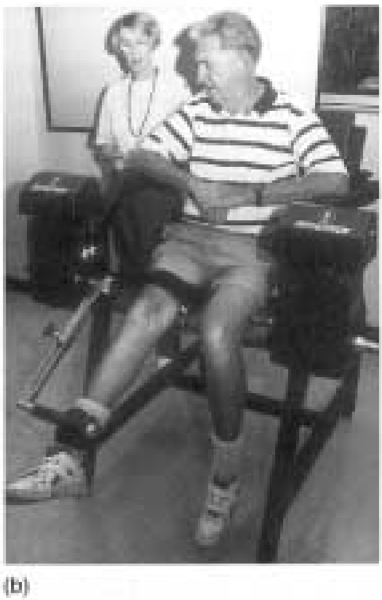
Walking dysfunction is common in neurologically impaired individuals, arising not only from the impairments associated with the lesion but also from secondary cardiovascular and musculoskeletal consequences of disuse and physical inactivity. Muscle weakness and paralysis, poor motor control and soft tissue contracture are major contributors to walking dysfunction after stroke. Functional gait performance, however, also depends on one's level of fitness. Impairments post-stroke frequently impose excessive energy cost (effort) during walking, limiting the type and duration of activities. Stroke patients, particularly those of advanced age, are often unable to maintain their most efficient gait speed comfortably for more than a very short distance, indicating that muscle weakness, elevated energy demands and poor endurance further compromise walking ability (Fisher and Gullikson 1978, Olney et al. 1986). Stroke patients may self-select a speed that requires least energy (Grimby 1983) and may not have the ability to increase this without increasing energy demands beyond their capacity (Holden et al. 1986). Such individuals are constrained to very limited activity in their home environment, and require the opportunity to exercise and increase their walking speed and endurance.

Individuals who are discharged showing improvements in gait are not necessarily functional walkers. For example, the calculation of walking speed over 10 m, a commonly used clinical measure of gait, may overestimate locomotor capacity after stroke. Whereas healthy subjects can walk in excess of their comfortable

FIGURE 3.25 *Walking up a ramp. She needs to be encouraged to use her calf muscles to push off.*

FIGURE 3.26 *Some examples of semi-supervised exercising. (a) The MOTOmed provides resistance or assistance in response to the patient's performance (Reck, Reckstrasse 1-1, D-88422 Betzenweiller, Germany). (b) Exercising on the Orthotron to strengthen knee extensor muscles concentrically and eccentrically or isometrically (Cybex Human Performance Rehabilitation, 2100 Smithtown Ave, Ronkon Koma, NY 11779, USA).*

(a)



(b)

Biomechanical tests

Variables to be tested include:

- angular displacements
- ground reaction forces
- moments of force, power, energy.

Matching observations with biomechanical test results enables physiotherapists to get feedback on and improve their observational skills.

Calf muscle length test

A reliable method of measuring passive ankle dorsiflexion in a clinical setting is described by Moseley and Adams (1991). It involves the use of skin surface markers (head of 5th metatarsal, lateral malleolus and head of fibula), polaroid photography and the application of a known torque, using a specially designed template. The knee is held at a constant angle in extension with a velcro strap over the shank (see Fig. 7.4).

Physiological tests

Physiological tests have shown that speed and energy costs during gait are valid parameters in assessment of walking capacity. Fitness is typically tested using a treadmill, bicycle ergometer or MOTOmed Pico Leg Trainer. Fitness tests are described in Chapter 7. The fitness test most specific to gait uses the treadmill. Monitoring heart rate is a simple method of ensuring that exercise is sufficiently vigorous.

NOTES

Treadmill training

The rationale for considering treadmill training in rehabilitation of gait following stroke arose from animal research investigating motor control mechanisms in lesioned animals (Grillner and Shik 1973). There have been several recent clinical studies showing the positive effects of treadmill training on individuals with stroke, although such training has yet to be widely used in clinical settings. Several studies have demonstrated effects superior to those obtained by neurodevelopmental therapy (Bobath) intervention (Fig. 3.29) (Richards et al. 1993, Hesse et al. 1995, Pohl et al. 2002). There is no evidence that treadmill training causes 'mass synergies' or increases spasticity (Hesse et al. 1995, Hesse 1999), a concern which may be expressed by clinicians.

Many of the gait deviations seen in stroke patients result from their inability to adequately bear weight through the affected lower limb during the loading phase of the gait cycle (Carr and Shepherd 1998). Treadmill training using a

7 Strength training and physical conditioning

CHAPTER CONTENTS

INTRODUCTION

The major goal of physiotherapy in neurological rehabilitation is the optimization of functional motor performance. Major impairments limiting motor performance are muscle weakness or paralysis, soft tissue contracture, lack of endurance and physical fitness.

This appendix provides some general guidelines for strength training in relation to the optimization of motor control and skill, training to increase physical fitness and endurance, and methods of decreasing stiffness and preserving soft tissue length.

INCREASING MUSCLE STRENGTH

The physiological factors which affect strength are structural and functional. Structural factors include the cross-sectional area of the muscle (its size), the density of muscle fibres per unit cross-sectional area and the efficiency of mechanical leverage across joints. The functional factors include the number, type and frequency of motor units recruited during a contraction, the initial length of muscles and the efficiency of cooperation between synergic muscles involved in the action. In addition, biomechanical factors also affect strength. For example, the viscoelastic properties of the contractile and non-contractile tissues absorb energy when an active muscle is stretched and this can be used to increase the concentric force of the contraction. Strength is therefore a function of the properties of muscle and depends on intact neurological function (Buchner and de Lateur 1991).

It follows that strength training is necessary after stroke to improve the force-generating capacity and efficiency of weak muscles and to improve functional motor performance. The relationship between strength and performance is complex. The amount of strength required depends on the person's physical size (weight of hand, total body weight) – i.e. relative as opposed to absolute strength (Buchner and de Lateur 1991) – and on the action to be performed (walking on a flat surface vs stair climbing). Skilled motor performance, however, requires the following:

- each muscle involved in the action has to generate peak force at the length appropriate to the action
- this force has to be graded and timed so synergic muscle activity is controlled for task and context
- the force has to be sustained over a sufficient period of time
- peak forces must be generated fast enough to meet environmental and task demands such as increasing walking speed to cross the road at traffic lights.

Although reductions in muscle force production and its control cause major motor dysfunction after a lesion of the neuromotor system, strength training has been eliminated from many therapy programmes over the past five decades, to a large extent due to the continuing influence of certain physiotherapy beliefs. First, weakness has been thought to be due to inhibition from spastic antagonists and 'low tone' of agonists rather than a direct result of the reduction in descending inputs to spinal motoneurons; second, exercises causing effort are therefore contraindicated as they are expected to increase spasticity, co-contraction and abnormal movement patterns.

These views are still being taught and many clinicians are therefore maintaining an approach to rehabilitation that is no longer supported either by scientific theory or clinical evidence. Clinical research has shown that effort applied in strength training does not increase spasticity (reflex hyperactivity), associated movements, co-contraction or resistance to passive movement* (Butefisch et al. 1995, Davies et al. 1996, Sharp and Brouwer 1997, Brown and Kautz 1998, Smith et al. 1999, Teixeira-Salmela et al. 1999, Ada and O'Dwyer 2001, Bateman et al. 2001). On the other hand, not only does strength training result in increased muscle strength following stroke, but also improved functional performance and decreased spasticity, for example decreases in resistance to passive movement, stretch reflex hyperactivity and co-contraction (Butefisch et al. 1995, Miller and Light 1997, Smith et al. 1999, Teixeira-Salmela et al. 1999). The dynamic stretching that occurs during active exercise may play a part in decreasing reflex hyperexcitability and increasing muscle compliance (Otis et al. 1985, Hummelsheim et al. 1994). The evidence is mounting that repetitive, task-oriented strength training is effective following stroke, as is also being

*Variously tested by resistance to passive movement on the Ashworth scale, response to pendulum test, presence of abnormal movement patterns, or inappropriate muscle activity or co-contraction on EMG.

shown following cerebral palsy and traumatic brain injury. It is also likely that practice and training, by improving aspects of motor control such as timing of muscle activations, would result in decreased co-contraction (Carr and Shepherd 1987). There seems little doubt that active exercise and training provoke efficacious changes in motor control.

There is another consideration when planning intervention. Many individuals who have stroke are elderly. For some, their pre-stroke physical condition may have been poor due to ill health, excessive weight, or a sedentary lifestyle. Consequently, reductions in muscle strength due to the lesion, together with pre-existing reductions in joint flexibility, strength, endurance and physical fitness, combine to impact severely on the patient's ability to regain the necessary functional motor skills. Poor physical condition and being elderly are not barriers to strength and fitness training post-stroke but are instead imperatives. It is known that regular moderately vigorous exercise has positive effects on muscle mass and strength, postural stability and prevention of falls, joint flexibility, bone density, psychological function and cardiovascular responses to exercise (read Mazzeo et al. 1998 for review and recommendations). The avoidance of strength training in patients with muscle weakness who are also lacking in fitness is very likely, therefore, to have a significant negative impact on functional outcome after stroke (Miller and Light 1997).

Factors associated with the nature of the lesion, the patient's pre-stroke physical condition and subsequent physical inactivity provide, therefore, several compelling reasons for emphasizing strength training following a stroke, summarized as follows.

1. Muscle weakness is a major impairment to effective functional performance
   — a stroke usually results in some degree of muscle weakness, including paralysis, primarily as a direct result of a reduction in descending inputs on spinal motoneurons and of the number of motor units activated
   — the immobility which ensues results in mechanical and functional changes to the muscles and connective tissue, and predisposes to further reductions in strength
   — elderly individuals may have had varying degrees of muscle weakness and reduced endurance and cardiovascular responses pre-stroke due to a decline in physical activity.
2. There is mounting evidence that strength training is effective following stroke
   — muscle strength is increased
   — increased strength can be associated with improved functional performance
   — when incorporated into an intensive activity programme, exercise capacity and endurance are also improved.
3. There is no evidence that spasticity (hyperreflexia) or hypertonus (resistance to passive movement) increase, and some evidence that they decrease, after strength training.

The mechanisms underlying the improvement of muscle strength and motor control reported following stroke may be similar to those after strength training in able-bodied individuals. Neuromuscular adaptations associated with muscle functional ability. This may not, however, be the case. The body adapts specifically to the demands imposed upon it, and research over many years has shown that exercise effects tend to be specific to task and context (Rutherford 1988, Morrissey et al. 1995), with the greatest changes occurring in the training exercise itself. For example, increases in strength of a muscle appear to be specific to such factors as joint angle (muscle length), subject's posture (standing or supine), velocity of movement and muscle contraction type. Muscle length specificity is of particular interest, with the greatest increases in maximum voluntary contraction consistently found at the training angle after isometric exercise. Results of one study showed that the shorter the muscle length at which training was carried out the more the gain in maximum voluntary contraction was limited to the training angle (Thepaut-Mathieu et al. 1988).

The principle of specificity is usually explained with reference to such factors as the structure and function of particular muscles, biomechanical constraints such as length of moment arm, and the nature of synergic cooperation. Functional actions are made up of complex movements of the multisegment linkage which require strength, coordination and balance. The relationship between muscles that span one joint and those that span two (or many) joints is particularly complex and little understood (Bobbert and van Soest 2000).

The extent to which the intrinsic strength of stabilizer and other synergic muscles influences the strength of a prime mover muscle has been little investigated. However, a recent analysis of a task that involved pushing a heavy object (Kornecki et al. 2001) drew attention to the importance of muscles acting as stabilizers to 'stiffen' the degrees of freedom not involved in the action. The study found that the ability to stabilize a key joint influenced muscle activation patterns. Stabilizing the wrist joint was associated with decreased EMG in the upper arm muscles (triceps brachii, deltoid), the prime movers for the pushing movement.

After stroke, when muscle weakness is part of a more general motor control impairment, it may be critical that strength training is oriented toward specific tasks and designed to ensure the greatest transfer possible into improved functional motor performance. Strength training may need to focus on exercising muscles through a specific part of the range (e.g. calf muscles from fully lengthened to mid-range for stance phase of gait). It is therefore critical that a close examination is made of the patient's ability to generate and sustain force as active motor tasks are practised, and that this is followed up by exercise and training specifically targeting the muscles in which weakness is evident and apparently affecting function.

Transfer from strength to function

It is intuitive that a relationship should exist between strength and function; however, the nature of the relationship appears complex and dependent on the degree of muscle weakness. An hypothesis put forward by Buchner and de Lateur (1991) suggests that the relationship between strength and function is curvilinear and activity specific. In a study of elderly individuals, Buchner and colleagues (Buchner et al. 1996) showed that a curvilinear relationship exists between lower limb strength and walking velocity. They pointed out that this relationship reflects a mechanism by which small changes in strength may produce relatively large changes in performance in very weak adults, while large changes may have little or no effect in able-bodied adults. When muscles are beyond a certain task-dependent threshold (a threshold that for most everyday tasks is well below normal strength values), exercises are required that are task oriented. Buchner's hypothesis may explain the discrepant results in studies reporting a relationship between strength and function.

A recent study illustrated the beneficial transfer effects of task-oriented strength training in an able-bodied group. Glenohumeral internal and external rotation exercises (incorporating elastic band and hand weight resistance) performed by tennis players in standing, with shoulder at 90° abduction, resulted in significant increases in force production of the actions practised, with a transfer into increased speed of serve (Treiber et al. 1998). Transfer is unlikely to occur, however, unless subjects are also practising the task to be learned (in the above case, the tennis serve), even in some modified context.

Transfer from single joint exercise to kinetic (weightbearing) actions may be limited except where muscles are very weak. It has been shown that open-chain knee extension exercise can increase strength of quadriceps in terms of the weight that can be lifted through range (the exercise), with no improvement in maximum power output measured in isokinetic cycling (a closed-chain action in the pedal-pressing phase). Some studies have produced more equivocal results. This may be due to the relevance of the exercises to the functional action being learned or to the individual's strength level.

Variations in body position also affect muscle activity patterns. An early experiment showed that strength training of elbow muscles carried out in standing resulted in greater increases in strength than the same exercises carried out in supine (Rasch and Morehouse 1957). The strength increases found in standing were in large part the result of learning to coordinate all the muscles involved in the movement, which included those controlling balance.

Strength training that involves repetitive practice of the action being learned can improve strength and endurance if load is progressively increased in some way. For example, walking on a treadmill (and overground) can be progressed by increasing speed and slope; STS can be practised repetitively from increasingly lower seat heights, and at increasing speed. If done repetitively with sufficient load, such training provides a means of strengthening lower limb muscles and increasing endurance, as well as control over the dynamics of the particular action to be regained.

Also critical to the regaining of effective performance is the development of flexibility of performance, which is achieved by practising the action under a variety of different conditions, i.e. in different environmental and task contexts. Repetitive practice of the action to be learned can therefore have dual benefits, enabling the patient to practise the action as well as increasing muscle strength (Rutherford 1988). Strength training for individuals following stroke should be considered to have as its main effects improved performance in actions required in daily life and prevention of falls.

rate reserve. Teixeira-Salmela et al. (1999) assessed subjects' general level of physical activity on the Human Activity Profile, a survey of 94 activities including transportation, home maintenance, social and physical activities, which are rated according to their required metabolic equivalents. The results indicated that subjects were more able to perform household chores and recreational activities after strengthening and aerobic training. These subjects also reported an improved quality of life, as previously reported some years ago (Brinkman and Hoskins 1979).

Although clinical evidence of cardiovascular disease may limit exercise and training initially, Potempa and colleagues (1996) suggest that a monitored aerobic training programme may improve endurance and functional ability and have the following physiological benefits:

- increased work capacity
- decreased resting and sub-maximal heart rates and blood pressure
- weight loss
- improved lipoprotein profile
- decreased platelet aggregation
- delay in onset of angina.

A recent study has shown the early deconditioning that occurs within the first 6 weeks after stroke (Kelly et al. 2002) and illustrates the need for exercise of greater intensity than is typically provided. The study also shows that, for the patients investigated, exercise testing was well tolerated at this early stage. Patients performed incremental maximal effort tests on semi-recumbent cycle ergometers (see Fig. 3.26), with continual monitoring of heart rate and blood pressure by a physician.

Exercise prescription

Once intensive exercise can begin, patients can work on a cycle ergometer, with adaptive devices as necessary (e.g. foot can be strapped to pedal) (Potempa et al. 1995), on a device such as the Motomed Leg Trainer*, or on a treadmill. As an example of exercise prescription suitable for this patient group, Potempa et al. (1996) adapted the criteria of the American College of Sports Medicine for patients with low functional capacity (Kenney et al. 1995) for their conditioning programme:

- Initially patients train at a workload equivalent of 40–60% of VO_{2max} progressing up to 30 min, 3 times/week.
- When 30 min is reached, intensity is progressively increased to the highest workload tolerable without symptoms.
- 10 min warm-up and cool-down periods of unloaded cycling.

Another study describes a similar programme of graded treadmill walking (Macko et al. 1997).

Changes in muscle function, particularly in the elderly, are not maintained without ongoing training (Fiatarone et al. 1990). Ongoing post-discharge exercise

*MOTOmed Pico Leg Trainer, Reck, Reckstrasse 1–3, D-88422, Betzenweiller, Germany.

programmes, either home based, in which case they need monitoring at regular intervals, or gymnasium or health centre based, need to be available for individuals following stroke, particularly when they are elderly. Commenting on programmes for the healthy elderly, Mazzeo and colleagues (1998) point out that exercise programmes for strength and fitness should consist of scientifically based strategies rather than the non-specific 'movement' programmes typically offered.

As a general health precaution it is advisable for older individuals to have a medical check prior to starting a moderately vigorous exercise and fitness programme. This should also occur after stroke. The contraindications to exercise training appear to be few, even in the very old (Mazzeo et al. 1998). Certain conditions such as febrile illness or unstable chest pain need investigation. Patients with arthritis can also tolerate strength training well (Lyngberg et al. 1988). Exacerbation of joint pain from underlying arthritis may necessitate modification of exercise; for example, closed-chain exercise may be preferable to open-chain exercise for those with infrapatellar pain.

Measures of exercise response

Maximal effort exercise testing

Standardized maximal treadmill or cycle ergometer test. After stroke, exercise testing is typically carried out using a treadmill or bicycle ergometer. A stationary cycle is considered by some to be preferable to treadmill or arm-mobilized ergometer for testing after stroke (Potempa et al. 1995). A cycle ergometer makes it easier to quantify external workload. A standardized methodology, such as the Balke Protocol (Fletcher and Schlant 1994), is used (Macko et al. 1997). Maximal testing requires simultaneous electrocardiograph monitoring and is carried out by specially trained staff. Tests of VO_2 peak and O_2 consumption per kilogram body weight at a given power output while cycling, graded walking or treadmill walking provide a means of evaluating cardiovascular response to exercise (Jankowski and Sullivan 1990).

Submaximal effort exercise testing

Standardized submaximal treadmill test. Macko and colleagues (1997) describe a treadmill test (1 mph, no incline) representative of the slow walking typical after stroke, performed with open circuit spirometry to measure oxygen consumption (VO_2) under steady state conditions. Patients wore a nose clip and breathed through a mouthpiece, or were fitted with a non-rebreathing mask to collect expired air. All procedures must be standardized.

Monitoring exercise level during training

Standardized heart rate test. A simple measure of heart rate (HR) gives an indication of intensity of exercise. It can be used to monitor level of exercise to ensure it is sufficiently vigorous and as a simple test of whether or not the patient's cardiovascular system is adapting to exercise. The target HR is determined using a HR monitor:

Calculate maximum age-predicted HR by subtracting the patient's age from 220
Maximum age-predicted HR = 220 − age

Calculate target HR as between 60 and 80% of maximum age-predicted HR
Target HR range = 60−80% × maximum age-predicted HR

Endurance can be tested specifically for walking by the 6-minute or 12-minute walk tests (Guyatt et al. 1985), in which the distance walked in 6 or 12 minutes is measured.

CONCLUSION

Participation in exercise programmes designed to increase strength and fitness and preserve soft tissue length and flexibility can result in significant improvements in strength, functional motor performance and physical fitness in individuals following stroke. There may be additional benefits in terms of attitude, self-concept, self-efficacy, cognition, and confidence in engaging in physical actions, together with recognition of functional potential and the ability to deal with disabilities more effectively (Mazzeo et al. 1998, Teixeira-Salmela et al. 1999). The regaining of skill in critical tasks requires specific training, with intensive practice of actions in the appropriate contexts. The individual must, however, be fit enough to perform the tasks of daily life.

Mazzeo et al. (1998) in their position paper on exercise in the elderly comment that 'sedentariness' appears a far more dangerous condition than physical activity in the elderly. They point out that a large amount of data dispels myths of futility of exercise and provides reassurance about the safety of exercise in the oldest adults. Following discharge from rehabilitation, the potential for negative effects from immobility and inactivity following stroke should be an ongoing public health issue.

One focus of future research needs to be on the retention of gains after the completion of exercise programmes. It is likely that older individuals with stroke need to continue with both home-based and periodic supervised group exercise in order to retain functional gains and reduce the functional declines associated with ageing. Exercise for this group, as is advocated for the healthy elderly, appears critical to offset loss of muscle mass, improve bone density, decrease likelihood of falls and reduce the risk factors associated with, for example, diabetes and cardiovascular disease.

with post-rehabilitation exercise and training to not only maintain but also to progress their functional abilities and levels of physical fitness. We know from recent studies of individuals post-discharge that many people, even several years after stroke, are able to make positive gains in strength, fitness, endurance and skill. It has been suggested that the stress of adjusting to the major life change caused by stroke itself may interfere with full potential being achieved during initial inpatient rehabilitation. Patients may have increased motivation to improve function once in their home environment, where the impact of limited functional ability becomes more obvious (Tangeman et al. 1990). Without ongoing or 'top-up' exercise programmes to maintain and improve functional ability, however, rehabilitation gains can be lost once the individual is outside the structure of the rehabilitation setting.

Disability has serious consequences beyond physical function. Difficulty performing essential everyday actions can impose continuing physical inactivity and social isolation on disabled individuals, affecting well-being and quality of life. Psychological sequelae may include loss of self-esteem, fear of walking outside the house, or fear of falling. Social consequences may include role losses, isolation and increased demands on caregivers.

As leisure, sport and social activities are important to quality of life they need to be included as an integral part of planning for discharge and to continue beyond discharge. A community-based stroke group can play an important role; for example, the Stroke Recovery Association of Australia is a social and self-help organization for stroke persons and their families. Weekly group meetings organized by members at different locations offer a rewarding experience for people who have had a stroke, providing emotional support and assisting in the transition back into the community, and in some cases offering a weekly exercise group.

Recent evidence of the effectiveness of task-oriented training and muscle strengthening is promising. It is very likely that an increased understanding of human movement and of the effects of training in a stimulating and challenging environment will begin to give a clearer picture of the potential for brain reorganization and functional recovery after an acute brain lesion.

PHYSIOTHERAPY

Stroke Rehabilitation by Janet Carr and Roberta Shepherd

The last decade has seen rapid progress in the treatment and rehabilitation of stroke patients. This long-awaited guide covers essential task- and context-specific exercises and training regimes for optimal functional recovery. Based on scientific rationale and the latest clinical research, this book emphasises the training of effective functional motor performance using methods that both provide a stimulus to the acquisition of skill and increase strength, endurance and fitness.

This book includes guidelines for:

- training balance
- reaching and manipulation
- walking
- sitting-to-standing
- strength training

Written by two acknowledged experts in their field, *Stroke Rehabilitation* presents Carr and Shepherd's internationally respected system of stroke rehabilitation. The authors have applied scientific findings to clinical practice and have written in an accessible style to ensure maximum clarity and practicality.

An indispensable volume for physiotherapists, occupational therapists and all those involved in the rehabilitation of patients with stroke.

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