Stroke Care 2

Stroke rehabilitation

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Stroke is a common, serious, and disabling global health-care problem, and rehabilitation is a major part of patient care. There is evidence to support rehabilitation in well coordinated multidisciplinary stroke units or through provision of early supported provision of discharge teams. Potentially beneficial treatment options for motor recovery of the arm include constraint-induced movement therapy and robotics. Promising interventions that could be beneficial to improve aspects of gait include fitness training, high-intensity therapy, and repetitive-task training. Repetitive-task training might also improve transfer functions. Occupational therapy can improve activities of daily living; however, information about the clinical effect of various strategies of cognitive rehabilitation and strategies for aphasia and dysarthria is scarce. Several large trials of rehabilitation practice and of novel therapies (eg, stem-cell therapy, repetitive transcranial magnetic stimulation, virtual reality, robotic therapies, and drug augmentation) are underway to inform future practice.

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This is the second in a **Series** of two papers about stroke care

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Introduction

Stroke is a global health-care problem that is common, serious, and disabling.[1] In most countries, stroke is the second or third most common cause of death and one of the main causes of acquired adult disability.[1–3] Because most patients with stroke will survive the initial illness, the greatest health effect is usually caused by the long-term consequences for patients and their families. The prevalence of stroke-related burden is expected to increase over the next two decades. Although impressive developments have been made in the medical management of stroke, without a widely applicable or effective medical treatment most post-stroke care will continue to rely on rehabilitation interventions.[4]

In this Review, we focus mainly on the evidence underlying stroke rehabilitation, including the principles of rehabilitation practice, systems of care, and specific interventions. We also discuss the effects of interventions for stroke-related impairment and disability. Questions about these issues are the most common ones that are posed by clinicians.[5] Most research of stroke rehabilitation has been about the effect of interventions on recovery in different forms of impairment and disability. Our emphasis on randomised trials and systematic reviews is particularly important in stroke, for which variable and spontaneous recovery is an important confounder of rehabilitation interventions in observational studies in the first 3 months after stroke.[6]

Classification of the effect of stroke

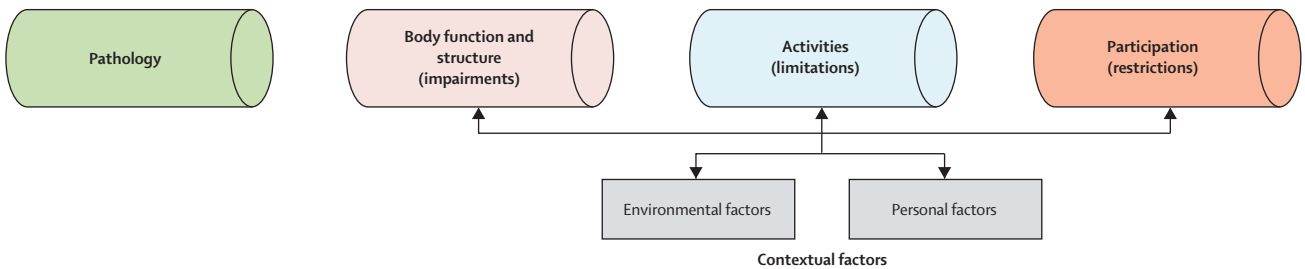
Disabling disorders such as stroke can be classified within WHO's international classification of function, disability, and health,[7] which provides a framework for the effect of stroke on the individual (figure 1) in terms of pathology (disease or diagnosis), impairment (symptoms and signs), activity limitations (disability), and participation restriction (handicap).

Stroke recovery is heterogeneous in its nature. The long-term effect of stroke is determined by the site and size of the initial stroke lesion and by the extent of subsequent recovery (figure 2). Recovery is a complex process that probably occurs through a combination of spontaneous and learning-dependent processes, including restitution (restoring the functionality of damaged neural tissue), substitution (reorganisation of partly-spared neural pathways to relearn lost functions), and compensation (improvement of the disparity between the impaired skills of a patient and the demands of their environment).[8] Although patient outcome is heterogeneous and individual recovery patterns differ, several cohort studies[8,9] suggest that recovery of body functions and activities is predictable in the first days after stroke.

Search strategy and selection criteria

We searched the Cochrane Library from first publication to October, 2010, with the search terms "stroke" and "rehabilitation" and various topic-specific terms. We also searched the Cochrane Stroke Group section of the Cochrane Library, which contains more than 137 reviews and protocols (reviews under development) of which 39 completed reviews and 13 protocols were directly relevant to this Review. If a Cochrane systematic review was identified that fully covered the intervention of interest, further searches were not done. If the review identified did not cover all topics of interest, further searches were done with the Database of Abstracts of Reviews of Effectiveness. In addition to seeking systematic reviews and randomised trials, we also sought to access the most up-to-date recommendations from clinical practice guidelines because such guidelines show a more consensual analysis of the evidence. We specifically sought guidelines that have been published in the past 2 years from the UK, USA, Australia, and Europe. We used the evidenced-based review of stroke rehabilitation website to cross-reference our findings with current evidence to ensure that no major topics were overlooked.

For the **stroke rehabilitation website** see http://www.ebrsr.com



Most relevant categories that are affected after stroke

Ischaemic stroke (about 80%)
Syndrome classified according to the Oxfordshire Community Stroke Project classification

Haemorrhagic stroke (about 15%)
- Intracerebral (about 10%)
- Subarachnoid (about 5%)

Not otherwise specified (about 5%)

Most relevant body functions affected
- Consciousness orientation and intellectual
- Temperament and personality
- Energy and drive
- Sleep, attention, and memory
- Psychomotor and perceptual
- Cognitive and seeing
- Proprioception and touch
- Voice and articulation
- Ingestion, defecation, urinary, and sexual
- Mobility and stability of joints
- Muscle power, tone, and reflexes
- Muscle endurance
- Control of (in)voluntary movement
- Gait pattern functions

Most relevant structures affected
- Brain
- Cardiovascular system
- Leg and arm
- Shoulder region

Most relevant activities affected
- Communicating with and speaking
- Reading, writing, and calculating
- Solving problems
- Undertake single and multiple tasks
- Transferring oneself
- Maintaining body position
- Walking
- Mobility
- Toileting
- Dressing
- Moving around, driving, and transportation
- Washing and self-care
- Hand and arm use
- Eating and drinking
- Preparation of meals
- Use of transportation
- Recreation and leisure
- Doing housework

Most common affected contextual factors (environmental and personal)
- Technology and products for personal use
- Health professionals
- Health services, system, and policies
- Products or substances for personal communication
- House services, systems, and policies
- Support and relationships

Most relevant restrictions in participation
- Acquisition of goods and services
- Doing housework
- Preparation of meals
- Basic interpersonal
- Recreation and leisure activities
- Remunerative employment

Classification of commonly used scales for outcome

Diagnostics
- CT or MRI scan (with or without contrast)
- Doppler
- Electrocardiogram

Examinations
- History from patient and family
- Clinical examination
- Fundoscopic examination
- Auscultation
- Blood analysis (including pressure)

Body structure (impairments)

Neurological scales
- Glasgow coma scale
- Mini mental state examination
- National Institutes of Health stroke scale
- Scandinavian stroke scale
- Canadian neurological scale

Other scales used by the stroke team
- Cumulative illness rating scale
- Bells and star cancellation tests
- Western aphasia battery
- Ontario Society of Occupation Therapists perceptual evaluation
- Medical Research Council
- Motricity index of arm and leg
- Fugl-Meyer motor assessment
- Motor assessment scale
- Fatigue severity scale
- Hospital anxiety and depression scale
- Hamilton rating scale for depression
- Cambridge cognition examination

Activity (disability)

Global ADL-scales
- Barthel index
- Functional independence measure
- Frenchay activities index
- (modified) Rankin scale

Other scales used by the stroke team
- Trunk control test
- Timed up-and-go
- Berg balance scale
- Rivermead mobility index
- 5 or 10 metre gait speed
- 2 or 6 minute walk test
- Stair climbing test
- Frenchay arm test
- Action research arm test
- Wolf motor function test
- Toronto bed-side swallowing screening test
- American Speech-Language-Hearing Association functional assessment of communication skills

Contextual factors
- Caregiver strain index
- Family assessment device

Participation (handicap)
- Euroqol-5D
- Frenchay activities index
- Nottingham extended activities of daily living
- Nottingham health profile
- General health questionnaire
- Stroke impact profile (stroke adapted version)
- Medical outcome study short form 36
- Stroke-specific quality of life

Figure 1: **The international classification of function, disability, and health framework for the effect of stroke on an individual**
This figure summarises key features of WHO's international classification of function, disability, and health model;[7] the most relevant categories affected after stroke; and examples of measurement scales used in those categories. ADL=activities of daily living.

Rehabilitation after stroke

In this Review we use a broad definition of rehabilitation, including stroke-care interventions, which are selected after a problem-solving process that aims to reduce the disability and handicap resulting from a stroke.

Stroke rehabilitation typically entails a cyclical process[1] involving: (1) assessment, to identify and quantify the patient's needs; (2) goal setting, to define realistic and attainable goals for improvement; (3) intervention, to assist in the achievement of goals; and (4) reassessment, to assess progress against agreed goals. The most widely recognised impairment caused by stroke is motor impairment, which restricts function in muscle movement or mobility.[10] Other common impairments include those of speech and language, swallowing, vision, sensation, and cognition. Although there seems to be a moderate non-linear relation between impairment and function, particularly for motor impairment,[8,9,11] evidence of impairment-focused therapies enhancing true neurological repair in the human brain is still scarce. By contrast, strong evidence shows that task-oriented training can assist the natural pattern of functional recovery, which supports the view that functional recovery is driven mainly by adaptive strategies that compensate for impaired body functions.[8,11,12] Therefore, most rehabilitation interventions seem to work best at the level to which they are targeted (panel 1).[8]

Challenges in evidence-based stroke rehabilitation

Stroke rehabilitation presents specific challenges for research and for the application of evidence-based practice. First, although learning of skills and theories of motor control are crucial to many rehabilitation interventions,[12] the neurophysiology underpinning stroke rehabilitation is often poorly established. Second, interventions tend to be complex and contain several interrelated components.[13] Third, treatments might target several different problems from relieving very specific impairments to improving activity and participation.[14] Interventions can occur at different points on a continuum of complexity ranging between highly complex treatments (panel 2) and specific treatments (panel 3).

Highly complex treatments include interventions that are provided by more than one individual or by a single operator (eg, a therapist or nurse). They comprise either a complex package of treatment (eg, rehabilitation teams), which is tailored to suit individual problems, or other rehabilitation principles, such as goal setting. Specific treatments comprise the assessment of individual reproducible interventions, which are usually targeted at specific stroke-related impairments—eg, constraint-induced movement therapy and treadmill gait-retraining for walking. Although these treatments are not simple, they can be regarded as less complex.

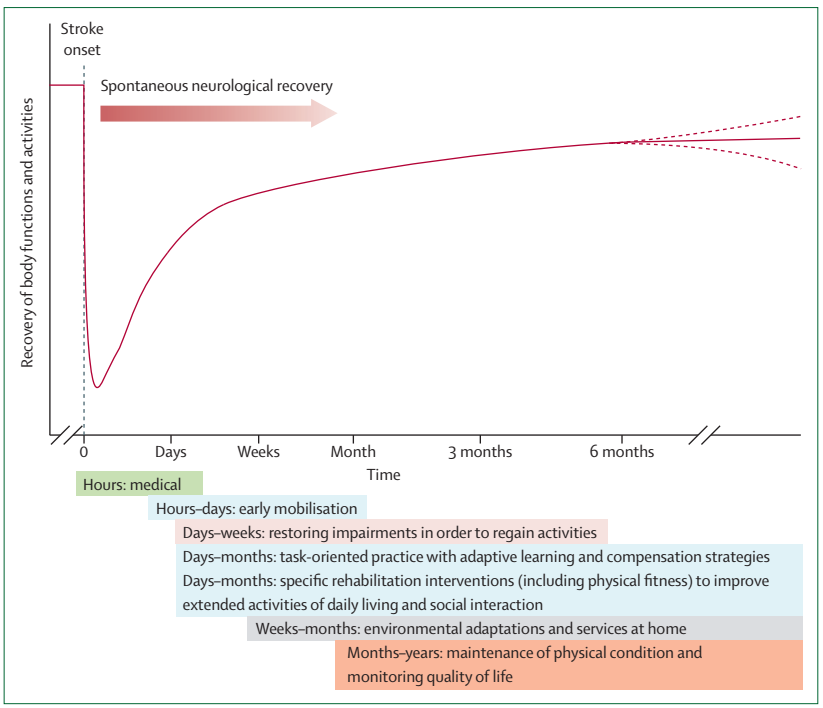


Figure 2: **Hypothetical pattern of recovery after stroke with timing of intervention strategies**
Colour coding of the intervention strategies matches the coding in figure 1.

Principles of stroke rehabilitation

Several general principles underpin the process of stroke rehabilitation, and some have been studied in randomised trials and systematic reviews. Substantial evidence supports multidisciplinary team care as the basis for delivery of stroke rehabilitation.[15,17] Research of integrated care pathways is limited by few randomised trials, suggesting that such formal pathways might be no more effective than care from a well-functioning multidisciplinary team.[24] Good rehabilitation outcome seems to be strongly associated with high patient (and family) motivation and engagement. Setting goals that replicate the specific rehabilitation aims of an individual might improve outcome. Although no extensive published work yet exists for goal setting in stroke,[42] research for other disorders is more widespread.[13]

Task-specific and context-specific training are well accepted principles in motor learning, which suggests that training should target the goals that are relevant for the needs of patients. Additionally, training should be given preferably in the patient's own environment (or context). Both learning rules are supported by various systematic reviews, which indicate that the effects of specific interventions generalise poorly to related tasks that are not directly trained in the programme.[54,81,82]

Several systematic reviews have explored whether high-intensity therapy improves recovery.[5,56,57] Although there are no clear guidelines for best levels of practice, the principle that increased intensive training is helpful is widely accepted.[46] Agreement is widespread that

rehabilitation should begin as soon as possible after stroke,[68] and clinical trials of early commenced mobility and speech interventions are underway. Recovery can continue for months or years after stroke—well beyond the formal rehabilitation period. How best to support survivors once they stop accessing formal services is of great importance. A systematic review[83] of education programmes for self-management in a general population has shown positive benefits, but no stroke-specific reviews were identified.

Complex systems of care

Organised inpatient (stroke-unit) care

Panel 2 summarises evidence for complex rehabilitation interventions. Stroke rehabilitation occurs in specific systems of care many of which have been assessed in randomised trials and systematic reviews to form the basis of service planning. A package of rehabilitation in an organised multidisciplinary stroke unit results in more patients surviving, returning home, and regaining independence in daily activities than does rehabilitation in general wards. Good descriptions indicate which features of these services seem to be important,[15] including the presence of a multidisciplinary team (medical, nursing and physiotherapy, occupational therapy, speech therapy, and social-work staff) who coordinate their work through regular meetings. Patients with stroke of varying ages and severity of symptoms seem to benefit from care in the stroke unit.[16]

Meetings with multidisciplinary teams introduce the patients to the team and provide a forum for multidisciplinary assessment, identification of problems,

Panel 1: **Description of rehabilitation terminology[10]**

Principles of rehabilitation

- Goal setting: establishment of specific, measurable, and time-dependent recovery goals to guide management.
- High-intensity practice: increased therapy or intervention.
- Multidisciplinary team care: a team of medical, nursing, therapy, and social-work staff who provide rehabilitation input and coordinate their work with regular meetings.
- Task-specific training: rehabilitation approaches where specific functional tasks are practised repeatedly.

Complex rehabilitation interventions

- Cognitive rehabilitation interventions: interventions addressing cognitive impairments (usually provided by occupational therapists or clinical psychologists).
- Early supported discharge service: service that aims to allow for an early hospital discharge and for the provision of multidisciplinary rehabilitation at home.
- Integrated-care pathways: formal documented care plan to promote coordinated and efficient interdisciplinary patient care.
- Multidisciplinary stroke unit: hospital ward in which patients with stroke are looked after by a specialist multidisciplinary stroke team who coordinate their work through regular meetings.
- Outpatient rehabilitation service: rehabilitation service provided through a clinic, day hospital, or in patients' homes to patients who live at home.
- Occupational therapy interventions: interventions provided by occupational therapists (usually aimed at improving activities of daily living, occupation, and leisure activity).
- Physiotherapy interventions: interventions provided by physiotherapists (usually aimed at balance, gait, and movement).
- Interventions for speech and language therapy: interventions provided by speech and language therapists (usually aimed at improving language, communication, or swallowing abilities).
- Services with stroke liaison workers: a multifaceted service, which is usually provided by a health-care or social-care worker typically including more than one of social support, education, and information provision and liaison with other services.
- Therapy-based rehabilitation service: service provided by physiotherapists, occupational therapists, or multidisciplinary team containing those disciplines.

Specific rehabilitation treatments

- Ankle-foot orthosis: device to reposition and support a foot that is affected by neuromuscular impairment, such as foot drop.
- Behavioural therapies for urinary incontinence: behavioural interventions (eg, timed voiding and training for pelvic-floor muscles) to reduce the severity of urinary incontinence.
- Bilateral arm training: training involving use of both arms for identical activities in a simultaneous but independent manner.
- Biofeedback—force and position feedback: special force sensors on a force platform can measure the weight under each foot and the centre of pressure of the body. Information (feedback) about the weight distribution between the legs and the centre of pressure can be provided to the patient with visual or auditory feedback.
- Constraint-induced movement therapy: involves many repetitions of task-specific training of the affected limb with restraint of the unaffected limb.
- Electromyographic biofeedback: the use of external electrodes that are applied to muscles to capture electrical potentials of motor units. Instrumentation converts the recorded potentials into visual or auditory information.
- Electromechanical-assisted gait training: electromechanical devices (eg, robot-driven orthoses, driven foot plates) are used to give non-ambulant patients intensive gait training.

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- Electrostimulation: electrostimulation is delivered to the peripheral neuromuscular system by internal or external electrodes.
- Fitness training or physical fitness training: physical fitness training is a planned, structured regimen of regular physical exercise to improve physical fitness. Regimens aim to improve or maintain either cardiorespiratory fitness, or strength and muscular endurance.
- High-intensity therapy: an increased amount of focused therapy compared to another reference group.
- Mental practice with motor imagery: mental practice of a physical action that aims to improve movement.
- Mirror therapy: use of a mirror alongside the unaffected limb so that the mirror image seems to be the affected limb.
- Moving platform training: standing on a moving platform allows patients to practise responding to movements.
- Music therapy: use of music to enhance recovery (can target several areas of recovery).
- Repetitive task training: repeated practice within a single training session of an active motor sequence that is aimed towards a clear functional objective.
- Rhythmic gait cueing: use of auditory cueing (eg, metronome) or visual cueing (eg, visual indicator) to give a rhythmical input to improve the timing of movement.
- Robotics: robotic devices can allow repetitive, interactive, high-intensity, task-specific treatment of a limb.
- Splinting or orthosis: external removable devices that can be used to improve functional movement, reduce spasticity and pain, or prevent contracture, overstretching, and oedema.
- Strength training: progressive resistance exercises aiming to improve muscle strength.
- Treadmill training plus bodyweight support: walking on a treadmill with a harness to support some bodyweight can increase the amount of practice that can be done.
- Walking aids: walking aids, including canes, crutches, walking frames, and 3-point or 4-point sticks, which aim to improve balance and stability during walking and standing.
- Seating and positioning policies: policies to encourage the optimum approaches for body positioning.

Specific therapy approaches

- Mixed approach: uses treatment components from various theoretical approaches.
- Motor learning or movement science: based on knowledge of learning (movement science) from both people who are healthy and those who are brain injured. Focuses on context-specific learning with feedback and practice.
- Neurophysiological: therapeutic approaches based on neurophysiological theories—eg, the Bobath approach.

establishment of short-term and long-term rehabilitation goals, and decision making. Stroke units usually have a programme of ongoing education and training and typically include early involvement of carers in the rehabilitation process.[15]

Early supported discharge teams

In the past 15 years, clinical trials have explored whether the discharge of patients with stroke from hospital can be accelerated and an equivalent programme of rehabilitation provided in their home settings—early supported discharge. Such services have resulted in patients returning home earlier with a reduced need for long-term institutional care and an increased likelihood of regaining independence in daily activities.[17] Evidence suggests that these services should be provided by skilled multidisciplinary teams whose work is coordinated by regular meetings.[18] Services seem to be most effective for a subgroup of patients with mild to moderate disability;[17,18] however, effective implementation of early supported discharge services is complicated because of their potential interaction with existing services.

Therapy-based rehabilitation at home

Therapy from a physiotherapist, occupational therapist, or multidisciplinary team in patients with stroke who live at home could prevent deterioration in activities of daily living,[19] although the absolute effect was modest. There was no clear information on the optimum intensity of such an intervention. Trials of occupational therapy have made the greatest contribution to this analysis. Findings from a meta-analysis[23] showed that occupational therapy services at home that were delivered within 1 year of stroke improved both activities of daily living and extended activities of daily living. However, a related review[21] of late interventions (more than 1 year after stroke) recorded insufficient evidence to establish the effect of such services.

A further question about outpatient rehabilitation is whether it can be best provided in day hospital services (in facilities that patients attend during the day) or in the patient's home.[20]

Other systems of care

A review[21] of several trials that have examined the effect of rehabilitation of elderly patients (many with stroke-related disability) in long-term care facilities showed that provision of interventions for physical rehabilitation could be safe and might improve independence. Furthermore, trials of services with stroke liaison workers—which incorporate interventions by a stroke nurse, social worker, or other health professional to assist with information provision, problem solving, and reintegration to normal living—have scored well on several aspects of satisfaction. However, none has shown

Panel 2: **Summary of evidence for complex rehabilitation interventions (delivered by a service or therapist) and their recommendation in clinical guidelines**

Beneficial or likely to be beneficial

- Multidisciplinary stroke-unit care to improve independence;[15,16] recommended (A)
- Early supported discharge services to improve independence;[17,18] recommended (A)
- Therapy-based rehabilitation services at home (within 1 year of stroke) to improve ADL;[19] recommended (A,B)
- Outpatient (day-hospital, community team) rehabilitation services to improve ADL;[20] selected use (A,B)
- Rehabilitation services in long-term care settings to improve ADL;[21] not mentioned or selected use (B)
- Occupational therapy services to improve ADL;[22] recommended (A,B)
- Occupational therapy services at home to improve ADL and extended ADL;[23] recommended (A)

Uncertain benefit

- Integrated-care pathways to improve independence;[24] not recommended or selected use (B)
- Services with stroke liaison workers to improve independence and participation;[25] not mentioned
- Information provision to improve knowledge and independence;[26] recommended (A)
- Therapy-based rehabilitation services at home (after 1 year) to improve ADL;[27] selected use (B,C)
- Speech and language therapy interventions for aphasia;[28,29] recommended (B)
- Speech and language therapy interventions for dysphagia;[30,31] recommended (B)
- Staff-led training interventions to improve oral hygiene;[32] not mentioned or selected use (B)
- Cognitive rehabilitation for spatial neglect;[33] not mentioned or selected use (B)

Unknown effect

- Cognitive rehabilitation for attention deficits;[34] not mentioned or selected use (B)
- Cognitive rehabilitation for memory deficits;[35] not mentioned or selected use (C)
- Cognitive rehabilitation for motor apraxia;[36] not mentioned or selected use (B,C)
- Interventions for perceptual disorders;[37] not mentioned or selected use (C)
- Occupational therapy for cognitive impairment;[38] not mentioned or selected use (C)
- Home-based intervention for arm recovery;[39] not mentioned
- Speech and language therapy for speech apraxia;[40] recommended (C)
- Speech and language therapy for dysarthria;[41] recommended (C)
- Goal setting in rehabilitation to improve recovery;[42] not mentioned or recommended (C)
- Behavioural therapies for urinary incontinence;[43] recommended (C)
- Pre-discharge home assessments;[44] selected use (C)

Guideline recommendation categories:[45–48] recommended=recommended use for a substantial proportion of stroke patients; selected use=might be considered in selected patients or circumstances, not mentioned=no specific recommendation made; not recommended=not recommended for routine use (outside the context of a clinical trial). Guideline grade of recommendation categories: (A)=based on robust information from randomised trials that is applicable to the target population; (B)=based on less robust information (from experimental studies); (C)=consensus or expert opinion. ADL=activities of daily living.

substantial effect in recovery of activities of daily living or subjective health status.[25] Occupational therapy has been shown to increase the chances of patients regaining independence in activities of daily living and extended activities of daily living (panel 1).[35,19]

Information provision to patients and caregivers

A Cochrane review of 17 trials recorded some evidence to support the routine provision of information to patients with stroke and their families, resulting in improved knowledge and reduced scores for patient depression.[20] Strategies involving patients and caregivers seemed to be the most effective, although the best way to provide information is not known.

Specific interventions

Motor impairment

Panel 3 summarises evidence for specific rehabilitation treatments. 19 categories of intervention have been identified from systematic reviews or randomised trials.[10] Panel 1 outlines some of the main approaches that have been described and panel 3 shows the related evidence. Bilateral training,[64] constraint-induced movement therapy at modified doses,[49] electrical stimulation,[53] high-intensity therapy,[10] repetitive task training,[63] robotics,[59] and splinting[71] have all been tested to improve hand function; however, none has shown consistent improvement. Different treatment approaches have been tested to improve arm function,[70] including bilateral training, modified constraint-induced movement therapy, electromyographic biofeedback,[54] electrical stimulation, high-intensity therapy, mental practice,[52] repetitive task training, robotics, mirror therapy,[65] and splinting or orthosis.[71] Constraint-induced movement therapy incorporating modified therapy, robotics, and possibly mental practice[52] was shown to be beneficial in improving arm function (at least within the selected populations studied). Repetitive task-specific training, electromyographic biofeedback, high-intensity therapy, mirror therapy, and electrical stimulation had an uncertain benefit on recovery.

Although many of these conclusions are based on small patient numbers, the conclusions for constraint-induced movement therapy (including the modified form) seemed to be robust, at least for studies that started after the first months of stroke. A major challenge with constraint-induced movement therapy is that trials focused on selective populations (in particular those with some preservation of wrist and finger extension who were able to tolerate periods of constraint). Studies of bilateral arm training and mirror therapy have been limited by small numbers of controlled studies with few participants. Interventions for biofeedback[55] and repetitive task-specific training to improve sit-to-stand function have been tested for their effect on sit-to-stand ability. Task-specific training might improve such function. Furthermore, several trials have tested biofeedback, moving-platform feedback,[66] and repetitive task training to improve aspects of standing balance. Biofeedback with a force plate or a moving platform seemed to show improvement in stand symmetry alone, and interventions with repetitive task training showed general patterns of benefit.[65]

Mixed cardiorespiratory and strength training and circuit-class training[50–57] have proved effective for improving physical fitness and mobility for patients with moderate stroke. Furthermore, beneficial effects have been recorded for high-intensity therapy, repetitive task training, and

Panel 3: Summary of the evidence for specific rehabilitation treatments

Beneficial or likely to be beneficial

Arm

- CIMT or modified CIMT for arm impairment and motor function;[10,49] selected use (A,B)
- Robot-assisted training for upper limb function;[10,50] selected use (A,B)

Leg

- Electromechanical-assisted gait training for walking;[10,51] selected use (B)
- Task-oriented physical fitness training for walking;[52–54] recommended (A)
- Cardiorespiratory fitness training for walking distance;[55] recommended (A)
- High-intensity therapy for gait recovery;[10,56] recommended (B)
- Repetitive task training for gait speed and transfers;[57] recommended (A,B)
- Speed-dependent treadmill training for gait speed and walking distance;[58] selected use (A,B)

Uncertain benefit

Arm

- Bilateral training for motor function of arm;[59] not mentioned or selected use (B)
- Mental practice for arm function;[60] selected patients (B,C)
- High-intensity therapy for arm function;[8] not recommended or recommended (B)
- Repetitive task training for arm function;[8,57] not recommended or recommended (B)
- Electrostimulation for arm function;[8,61] not mentioned, not recommended, or selected use (B)
- Electromyographic biofeedback for arm function;[62] not recommended or selected use (A,B)
- Mirror therapy for arm (or leg) impairment;[63] selected use (A,B)
- CIMT or modified CIMT for hand function;[10,49] selected use (A,B)
- EMG biofeedback for hand function;[62] not mentioned or not recommended (B)
- Electrostimulation for hand function;[10,61] not mentioned or not recommended (B)
- Robotics for hand function;[10,50] selected use (B)

Leg

- External (auditory) rhythmic gait cueing to improve walking;[10,64] not mentioned or selected use (B)
- Biofeedback (force and position) for balance or leg function;[10,65] not recommended or selected use (B)
- Moving platform for balance or leg function;[10,66] not mentioned or selected use (B)
- Treadmill training and bodyweight support for gait for mobile patients;[67] selected use (B)
- Very early mobilisation for mobility;[68] recommended (B)
- Leg-strengthening programmes for gait;[69,70] selected use (B)
- Ankle-foot orthosis for foot drop;[71] selected use (B)
- Functional electrical stimulation for foot drop;[72] selected patients (B,C)

Other

- Specific therapy approaches (Bobath, motor relearning, mixed);[73] no recommended approach (A)

Unknown effect

Arm

- Splinting or orthoses for arm function;[74] not recommended (B,C)

Leg

- Walking aids for gait;[8] recommended (B,C)
- Interventions for motor apraxia;[75] not mentioned
- Seating and positioning policies;[76] recommended (B,C)

Other

- Interventions for visual field impairments;[77] not mentioned or selected use (B,C)
- Treatments for sensory impairments[78] not mentioned or selected use (B,C)
- Acupuncture for stroke recovery[79] not mentioned or not recommended (B)
- Music therapy for stroke recovery[80] not mentioned

Guideline recommendation categories:[45–48] recommended=recommended use for a substantial proportion of stroke patients; selected use=might be considered in selected patients or circumstances; not mentioned=no specific recommendation made; not recommended=not recommended for routine use (outside the context of a clinical trial). Guideline grade of recommendation categories: (A)=based on robust information from randomised trials that is applicable to the target population; (B)=based on less robust information (from experimental studies); (C)=consensus or expert opinion. CIMT=constraint-induced movement therapy.

electromechanical gait training. Uncertain benefits were noted for rhythmic auditory stimulation of gait[75] and leg-strengthening programmes.[67,68] However, the conclusions of these reviews could be overturned by a relatively small number of neutral studies. Although bodyweight-supported treadmill training showed uncertain benefit,[76] overground-walking training for patients with mobility deficits[75] and speed-dependent treadmill training as a form of physical fitness training might improve aspects of gait.[51] Ankle-foot orthoses might also improve gait performance and reduce energy expenditure with gait in patients who have persistent foot drop.[58]

Cognitive and other impairments

Of reviews that have addressed the effect of various interventions of cognitive rehabilitation (mainly compensatory strategies) in attention deficits,[30] memory deficits,[31] spatial neglect,[22] and perceptual disorders[23] evidence has indicated that training can improve alertness and attention span for patients with attention deficit. However, little is known about the effect of memory rehabilitation or interventions for perceptual disorders on recovery after stroke. Although cognitive rehabilitation interventions for spatial neglect (visual scanning training, compensatory strategies, prisms) might improve test

performance, less data are available for the effect on activities of daily living and independence.[22] Evidence is scarce about the effectiveness of motor apraxia for reducing disability.[39]

Several studies[21,37] have reviewed apraxia of speech[33] and speech and language therapy for aphasia and dysarthria[41] after stroke; however, no clear conclusions have yet been made. Common practice would be to provide early, intensive input from a trained speech and language therapist who would provide several strategies to improve language and communication. For the management of dysphagia in acute stroke, some evidence[30,31] shows that specific swallowing therapy (compensatory strategies and texture modification) might improve early recovery of feeding and might prevent chest infection.

Studies have also investigated specific interventions for improving sensory impairment,[78] visual impairment (eg, haemianopia, diplopia, and nygstagmus) with compensatory techniques and prisms for field defects,[77] and incontinence (bladder retraining, pelvic-floor exercises, and continence aids), but evidence shows uncertain benefit and information is insufficient to guide practice.

Novel therapies

Several novel therapies are being developed and tested, including stem-cell therapy,[84] repetitive transcranial magnetic stimulation and transcranial direct-current stimulation,[85] motor imagery,[86] virtual reality,[87] novel robotic therapies,[59] drug augmentation of exercise training with amphetamines,[88] dopamine agonists, and antidepressants. These interventions are typically combined with traditional task-specific training and trials. Although these interventions are not yet known to improve functional outcome, major developments in these areas of combined therapies are likely to be seen.

Conclusions

Major advances have occurred in the past 20 years in the development and testing of interventions for stroke rehabilitation, but there are many gaps and shortcomings in the evidence base to inform clinical practice. Therefore, for the foreseeable future many clinical decisions will continue to rely on the knowledge and judgment of individual health professionals. Although improvements in management have been noted, research is still needed to clearly define the effect of specific rehabilitation interventions in a routine clinical setting. The mechanisms that drive recovery of impairments and disabilities, and their associated time limitations, need to be better understood than they are now. Although animal models of neuroplasticity suggest that training results in an upregulation of growth-promoting factors mostly in the first 4 weeks after stroke,[12] this process needs to be further explored in human beings. What patients actually learn during functional recovery in terms of restitution of impairments and learning adaptive strategies should also be further explored.

There is an absence of consistency between researchers and clinicians in the use of terminology that describes changes in motor ability after stroke. Recovery is a dynamic process that cannot be encapsulated at one timepoint. New interventions should be developed that expand on a valid biological construct after a standardised staging approach,[13] including dose-ranging studies that are often missing in rehabilitation research. Task and context specificity should be understood to overcome problems of poor transfer from one task to another. Trials will need to clearly define the target populations and rehabilitation interventions because no individual treatment is likely to be applicable to every patient. Furthermore, large clinical trials that have applied proper methodology with sufficient statistical power to avoid false-positive results should be developed. Increased cooperation is needed between researchers during the design phase, which ideally would include a core set of outcomes and standardised interventions to allow for future meta-analysis. The implementation of complex interventions in a routine clinical setting, including potential barriers, should be better understood because many effective interventions do not reach the clinic. The substantial growth in the number of clinical trials of rehabilitation in the past 10 years shows the increased interest of rehabilitation clinicians in evidence-based care and the success of the development of research capacity across the many groups of health professionals who deliver rehabilitation to people with stroke.

Ongoing trials of repetitive task training, early mobilisation, treadmill training, physical fitness training, and speech and language training for aphasia and dysarthria are high-quality, multicentre, multidisciplinary studies of complex interventions, which meet many of the above recommendations. The results of these trials will hopefully provide better information to guide future practice.

Contributors

All authors did the literature search, interpretation, and writing of the Review. PL provided the first draft of the Review.

Conflicts of interest

PL has received honoraria and travel expenses for educational conference sessions run by Sanofi-Aventis and Boehringer Ingelheim, grant support from The Stroke Association and Chest, Heart and Stroke, Scotland, and royalties from Wiley. JB and GK declare that they have no conflicts of interest.

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