CHAPTER

2

A framework for physiotherapy management

Contents

The overall purpose of physiotherapy for patients with spinal cord injury is to improve health-related quality of life. This is achieved by improving patients' ability to participate in activities of daily life. The barriers to participation which are amenable to physiotherapy interventions are impairments that are directly or indirectly related to motor and sensory loss. Impairments prevent individuals from performing activities such as walking, pushing a wheelchair and rolling in bed. During the acute phase, immediately after injury when patients are restricted to bed, the key impairments physiotherapists can prevent or treat are pain, poor respiratory function, loss of joint mobility and weakness (see Chapters 8–11). Once patients commence rehabilitation physiotherapists can also address impairments related to poor skill and fitness (see Chapters 7 and 12).

It is possible to define the role and purpose of physiotherapy for patients with spinal cord injury within the framework of the International Classification of Functioning, Disability and Health (ICF). The ICF was introduced by the World Health Organization in 2001[1] and is a revised version of the International Classification of Impairment, Disability and Handicap.[2] The ICF defines components of health from the perspective of the body, the individual and society (see Figure 2.1). One of its primary purposes is to provide unified and standard language for those working in the area of disability.[1,3]

The ICF can be used to articulate the goals and purpose of physiotherapy for patients with spinal cord injury. For example, the health condition is spinal cord injury. An associated impairment is poor strength. Poor strength directly impacts on the ability to perform activities such as walking and moving. This in turn has implications for participation, such as working, engaging in family life and participating in community activities. Impairments, activity limitations and participation restrictions are all affected by environmental and personal factors, such as support from family and employers, access to appropriate equipment, financial situation and coping mechanisms. In the ICF framework, such environmental and personal influences are termed contextual factors.

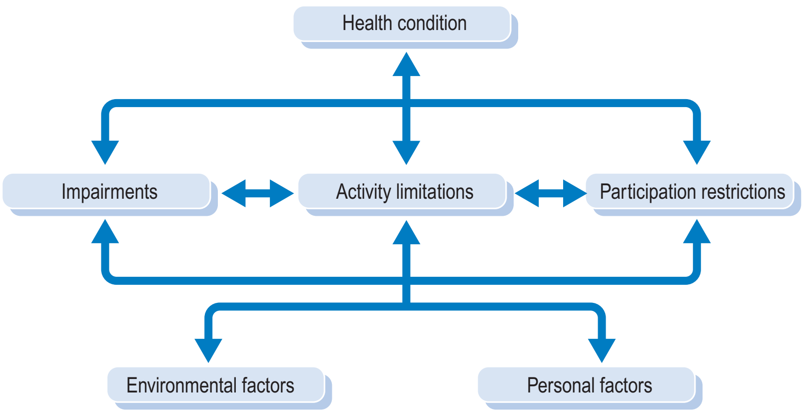

Figure 2.1 The ICF framework. Reproduced with permission from World Health Organization: International Classification of Functioning, Disability and Health: ICF short version. Geneva, World Health Organization, 2001.

The ICF framework can also be used to describe the process involved in formulating a physiotherapy programme. The process involves five steps:

Step one: assessing impairments, activity limitations and participation restrictions
Step two: setting goals with respect to activity limitations and participation restrictions
Step three: identifying key impairments
Step four: identifying and administering treatments
Step five: measuring outcomes

Each of these steps is described in this chapter and provides the framework for formulating physiotherapy programmes. The focus is primarily on patients undergoing rehabilitation. In the period immediately after injury when patients are restricted to bed it is not feasible to assess activity limitations and participation restrictions, and it may not be appropriate to set goals in these domains.

Step one: assessing impairments, activity limitations and participation restrictions

Assessment is the first step in devising an appropriate physiotherapy programme. The assessment forms the basis of the goal-setting process. It identifies participation restrictions, activity limitations, and impairments.

Initially, various sources need to be used to extract details such as age, cause of injury, time since injury, neurological status, orthopaedic status, other injuries and complications, socio-economic background, medical and surgical management since injury, prior medical history, family support, employment status and living arrangements. These provide key insights into patients' problems, and help direct the subsequent physical assessment.

Assessing activity limitations and participation restrictions

There are several well-accepted assessment tools used to measure activity limitations and participation restrictions,[4,5] including the Functional Independence Measure (FIM®),[6–8] Spinal Cord Independence Measure,[9–11] and Quadriplegic Index of

Function[12–14] (see Table 2.1). They all measure independence across a range of domains, reflecting different aspects of activity limitations and participation restrictions. For example, they assess ability to dress, maintain continence, mobilize, transfer and feed. Some have been specifically designed for patients with spinal cord injury, and others are intended for use across all disabilities.

More physiotherapy-specific assessments of activity limitations and participation restrictions quantify different aspects of mobility and motor function. For example, some assess the ability to walk (e.g. the WISCI, 10 m Walk Test, the Motor Assessment Scale, 6-minute Walk Test, Timed Up and Go), ability to use the hands (e.g. the Grasp and Release test, Sollerman test, Carroll test, Jebsen test) and ability to mobilize in a wheelchair[15,16] (see Table 2.1). There is as yet no consensus on the most appropriate tests, and currently physiotherapists tend to use a battery of different assessments, including non-standardized, subjective assessments of the way patients move.

TABLE 2.1 **Assessment tools for measuring activity limitations and participation restrictions**

	Brief description
General	
Functional Independence Measure (FIM®)[65,66]	The FIM assesses activity limitations. It contains 18 items across six domains: self-care, sphincter control, transfers, locomotion, communication and social cognition. Each item is scored on a seven-point ordinal scale ranging from total assistance (one) to complete independence (seven).
Spinal Cord Independence Measures (SCIM)[9,10]	The SCIM was developed specifically for patients with spinal cord injury and contains 16 items covering self-care (four items), respiration and sphincter management (four items), and mobility (eight items). The original SCIM was modified in 2001[67] and more recently a questionnaire version has been devised.
Barthel Index[68–72]	The Barthel Index contains 15 self-care, bladder and bowel, and mobility items. Transfers and mobility items (both wheelchair and ambulation) encompass 30%, and toileting and bathing a further 10% of the total score.
Craig Handicap and Reporting Technique (CHART)[73–78]	The CHART was specifically designed for patients with spinal cord injury to measure community integration. It consists of 27 items which cover five domains: physical independence (three questions), mobility (nine questions), occupation (seven questions), social integration (six questions) and economic self-sufficiency (two questions). Each item is assessed on a behavioural criteria (i.e. hours out of bed). It is administered via interview or questionnaire.
Clinical Outcomes Variable Scale (COVS)[79,80]	The COVS consists of 13 items scored on a seven-point scale and measures mobility in activities such as rolling, lying to sitting, sitting balance, transfers, ambulation, wheelchair mobility and arm function. Lower scores reflect poorer levels of mobility. Although originally developed for a general rehabilitation population, COVS discriminates across lesion level, injury completeness and walking status in patients with spinal cord injury.
PULSES[69,81]	The PULSES assesses activity limitation and participation restriction of those with chronic illness and covers six domains: physical condition (P), upper limb function (U), lower limb function (L), sensation (S), excretory function (E) and support factors (S). The scoring for each item ranges from one (independent) to four (fully dependent).

(continued)

TABLE 2.1 **(continued)**

	Brief description
Quadriplegic Index of Function (QIF)[14]	The QIF was specifically designed for patients with tetraplegia. It contains 10 items, three of which encompass mobility (transfers 8%, wheelchair mobility 14% and bed activities 10%). Each item is scored on a five-point scale. There is a shorter form of the original QIF.
The Katz Index of ADL[82]	The Katz Index of ADL assesses independence in six activities including bathing, dressing, toileting, transferring, continence and feeding. Each activity is scored on a two-point scale, and summated into an overall score (represented by letters from A to G). There are no mobility items.
SF-36® Health Survey[83,84]	The SF-36 measures health-related quality of life in eight domains (physical functioning, role limitations due to physical problems, bodily pain, general health, vitality, social functioning, role limitations due to emotional problems, mental health). These can be summarized into two measures (physical and mental). The SF-36 has been used in patients with spinal cord injury.[85–88]
Sickness Impact Profile (SIP-136)[89]	The SIP-136 is a generic measure of the impact of disability on physical status and emotional well-being. It is administered via a 136-item questionnaire which requires 'yes' or 'no' responses. It has 12 domains including mobility and ambulation items. A shorter version (68 items) is also available.[90] It has three main domains including a physical domain which assesses ambulation, mobility and body care.
Canadian Occupational Performance Measure (COPM)[91–94]	The COPM was designed to assess patients' perspectives about changes in activity limitations and participation restrictions. The COPM is administered in a semi-structured interview where patients are required to identify specific activity limitations and participation restrictions. Patients use a 10-point scale to rate each identified problem with respect to importance, performance and satisfaction. The COPM is primarily used to monitor change.
The Physical Activity Recall Assessment for People with Spinal Cord Injury (PARA-SCI)[95,96]	The PARA-SCI is a self-report measure of physical activity. It was designed for patients with spinal cord injury and is administered via a semi-structured interview. The time spent on all physical activities related to leisure and daily living is recorded. Each activity is graded for intensity.
Valutazione Funzionale Mielolesi (VFM)[97,98]	The VFM questionnaire was developed specifically for patients with spinal cord injury to assess activity limitations. It covers bed mobility, eating, transfers, wheelchair use, grooming and bathing, dressing and social and vocational skills.
The Tufts Assessment of Motor Performance (TAMP)[99–101]	The TAMP was developed to measure gross and fine motor performance of the upper and lower limbs. It consists of 105 tasks grouped into 31 domains including fine hand function and independence with dressing, mobility, transfers and wheelchair skills. Each item is rated on a seven-point scale.
Needs Assessment Checklist (NAC)[28]	The NAC was designed specifically for patients with spinal cord injury to measure the success of rehabilitation. It consists of 199 items grouped into nine domains including activities of daily living, skin management, bladder management, bowel management, mobility, wheelchair and equipment, community preparation, discharge coordination and psychological issues. It does not differentiate between the ability to direct others to help and the ability to independently perform activities.

(continued)

TABLE 2.1 **(continued)**

	Brief description
Gait-related	
Walking Index for Spinal Cord Injury (WISCI)[102–104]	The WISCI was developed specifically for patients with spinal cord injury. It measures ability to walk 10 m and need for physical assistance, orthoses and walking aids on an incremental scale ranging from zero (unable to stand or walk) to 20 (ambulates without orthoses, aids or physical assistance).
The Spinal Cord Injury Functional Ambulation Inventory (SCI-FAI)[105]	The SCI-FAI is an observational gait assessment which uses an ordinal scale to rate nine different aspects of walking. It includes a 2-minute walk test.
The Walking Mobility Scale[106–108]	The Walking Mobility Scale is a five-point scale that classifies ability to walk into the following categories: physiological ambulators, limited household ambulators, independent household ambulators, limited community ambulators and independent community ambulators.
Timed Up and Go[109,110]	The Timed Up and Go test measures the time taken to stand up from a chair, walk 3 m, turn around and walk back to sit down on the chair. No physical assistance is given.
10 m Walk Test[65,111,112]	The 10 m Walk Test measures speed of walking ($m.sec^{-1}$). Patients are instructed to walk 14 m at their preferred speed but time is only recorded for the middle 10 m.
6-minute Walk Test[65,113]	The 6-minute Walk Test is a measure of endurance. Patients are instructed to walk as far as possible in 6 minutes, taking rests whenever required. The distance covered and the number of rests required are recorded.
Functional Standing Test (FST)[114]	The FST measures patients' ability to reach while standing. It consists of 20 items requiring manipulation and lifting of different objects. Orthoses can be worn and the tasks are done as quickly as possible. Some of the tasks are from the Jebsen Test of Hand Function.[115]
Modified Benzel Classification[116]	The Modified Benzel Classification is a seven-point scale that classifies patients according to both neurological and ambulatory status. Neurological classification is based on ASIA and ambulatory classification is crudely based on key gait parameters including ability to walk 25–250 feet (~ 7–75 m).
Upper limb function	
Capabilities of Upper Extremity Instrument (CUE)[117]	The CUE is a measure of upper limb function. It was specifically designed for patients with tetraplegia and is administered via a self-report questionnaire. Patients rate their ability to perform 32 different tasks on a seven-point scale.
The Tetraplegic Hand Activity Questionnaire (THAQ)[118]	The THAQ was designed to measure patients' perceptions about their hand and upper limb function. Patients are required to rate 153 motor tasks according to their ability to perform the task (four-point scale), need for an aid (four-point scale) and importance of the task (three point scale).
The Common Object Test (COT)[119]	The COT was designed to evaluate the usefulness of neuroprostheses. Patients are required to perform 14 motor tasks. Each task is divided into its sub-tasks and scored on a six-point scale according to the amount of assistance required.
Grasp and Release Test (GRT)[120]	The GRT is a test of hand function. It was initially designed to evaluate the usefulness of neuroprostheses in patients with C5 and C6 tetraplegia.

(continued)

TABLE 2.1 (continued)

	Brief description
	The test requires patients to use either a palmar or lateral grasp to manipulate six different objects. Patients are assessed on the speed at which they can complete the tasks as well as their success rate.
Wheelchair mobility	
Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST)[121,122]	The QUEST is a 12-item questionnaire which assesses patients' satisfaction with assistive technology, including wheelchairs. Each item is rated on a six-point scale ranging from 'not at all satisfied' to 'very satisfied'. Eight items relate to the device and four items to service provision.
Modified Functional Reach Test (mFRT)[123]	The mFRT assesses patients' ability to reach forward while seated. The maximal distance reached following three trials is recorded.
Timed Motor Test (TMT)[124]	The TMT was designed for children with spinal cord injury. It consists of six items and children are assessed on the time taken to complete each task. The tasks include putting on clothing, transferring and manoeuvring a manual wheelchair.
Five Additional Mobility and Locomotor Items (5-AML)[125,126]	The 5-AML was specifically designed for patients who are wheelchair-dependent. It contains five items assessing patients' ability to transfer, move about a bed and mobilize in a manual wheelchair. It is used in conjunction with the FIM.
Wheelchair Circuit Test (WCT)[127]	The WCT contains nine items and assesses different aspects of wheelchair mobility and the ability to transfer and walk. Three items require propelling a wheelchair on a treadmill.
Wheelchair Skills Test (WST)[15,128,129]	The WST is a 57-item test to assess ability to mobilize in a manual wheelchair. It includes simple tasks such as applying brakes, and complex tasks such transferring and ascending kerbs. Each item is scored on a three-point scale reflecting competency and safety. A questionnaire version is also available.[130]

Assessing impairments

The physical assessment also includes an assessment of impairments. These are similar to standard assessments used by physiotherapists in other populations. They include assessments of strength, sensation, respiratory function, cardiovascular fitness and pain. Details of how to assess impairments in patients with spinal cord injury can be found in subsequent chapters (see Chapters 8–12).

Step two: setting goals

Benefits of goals

Goal setting is an important aspect of a comprehensive physiotherapy and rehabilitation programme.[17–28] The process needs to be patient-centred. Initially, a few key goals of rehabilitation are articulated by the patient and negotiated with the multi-disciplinary team.[17,19,22,23,25,29–33] These goals should be expressed in terms of participation restrictions.[20,25] For example, a key goal of rehabilitation might be to return to work or school. Physiotherapy-specific goals then need to be identified and linked to each participation restriction goal. The physiotherapy-specific goals should be functional and purposeful activities as defined within the activity limitation and participation restriction domains of ICF and, specifically, within the ICF sub-domains of mobility, self-care and domestic life. These sub-domains include tasks such as pushing a manual wheelchair, rolling in bed, moving from lying to sitting, eating, drinking, looking after one's health, and pursuing recreation and leisure interests (see Ref. 34 for examples of ways to articulate functional goals appropriate for patients with spinal cord injury). Physiotherapy-specific goals are formulated in conjunction with the patient and other team members who share responsibility for their attainment. Both short- and long-term goals need to be set.[24,25] These may include goals to be achieved within a week or goals to be achieved over 6 months. In addition, specific goals (or targets) should be set as part of each treatment session[25] (see Chapter 7).

Goals are important for several reasons.[24] They ensure that the expectations of patients and staff are similar and realistic, and provide clear indications of what everyone is expected to achieve.[26] If compiled in an appropriate way, they actively engage patients in their own rehabilitation plan, empowering them and ensuring that their wishes and expectations are met.[26] Without goals, rehabilitation programmes can lack direction, and patients can feel like the passive recipients of mystical interventions.[19,22,23,30,35] Goals also help focus the rehabilitation team on the individual needs of patients, and provide team members with common objectives.[24] Perhaps most importantly, goals provide a source of motivation and enhance adherence.

Goals are also used to monitor the success of therapy and to identify problems. Goals achieved indicate success and goals not achieved indicate failure. Failure may be due to any number of reasons which need exploring. For example, a patient may fail to achieve a goal because of medical complications or because equipment fails to arrive, factors which may be difficult to avoid. Failure to achieve goals may reflect poor therapy attendance. Alternatively, failure may indicate unrealistic goals which need revising. A risk of excessive reliance on goals to measure success is that it encourages the selection of non-challenging goals which have a high likelihood of success.[27]

Guidelines to setting goals

Goals should be SMART. That is, they should be: Specific, Measurable, Attainable, Realistic and Timebound.[36] Physiotherapy-related goals need to be based on predictions of future independence, taking into account contextual factors such as patients' and families' perspectives, priorities and personal ambitions.[19,35,37] Other factors which influence outcome include access to products, technology and support, and personal attributes such as age, personality and anthropometrical characteristics.[37–43] Clearly, however, the strongest predictor of future independence is neurological status.[32,44,45] Neurological status determines the strength of muscles which in turn largely determines patients' ability to move.

A simplistic summary of levels of innervation for key upper and lower limb muscles is provided in Table 2.2 (for more details see Tables A1 and A2 in the Appendix). The summary is simplistic because muscles have been grouped together even though different muscles and parts of the same muscle often receive innervation from different spinal nerve roots. For example, the pectoralis muscles consist of pectoralis minor and the sternocostal and clavicular parts of pectoralis major. These muscles receive innervation from C5 to T1.[46]

TABLE 2.2 **The levels at which muscles receive sufficient innervation to enable reasonable movement**[46]

C4		Diaphragm
C5	*Shoulder*	Flexors
		Abductors
	Elbow	Flexors*
C6	*Shoulder*	Extensors
		Adductors
	Wrist	Extensors*
C7	*Elbow*	Extensors*
	Wrist	Flexors
	Finger	Extensors
	Thumb	Abductors and adductors
C8	*Finger*	Flexors*
	Thumb	Flexors and extensors
T1	*Finger*	Abductors*
		Adductors
T1–T12		Intercostals, abdominals and trunk
L2	*Hip*	Flexors*
		Adductors
L3	*Knee*	Extensors*
L4	*Hip*	Abductors
	Ankle	Dorsiflexors*
L5	*Hip*	Extensors
	Toe	Extensors*
S1	*Knee*	Flexors
	Ankle	Plantarflexors*
S2	*Toe*	Flexors

The ASIA muscles are asterisked (see Appendix for more details).

For some patients, particularly those with motor complete lesions without zones of partial preservation, it is relatively simple to look at the extent of paralysis and identify the *optimal* levels of independence which patients can hope to attain.[32,47–49] For instance, patients with complete T12 paraplegia and paralysis of the lower limbs have the potential to independently dress and transfer. In contrast, patients with complete C4 tetraplegia do not. However, this type of information can only be used as a starting point. Not only will outcomes be affected by contextual and other factors, but also by individual variations in neurological status. Often patients with the same ASIA classification have subtle but important differences in strength. For instance, a patient with C6 tetraplegia and grade 4/5 strength in the wrist extensor muscles will generally attain a higher level of function than a patient with the same level of tetraplegia but grade 3/5 strength in the wrist extensor muscles.[50] This is not only due to the implications of wrist extensor strength for function, but also due to the fact that wrist extensor strength is usually indicative of strength in other muscles which are primarily innervated at the C6 level, such as the latissimus dorsi and pectoralis muscles. Weakness in either of these shoulder girdle muscles has deleterious implications for function.[51]

Setting goals for patients with complete lesions

This section provides a brief overview of typical outcomes attained by patients with ASIA complete lesions and no zones of partial preservation.[32,52] A summary is provided in Table 2.3.

C1–C3 tetraplegia

Patients with C2 and above tetraplegia have total paralysis of the diaphragm and other respiratory muscles and consequently are ventilator-dependent. Patients with C3 tetraplegia retain a small amount of diaphragm function but not usually enough to breathe spontaneously (see Chapter 11).[53] All have paralysis of upper and lower limbs and trunk muscles but are able to move their heads. They are fully dependent

TABLE 2.3 Typical level of independence attained by patients with ASIA complete spinal cord injury

	C1–C3 tetraplegia	C4 tetraplegia	C5 tetraplegia	C6 tetraplegia	C7–C8 tetraplegia	Thoracic paraplegia	Lumbar and sacral paraplegia
Unassisted ventilation	no	yes	yes	yes	yes	yes	yes
Push manual wheelchair	no	no	limited	limited	yes	yes	yes
Hand to mouth activities	no	no	yes	yes	yes	yes	yes
Self-feeding	no	no	limited	yes	yes	yes	yes
Hand function	no	no	no	limited (tenodesis)	limited (tenodesis)	yes	yes
Driving[64]	no	no	no	yes	yes	yes	yes
Rolling	no	no	limited	yes	yes	yes	yes
Horizontal transfer	no	no	limited	yes	yes	yes	yes
Lying to sitting	no	no	limited	yes	yes	yes	yes
Floor to wheelchair	no	no	no	limited	limited	yes	yes
Standing in parallel bars with orthoses	no	no	no	no	limited	yes	yes
Walking with orthoses and aids	no	no	no	no	no	limited	yes

on others for all motor tasks and personal care activities. They mobilize in chin-control power wheelchairs and can use head-, mouth- or voice-activated technology (see Figure 2.2).

C4 tetraplegia

Patients with C4 tetraplegia have partial paralysis of the diaphragm and total paralysis of all four limbs and trunk muscles. They retain a small amount of voluntary control around the shoulders and have good strength in the rhomboid muscles but still mobilize in a chin-control power wheelchair. They can breathe independently but in all other respects their activity limitations are similar to those of patients with C1–C3 tetraplegia.

C5 tetraplegia

Patients with C5 tetraplegia have partial paralysis of the upper limbs but full paralysis of the trunk and lower limb muscles. They have good strength of the deltoid and

Figure 2.2 Patients with C1–C3 tetraplegia mobilize in chin-control wheelchairs and use head-, mouth- or voice-activated technology.

biceps muscles, but poor strength of other shoulder muscles. They have no function in the triceps muscles or any muscles about the wrist or hand. Despite this, they can use a hand-control power wheelchair with the hand passively rested on or secured to the joystick (see Chapter 13). They are unable to perform gross motor tasks such as transferring, rolling or moving from lying to sitting and require assistance for most personal care activities. They can, however, take their hands to their mouth, head and face. They can use the upper limbs to perform simple tasks provided no fine hand control is required and the appliance or utensil is attached to the hand with a splint. Upper limb function is usually possible with splints to stabilize the paralysed wrist. For example, a keyboard can be used with a typing stick attached to the hand and a steering wheel of a car can be turned with adaptations to the wheel (see Chapter 5).[54]

C6 tetraplegia

There is a large functional difference between patients with C5 and C6 tetraplegia. This is due to the preservation of the pectoralis, serratus anterior, latissimus dorsi and wrist extensor muscles. The latissimus dorsi muscle, in combination with the pectoralis and serratus anterior muscles, enables weight bearing through the upper limbs. This provides the potential to lift body weight and transfer (see Chapter 3). The latissimus dorsi muscle also provides some trunk stability.[55] Although not normally considered a trunk muscle, the latissimus dorsi becomes important in the absence of other trunk muscles. Preservation of the pectoralis muscles makes it possible to roll over in bed and provides stability around the shoulder when weight bearing. Serratus anterior is also important for scapula stability.

Patients with C6 tetraplegia have the potential to live independently, provided they are adequately equipped and set up. Some can transfer, roll, move from lying to sitting, dress, bathe and attend to personal hygiene, although all these motor tasks are time-consuming and difficult to master. Patients with C6 tetraplegia mobilize in a manual wheelchair, but most also use a power wheelchair. Voluntary control of the wrist extensor muscles provides crude grasp (tenodesis grip; see Chapter 5). This makes it possible to hold objects between the index finger and thumb, or in the palm of the hand, despite paralysis of the finger and thumb flexor muscles.

C7 tetraplegia

Patients with C7 tetraplegia typically attain higher levels of independence than those with C6 tetraplegia because of the function provided by the triceps, wrist flexor and finger extensor muscles. The triceps muscles are particularly important because they increase the ability to bear weight through a flexed elbow. The triceps muscles also enable patients to carry and hold objects above their heads. Patients with C7 tetraplegia still have paralysis of the finger and thumb flexor muscles so, despite the ability to extend the fingers, they rely on a tenodesis grip for hand function.

C8 tetraplegia

Patients with lesions at C8 have finger and thumb flexor activity, and therefore can actively grasp and release objects. Consequently, hand function is superior to that of patients who rely on a tenodesis grip. Greater strength in the triceps and shoulder muscles enables these patients to more easily attain independence than those with lesions at C6 and C7.

T1 paraplegia

Patients with lesions at T1 have near-normal hand function, although they retain some weakness in the intrinsic and lumbrical muscles affecting fine hand control. They still have extensive paralysis of the trunk muscles and therefore, like those with higher lesions, have difficulty sitting unsupported (see Chapter 3).

Thoracic paraplegia

Patients with thoracic paraplegia have full upper limb movement, varying degrees of paralysis of the trunk and total paralysis of the legs. They are predominantly wheelchair-dependent, although some can walk short distances with extensive bracing and walking aids (see Chapter 6). Patients with high thoracic paraplegia have more extensive paralysis of the trunk muscles than those with lower thoracic paraplegia, primarily affecting their ability to sit unsupported and master complex transfers.

Lumbar and sacral paraplegia

Patients with lumbar and sacral paraplegia have varying extents of paralysis of the lower limbs and do not commonly have complete lesions. Most can walk with or without aids and orthoses although some remain wheelchair-dependent (see Chapter 6).

Setting goals for patients with incomplete lesions

Outcomes for patients with zones of partial preservation, or ASIA C or D incomplete lesions, are less predictable. In these patients, patterns of neurological loss are diverse,[45,56,57] the extent of possible neurological recovery is unclear,[32,45,56,58–60] and consequently accurate and detailed predictions of motor function are difficult.[61–63] Knowledge about levels of independence attainable by patients with complete spinal cord injury is used as a starting reference then modified depending on individual circumstances and neurological status. Some degree of intuition, developed with experience, is needed to generate goals that are realistic and appropriate.

Step three: identifying key impairments

Once goals of treatment are defined in terms of activity limitations and participation restrictions, it is then necessary to determine which impairments prevent the attainment of each goal. That is, key impairments need to be linked to specific activity restrictions and participation limitations. Identification and treatment of impairments without linking them to activity limitations and participation restrictions risks wasting time, money and resources on impairments which are of little consequence. For example, limited hamstring extensibility is an important impairment for some but not all patients. Unless limited hamstring extensibility is linked to activity and participation goals, physiotherapists might be tempted to direct therapeutic attention at increasing the extensibility of the hamstring muscles in some patients unnecessarily (see Chapter 9).

The process of linking impairments to activity restrictions and participation limitations is the same, regardless of whether one is trying to determine the impairments which prevent a patient with incomplete paraplegia from walking, a patient with C6 tetraplegia from rolling, or a patient with T4 paraplegia from transferring. Each motor task is analysed with respect to sub-tasks. For instance, analysis of transferring between a bed and wheelchair for a patient with C6 tetraplegia is done in relation to the sub-tasks of positioning the legs on the bed, moving forward in the wheelchair and transferring between surfaces (see Table 3.8, p. 71). The underlying reasons for the inability to perform any of these sub-tasks need to be identified and expressed in terms of impairments which are responsive to physiotherapy interventions.

The analysis of motor tasks needs to be done within a realistic framework. For instance, the identification of key impairments preventing a patient with incomplete paralysis from walking needs to be done within the context of how that particular patient can best hope to walk (see Chapter 6). Clearly, someone with paralysis of the quadriceps muscles will not walk in the same way as someone with full strength in the quadriceps muscles. Consequently, gait needs to be analysed with respect to the best gait pattern that can be hoped for, not with respect to the normal kinematics and kinetics of gait for an able-bodied individual. This same principle applies across all mobility tasks and, consequently, physiotherapists require a good understanding of how patients with different patterns of paralysis move (see Chapters 3–6).

Only impairments which are amenable to physiotherapy interventions are of real interest. For example, there is little point linking the inability of a patient with paraplegia to get from the floor back into the wheelchair with permanent paralysis of the legs because this will not guide treatment. A far more helpful analysis would be to link the inability to vertically transfer with insufficient upper limb strength because this is an impairment which can be addressed with an appropriately targeted strength-training programme (see Chapter 8).

Step four: identifying and administering treatments

Six key impairments are responsive to physiotherapy intervention and commonly impose activity restrictions and participation limitations. These are largely contained within the Neuromusculoskeletal and Movement-Related Functions domains of ICF. They include:

- poor skill (see Chapter 7)
- poor strength (see Chapter 8)
- poor joint mobility (see Chapter 9)
- pain (see Chapter 10)
- poor respiratory function (see Chapter 11)
- poor cardiovascular fitness (see Chapter 12)

Some interventions administered by physiotherapists are directed at preventing, rather than treating, impairments, activity limitation and participation restrictions. In addition, physiotherapists are often responsible for prescribing mobility equipment such as wheelchairs and cushions. These issues will be discussed throughout subsequent chapters.

Step five: measuring outcomes

Measurement of outcomes is an integral part of any physiotherapy programme. It determines whether the type and extent of physiotherapy intervention should continue, stop or change (see Chapter 14). Outcomes are best expressed in terms of initial goals and, in particular, with respect to activity limitations and participation restrictions. The assessment tools used in the initial examination can be used for this purpose (see p. 36). Alternatively, outcomes can be measured with respect to patient-articulated goals using tools such as the Canadian Outcome Performance Measure (see Table 2.1). Reassessment at the impairment level often provides more sensitive measures of change. Such reassessments are also useful for confirming whether the initial analysis was correct. For example, if an inability to transfer was deemed to be the consequence of poor strength in the shoulder adductor muscles, then improvements in shoulder adductor strength should be accompanied by improvements in the ability to transfer. Measurements which demonstrate an increase in shoulder adductor strength alone are of little relevance if there is no accompanying measurement to demonstrate a change in ability to perform some purposeful motor task.

While there is a temptation to use increasingly sophisticated tools to assess outcomes, there is little to be gained from using expensive technology to detect minuscule changes in impairment or function if the changes are of little clinical relevance. Likewise, there is little to be gained from assessments if they do not influence the clinical decision-making process. For instance, while three-dimensional gait analysis can provide detailed information about angular velocity of the ankle during terminal swing, this information is only useful to clinicians if physiotherapy interventions are sophisticated enough to be able to specifically address terminal velocity of the ankle during swing.

Physiotherapy as part of the multi-disciplinary team

Physiotherapists are members of a multi-disciplinary team, and the overall success of any rehabilitation programme depends on the contribution of all team members. Development of physical independence will be of little avail if patients do not have appropriate accommodation or financial support on discharge home. In the same way, the success of a physiotherapy programme will be undermined if patients return home incontinent or psychologically distressed. The success of rehabilitation is dependent on team members working closely together to ensure continuity and consistency in their individual therapeutic approaches.[24] For example, occupational therapists, nursing staff and physiotherapists are all involved with the day-to-day physical aspects of patients' care. New motor tasks learnt in physiotherapy need to be appropriately practised and reinforced outside formal physiotherapy sessions (see Chapter 7). However, motor tasks need to be taught and reinforced in the same way by all health professions. The application of different treatment approaches to inconsistent goals by different team members can be confusing, frustrating and counter-productive for patients. Inconsistencies of this kind are avoided by close teamwork and clear role delineations.

References

1. World Health Organization: International Classification of Functioning, Disability and Health: ICF short version. Geneva, World Health Organization, 2001.
2. World Health Organization: International Classification of Impairments, Disabilities, and Handicaps: a Manual of Classification Relating to the Consequences of Disease. Geneva, World Health Organization, 1980.
3. Heerkens Y, Van der Brug Y, Ten Napel H et al: Past and future use of the ICF (former ICIDH) by nursing and allied health professionals. Disabil Rehabil 2003; 25:620–627.
4. Marino RJ, Stineman MG: Functional assessment in spinal cord injury. Top Spinal Cord Inj Rehabil 1996; 1:32–45.

5. Dittmar SS, Gresham GE: Functional Assessment and Outcome Measures for the Rehabilitation Health Professional. Gaithersburg, MD, Aspen Publications, 1997.
6. Middleton JW, Truman G, Geraghty TJ: Neurological level effect on the discharge functional status of spinal cord injured persons after rehabilitation. Arch Phys Med Rehabil 1998; 79:1428–1432.
7. Stineman MG, Marino RJ, Deutsch A et al: A functional strategy for classifying patients after traumatic spinal cord injury. Spinal Cord 1999; 37:717–725.
8. Ota T, Akaboshi K, Nagata M et al: Functional assessment of patients with spinal cord injury: measured by the motor score and the Functional Independence Measure. Spinal Cord 1996; 34:531–535.
9. Catz A, Itzkovich M, Agranov E et al: SCIM — spinal cord independence measure: a new disability scale for patients with spinal cord lesions. Spinal Cord 1997; 35:850–856.
10. Catz A, Itzkovich M, Agranov E et al: The spinal cord independence measure (SCIM): sensitivity to functional changes in subgroups of spinal cord lesion patients. Spinal Cord 2001; 39:97–100.
11. Yavuz N, Tezyurek M, Akyuz M: A comparison of two functional tests in quadriplegia: the quadriplegia index of function and the functional independence measure. Spinal Cord 1998; 36:832–837.
12. Marino RJ, Rider-Foster D, Maissel G et al: Superiority of motor level over single neurological level in categorizing tetraplegia. Paraplegia 1995; 33:510–513.
13. Marino RJ, Goin JE: Development of a short-form Quadriplegia Index of Function Scale. Spinal Cord 1999; 37:289–296.
14. Gresham GE, Labi MC, Dittmar SS et al: The Quadriplegia Index of Function (QIF): Sensitivity and reliability demonstrated in a study of thirty quadriplegic patients. Paraplegia 1986; 24:38–44.
15. Kirby RL, Swuste J, Dupuis DJ et al: The wheelchair skills test: a pilot study of a new outcome measure. Arch Phys Med Rehabil 2002; 83:10–18.
16. Kilkens OJ, Post MW, Dallmeijer AJ et al: Wheelchair skills tests: a systematic review. Clin Rehabil 2003; 17:418–430.
17. Baker SM, Marshak HH, Rice GT et al: Patient participation in physical therapy goal setting. Phys Ther 2001; 81:1118–1126.
18. Brincat CA: Managed care and rehabilitation: adapting a true team approach. Top Stroke Rehabil 1999; 6:62–65.
19. Donnelly C, Eng JJ, Hall J et al: Client-centred assessment and the identification of meaningful treatment goals for individuals with a spinal cord injury. Spinal Cord 2004; 42:302–307.
20. Elsworth JD, Marks JA, McGrath JR et al: An audit of goal planning in rehabilitation. Top Stroke Rehabil 1999; 6:51–61.
21. McGrath JR, Adams L: Patient-centered goal planning: a systemic psychological therapy? Top Stroke Rehabil 1999; 6:43–50.
22. Randall KE, McEwen IR: Writing patient-centered functional goals. Phys Ther 2000; 80:1197–1203.
23. Wressle E, Eeg-Olofsson AM, Marcusson J et al: Improved client participation in the rehabilitation process using a client-centred goal formulation structure. J Rehabil Med 2002; 34:5–11.
24. Wade DT: Goal planning in stroke rehabilitation: why? Top Stroke Rehabil 1999; 6:1–7.
25. Wade DT: Goal planning in stroke rehabilitation: what? Top Stroke Rehabil 1999; 6:8–15.
26. Wade DT: Goal planning in stroke rehabilitation: how? Top Stroke Rehabil 1999; 6:16–36.
27. Wade DT: Goal planning in stroke rehabilitation: evidence. Top Stroke Rehabil 1999; 6:37–42.
28. Berry C, Kennedy P: A psychometric analysis of the Needs Assessment Checklist (NAC). Spinal Cord 2002; 41:490–501.
29. Law M, Baptiste S, Mills J: Client-centred practice: what does it mean and does it make a difference? Can J Occup Ther 1995; 62:250–257.
30. Playford ED, Dawson L, Limbert V et al: Goal-setting in rehabilitation: report of a workshop to explore professionals' perceptions of goal-setting. Clin Rehabil 2000; 14:491–496.
31. Saadah MA: Clinical commentary. 'On autonomy and participation in rehabilitation.' Disabil Rehabil 2002; 24:977–982.
32. Consortium for Spinal Cord Medicine: Outcomes Following Traumatic Spinal Cord Injury: Clinical Practice Guidelines for Health Care Professionals. Washington, DC, Paralyzed Veterans of America, 1999.
33. Duff J, Evans MJ, Kennedy P: Goal planning: a retrospective audit of rehabilitation process and outcome. Clin Rehabil 2004; 18:275–286.
34. Laskin JJ, James SA, Cantwell BM: A fitness and wellness program for people with spinal cord injury. Top Spinal Cord Inj Rehabil 1997; 3:16–33.
35. Kennedy P, Evans MJ, Berry C et al: Comparative analysis of goal achievement during rehabilitation for older and younger adults with spinal cord injury. Spinal Cord 2003; 41:44–52.
36. Independent Living Research Utilization: Application of the concept of health and wellness to people with disabilities: from academia to real life. http://www.ilru.org/html/training/webcasts/handouts/2001/10-31-CC/carla1.html. Houston, 2005.
37. Norris-Baker C, Stephens MA, Rintala DH et al: Patient behavior as a predictor of outcomes in spinal cord injury. Arch Phys Med Rehabil 1981; 62:602–608.

38. Grover J, Gellman H, Waters RL: The effect of a flexion contracture of the elbow on the ability to transfer in patients who have quadriplegia at the sixth cervical level. J Bone Joint Surg (Am) 1996; 78:1397–1400.
39. Yarkony GM, Bass LM, Keenan V et al: Contractures complicating spinal cord injury: incidence and comparison between spinal cord centre and general hospital acute care. Paraplegia 1985; 23:265–271.
40. Cifu DX, Steel RT, Kreutzer JS et al: A multicenter investigation of age-related differences in lengths of stay, hospitalization charges, and outcomes for a matched tetraplegia sample. Arch Phys Med Rehabil 1999; 80:733–740.
41. Penrod LE, Hegde SK, Ditunno JF. Age effect on prognosis for functional recovery in acute, traumatic central cord syndrome. Arch Phys Med Rehabil 1990; 71:963–968.
42. Bergstrom EM, Frankel HL, Galer IA et al: Physical ability in relation to anthropometric measurements in persons with complete spinal cord lesion below the sixth cervical segment. Int Rehabil Med 1985; 7:51–55.
43. De Vivo MJ, Kartus PL, Rutt RD et al: The influence of age at time of spinal cord injury on rehabilitation outcome. Arch Neurol 1990; 47:687–691.
44. Fujiwara T, Hara Y, Akaboshi K et al: Relationship between shoulder muscle strength and functional independence measure (FIM) score among C6 tetraplegics. Spinal Cord 1999; 37:58–61.
45. Marino RJ, Ditunno JF, Donovan WH et al: Neurological recovery after traumatic spinal cord injury: data from the Model Spinal Cord Injury Systems. Arch Phys Med Rehabil 1999; 80:1391–1396.
46. Williams PL, Bannister LH, Berry MM et al: Gray's Anatomy, 38th edn. New York, Churchill Livingstone, 1995.
47. Somers MF: Spinal Cord Injury: Functional Rehabilitation, 2nd edn. Upper Saddle River, NJ, Prentice Hall, 2001.
48. Buchanan LE, Nawoczenski DA: Spinal Cord Injury: Concepts and Management Approaches. Baltimore, Williams & Wilkins, 1987.
49. Nixon V: Spinal Cord Injury. A Guide to Functional Outcomes in Physical Therapy Management. London, Heinemann Medical, 1985.
50. Marciello MA, Herbison GJ, Ditunno JF et al: Wrist strength measured by myometry as an indicator of functional independence. J Neurotrauma 1995; 12:99–106.
51. Powers CM, Newsam CJ, Gronley JK et al: Isometric shoulder torque in subjects with spinal cord injury. Arch Phys Med Rehabil 1994; 75:761–765.
52. UAB Model SCI Center: Functional goals following spinal cord injury. In Network SCII (ed): http://www.spinalcord.uab.edu/show.asp?durki = 28922. Birmingham, UAB Model SCI System, 2006.
53. Wicks AB, Menter RR: Long-term outlook in quadriplegic patients with initial ventilator dependency. Chest 1986; 90:406–410.
54. Gittler MS: Acute rehabilitation in cervical spinal cord injuries. Top Spinal Cord Inj Rehabil 2004; 9:60–73.
55. Bogduk N, Johnson G, Spalding D: The morphology and biomechanics of latissimus dorsi. Clin Biomech 1998; 13:377–385.
56. Mange KC, Marino RJ, Gregory PC et al: Course of motor recovery in the zone of partial preservation in spinal cord injury. Arch Phys Med Rehabil 1992; 73:437–441.
57. Mange KC, Dituno JF, Herbison GJ et al: Recovery of strength at the zone of injury in motor complete and motor incomplete cervical spinal cord injured patients. Arch Phys Med Rehabil 1990; 71:562–565.
58. Waters RL, Adkins RH, Yakura JS et al: Motor and sensory recovery following incomplete paraplegia. Arch Phys Med Rehabil 1994; 75:67–72.
59. Waters RL, Adkins RH, Yakura JS et al: Motor and sensory recovery following incomplete tetraplegia. Arch Phys Med Rehabil 1994; 75:306–311.
60. Waters RL, Adkings RH, Yakura JS et al: Motor and sensory recovery following complete tetraplegia. Arch Phys Med Rehabil 1993; 74:242–247.
61. Burns SP, Golding DG, Rolle WA et al: Recovery of ambulation in motor incomplete tetraplegia. Arch Phys Med Rehabil 1997; 78:1169–1172.
62. Ditunno JF, Cohen ME, Hauck WW et al: Recovery of upper-extremity strength in complete and incomplete tetraplegia: a multicenter study. Arch Phys Med Rehabil 2000; 81:389–393.
63. Ditunno JF, Stover SL, Freed MM et al: Motor recovery of the upper extremities in traumatic quadriplegia: a multicenter study. Arch Phys Med Rehabil 1992; 73:431–436.
64. Kiyono Y, Hashizume C, Matsui N et al: Car-driving abilities of people with tetraplegia. Arch Phys Med Rehabil 2001; 82:1389–1392.
65. Finch E, Brooks D, Stratford PW et al: Physical Rehabilitation Outcome Measures: A Guide to Enhanced Clinical Decision Making, 2nd edn. Hamilton, ON, BC Decker, 2002.
66. Keith RA, Granger CV, Hamilton BB et al: The functional independence measure: a new tool for rehabilitation. In Eisenberg MG, Grzesiak RC (eds): Advances in Clinical Rehabilitation. New York, Springer, 1987:6–18.

67. Catz A, Itzkovich M, Steinberg F et al: The Catz-Itzkovich SCIM: a revised version of the Spinal Cord Independence Measure. Disabil Rehabil 2001; 23:263–268.
68. Collin C, Wade DT, Davies S et al: The Barthel ADL Index: a reliability study. Int Disabil Stud 1988; 10:61–63.
69. Granger CV, Albrecht GL, Hamilton BB: Outcome of comprehensive medical rehabilitation: measurement by PULSES Profile and the Barthel Index. Arch Phys Med Rehabil 1979; 60:145–154.
70. Yarkony GM, Roth EJ, Heinemann AW et al: Spinal cord injury rehabilitation outcome: the impact of age. J Clin Epidemiol 1988; 41:173–177.
71. Yarkony GM, Roth EJ, Heinemann AW et al: Benefits of rehabilitation for traumatic spinal cord injury: Multivariate analysis in 711 patients. Arch Neurol 1987; 44:93–96.
72. Yarkony GM, Roth EJ, Heinemann AW et al: Rehabilitation outcomes in C6 tetraplegia. Paraplegia 1988; 26:177–185.
73. Whiteneck GG, Charlifue SW, Gerhart JA et al: Quantifying handicap: a new measure of long-term rehabilitation outcomes. Arch Phys Med Rehabil 1992; 73:519–526.
74. Menter RR, Whiteneck GG, Charlifue SW et al: Impairment, disability, handicap and medical expenses of persons aging with spinal cord injury. Paraplegia 1991; 29:613–619.
75. Gerhart KA, Bergstrom E, Charlifue SW et al: Long-term spinal cord injury: functional changes over time. Arch Phys Med Rehabil 1993; 74:1030–1034.
76. Fuhrer MJ, Rintala DH, Hart KA et al: Depressive symptomatology in persons with spinal cord injury who reside in the community. Arch Phys Med Rehabil 1993; 74:255–260.
77. Tate D, Forchheimer M, Maynard F et al: Predicting depression and psychological distress in persons with spinal cord injury based on indicators of handicap. Am J Phys Med Rehabil 1994; 73:175–183.
78. Prince JM, Manley MS, Whiteneck GG: Self-managed versus agency-provided personal assistance care for individuals with high level tetraplegia. Arch Phys Med Rehabil 1995; 76:919–923.
79. Campbell J, Kendall M: Investigating the suitability of the clinical outcome variables scale (COVS) as a mobility outcome measure in spinal cord injury rehabilitation. Physiother Can 2003; 55:135–144.
80. Seaby L, Torrance G: Reliability of a physiotherapy functional assessment used in a rehabilitation setting. Physiother Can 1989; 41:264–270.
81. Mattison PG, Aitken RC, Prescott RJ: Rehabilitation status — the relationship between the Edinburgh Rehabilitation Status Scale (ERSS), Barthel Index, and PULSES profile. Int Disabil Stud 1991; 13:9–11.
82. Katz S, Stroud MW: Functional assessment in geriatrics. A review of progress and directions. J Am Geriatr Soc 1989; 37:267–271.
83. Andresen EM, Meyers AR: Health-related quality of life outcomes measures. Arch Phys Med Rehabil 2000; 81:S30–S45.
84. Ware JE: SF-36 health survey update. Spine 2000; 25:3130–3139.
85. Andresen EM, Fouts BS, Romeis JC et al: Performance of health-related quality-of-life instruments in a spinal cord injured population. Arch Phys Med Rehabil 1999; 80:877–884.
86. Forchheimer M, McAweeney M, Tate DG: Use of the SF-36 among persons with spinal cord injury. Am J Phys Med Rehabil 2004; 83:390–395.
87. Haran MJ, Lee BB, King MT et al: Health status rated with the Medical Outcomes Study 36-Item Short-Form Health Survey after spinal cord injury. Arch Phys Med Rehabil 2005; 86:2290–2295.
88. Leduc BE, Lepage Y: Health-related quality of life after spinal cord injury. Disabil Rehabil 2002; 24:196–202.
89. Post MW, Gerritsen J, Diederikst JP et al: Measuring health status of people who are wheelchair-dependent: validity of the Sickness Impact Profile 68 and the Nottingham Health Profile. Disabil Rehabil 2001; 23:245–53.
90. de Bruin AF, Diederiks JP, de Witte LP et al: Assessing the responsiveness of a functional status measure: the Sickness Impact Profile versus the SIP68. J Clin Epidemiol 1997; 50:529–540.
91. Dedding C, Cardol M, Eyssen IC et al: Validity of the Canadian Occupational Performance Measure: a client-centred outcome measurement. Clin Rehabil 2004; 18:660–667.
92. Law M, Baptiste S, McColl M et al: The Canadian Occupational Performance Measure: An outcome measure for occupational therapy. Can J Occup Ther 1990; 57:82–87.
93. Law M, Cadman D, Rosenbaum P et al: Neurodevelopmental therapy and upper-extremity inhibitive casting for children with cerebral palsy. Dev Med Child Neurol 1991; 33:379–387.
94. Law M, Baptiste S, Carswell AC et al (eds): Canadian Occupational Performance Measure, 3rd edn. Toronto, ON, CAOT Publications ACE, 1998.
95. Martin Ginis KA, Latimer AE, Hicks AL et al: Development and evaluation of an activity measure for people with spinal cord injury. Med Sci Sports Exerc 2005; 37:1099–1111.
96. Latimer AE, Martin Ginis KA, Craven BC et al: The physical activity recall assessment for people with spinal cord injury: validity. Med Sci Sports Exerc 2006; 38:208–216.

97. Taricco M, Apolone G, Colombo C et al: Functional status in patients with spinal cord injury: a new standardized measurement scale. Arch Phys Med Rehabil 2000; 81:1173–1180.
98. Taricco M, Colombo C, Adone R et al: The social and vocational outcome of spinal cord injury patients. Paraplegia 1992; 30:214–219.
99. Gans BM, Haley SM, Hallenborg SC et al: Description and interobserver reliability of the Tufts Assessment of Motor Performance. Am J Phys Med Rehabil 1988; 67:202–210.
100. Haley SM, Ludlow LH, Gans BM et al: Tufts assessment of motor performance: an empirical approach to identifying motor performance categories. Arch Phys Med Rehabil 1991; 72:359–66.
101. Haley SM, Ludlow LH: Applicability of the hierarchical scales of the Tufts Assessment of Motor Performance for school-aged children and adults with disabilities. Phys Ther 1992; 72:191–206.
102. Ditunno PL, Dittunno JF. Walking index for spinal cord injury (WISCI II): scale revision. Spinal Cord 2001; 39:654–656.
103. Ditunno JF, Ditunno PL, Graziani V et al: Walking Index for Spinal Cord Injury (WISCI): an international multicenter validity and reliability study. Spinal Cord 2000; 38:234–243.
104. Morganti B, Scivoletto G, Ditunno P et al: Walking index for spinal cord injury (WISCI): criterion validation. Spinal Cord 2005; 43:27–33.
105. Field-Fote EC, Fluet GG, Schafer SD et al: The Spinal Cord Injury Functional Ambulation Inventory (SCI-FAI). J Rehabil Med 2001; 33:177–181.
106. Hussey RW, Stauffer ES: Spinal cord injury: requirements for ambulation. Arch Phys Med Rehabil 1973; 54:544–547.
107. Hoffer MM, Feiwell E, Walker JM et al: Functional ambulation in patients with myelomeningocele. J Bone Joint Surg (Am) 1973; 55:137–148.
108. Nene AV, Hermens HJ, Zilvold G: Paraplegic locomotion: a review. Paraplegia 1996; 34:507–524.
109. Podsiadlo D, Richardson S: The timed 'Up & Go': a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc 1991; 39:142–148.
110. Siggeirsdottir K, Jonsson BY, Jonsson HJ et al: The timed 'Up and Go' is dependent on chair type. Clin Rehabil 2002; 16:609–616.
111. van Herk I, Arendzen JH, Rispens P: Ten-metre walk, with or without a turn? Clin Rehabil 1998; 21:30–35.
112. van Loo MA, Moseley AM, Bosman JM et al: Inter-rater reliability and concurrent validity of walking speed measurement after traumatic brain injury. Clin Rehabil 2003; 17:775–779.
113. Butland RJ, Pang J, Gross ER et al: Two-, six-, and 12-minute walking tests in respiratory disease. BMJ 1982; 284:1607–1608.
114. Triolo RJ, Bevelheimer T, Eisenhower G et al: Inter-rater reliability of a clinical test of standing function. J Spinal Cord Med 1995; 18:14–22.
115. Jebsen RH, Taylor N, Trieschmann RB et al: An objective and standardized test of hand function. Arch Phys Med Rehabil 1969; 50:311–399.
116. Giesler F, Coleman WP, Grieco G et al: Measurements and recovery patterns in a multicenter study of acute spinal cord injury. Spine 2001; 26:S68–S86.
117. Marino RJ, Shea JA, Stineman MG: The capabilities of upper extremity instrument: reliability and validity of a measure of functional limitation in tetraplegia. Arch Phys Med Rehabil 1998; 79:1512–1521.
118. Land NE, Odding E, Duivenvoorden HJ et al: Tetraplegia Hand Activity Questionnaire (THAQ): the development, assessment of arm–hand function-related activities in tetraplegic patients with a spinal cord injury. Spinal Cord 2004; 42:294–301.
119. Stroh KC, Van Doren C: An ADL test to assess hand function with tetraplegic patients. J Hand Ther 1994; 7:47–48.
120. Wuolle KS, Van Doren CL, Thrope GB et al: Development of a quantitative hand grasp and release test for patients with tetraplegia using a hand neuroprosthesis. J Hand Surg (Am) 1994; 19:209–218.
121. Demers L, Weiss-Lambrou R, Ska B: Development of the Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST). Assist Technol 1996; 8:3–13.
122. Demers L, Weiss-Lambrou R, Ska B: Item analysis of the Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST). Assist Technol 2000; 12:96–105.
123. Lynch SM, Leahy P, Barker SP: Reliability of measurements obtained with a modified functional reach test in subjects with spinal cord injury. Phys Ther 1998; 78:128–133.
124. Chafetz R, McDonald C, Mulcahey MJ et al: Timed motor test for wheelchair users: initial development and application in children with spinal cord injury. J Spinal Cord Med 2004; 27:S38–43.
125. Middleton JW, Harvey LA, Batty J et al: Five additional mobility and locomotor items to improve responsiveness of the FIM in wheelchair-dependent individuals with spinal cord injury. Spinal Cord 2006; 44:495–504.
126. Harvey LA, Batty J, Fahey A: Reliability of a tool for assessing mobility in wheelchair-dependent paraplegics. Spinal Cord 1998; 36:427–431.

127. Kilkens OJ, Post MW, van der Woude LH et al: The wheelchair circuit: reliability of a test to assess mobility in persons with spinal cord injuries. Arch Phys Med Rehabil 2002; 83:1783–1788.
128. Best KL, Kirby RL, Smith C et al: Comparison between performance with a pushrim-activated power-assisted wheelchair and a manual wheelchair on the Wheelchair Skills Test. Disabil Rehabil 2006; 28:213–220.
129. Faculty of Medicine Dalhousie University (2005): Wheelchair skills program. http://www.wheelchairskillsprogram.ca.
130. Mountain AD, Kirby RL, Smith C: The wheelchair skills test, version 2.4: validity of an algorithm-based questionnaire version. Arch Phys Med Rehabil 2004; 85:416–423.