PART 6

Neurologic System: Data Collection and Interventions

SECTION 6-1

Review of Nervous System Anatomy and Physiology

Parts of the Brain and Their Functions

See **Figure 6.1**, **Figure 6.2**, and **Figure 6.3**.

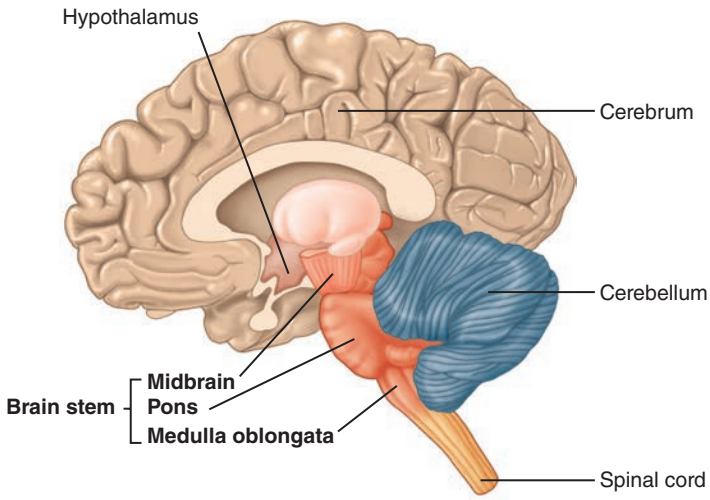

Figure 6.1 Brain stem

Anatomy and Physiology: Understanding the Human Body by Robert K. Clark, page 196, Figure 12.9 "The brainstem consists of the medulla oblongata, pons, and midbrain"

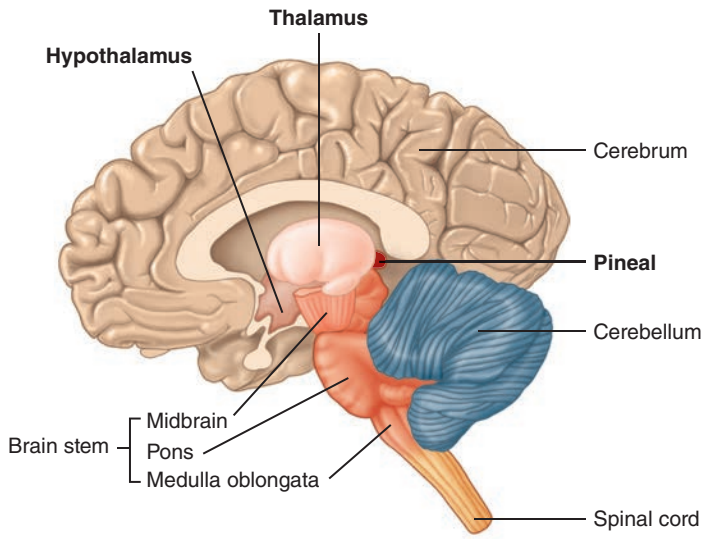

Figure 6.2 Diencephalon

Anatomy and Physiology: Understanding the Human Body by Robert K. Clark, page 197, Figure 12.10 "The thalamus, hypothalamus, and epithalamus represented here by the pineal gland are included in the diencephalon"

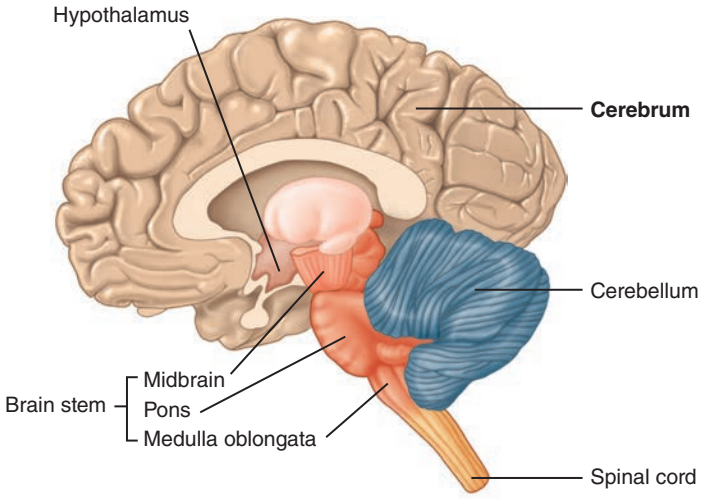

Figure 6.3 Cerebrum
Anatomy and Physiology: Understanding the Human Body by Robert K. Clark, page 199, Figure 12.12 "The cerebrum"

Table 6.1 Brain Stem, Diencephalon, Cerebrum, and Cerebellum and Their Functions

Brain Components	Functions
Brain stem: midbrain, pons, medulla oblongata	■ Midbrain: contains ascending and descending tracts and specific cranial nerve nuclei; important for motor control ■ Pons: contains nuclei for regulation of respiration and for cranial nerves V, VI, and VII ■ Medulla oblongata: regulates respiratory, cardiac, and vasomotor centers; contains nuclei for cranial nerves VIII through XII
Diencephalon: thalamus and hypothalamus	■ Thalamus: relays information to specific cortical sensory areas ■ Hypothalamus: controls body temperature, emotions, aggression, eating, drinking, sleep/wake cycles, sexual behaviors, and regulation of the autonomic nervous system
Cerebrum: cerebral hemispheres and basal ganglia	■ Cerebral hemispheres: see functions of each lobe in Table 6.2 ■ Basal ganglia: forms an associated motor system called the extrapyramidal system; important in formation of motor plans and adjustment of movements
Cerebellum: archicerebellum, paleocerebellum, and neocerebellum	■ Archicerebellum: equilibrium and regulation of muscle tone ■ Paleocerebellum: maintenance of posture and control of voluntary movement ■ Neocerebellum: smooth coordination of voluntary movements

Cerebral Hemispheres and Their Functions

See **Figure 6.4** and **Figure 6.5**.

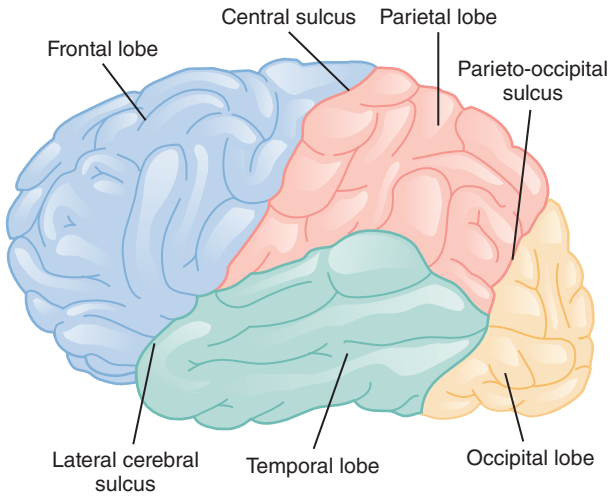

Figure 6.4 Lobes of the cerebrum
Anatomy and Physiology: Understanding the Human Body by Robert K. Clark, page 201, Figure 12.16 "The Lobes of the Cerebrum"

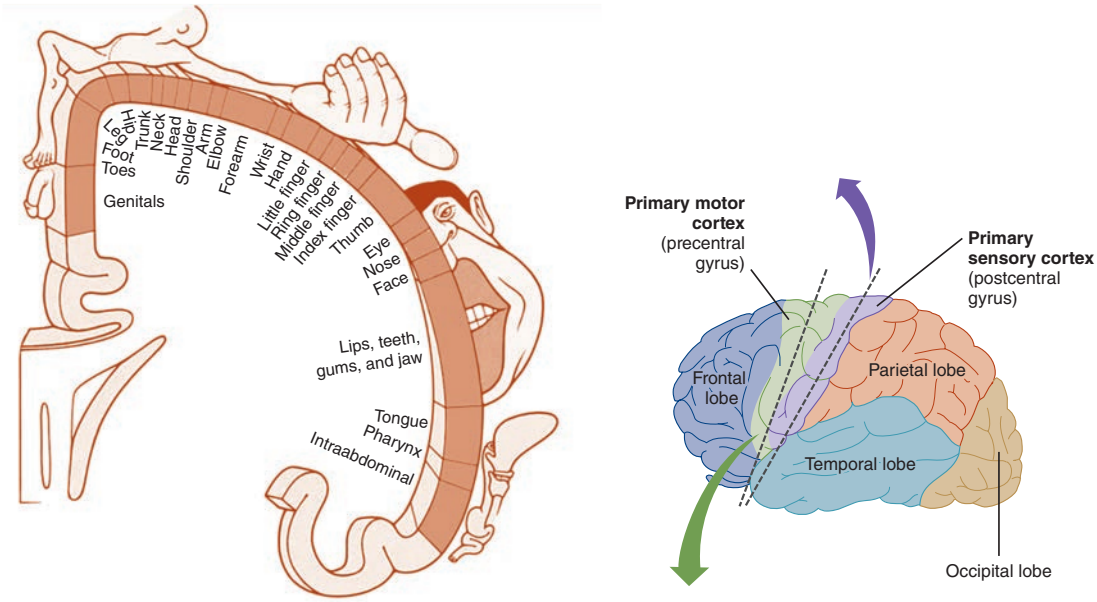

Figure 6.5 Specific functions of the central lobes. **A.** Sensory. **B.** Motor
Anatomy and Physiology: Understanding the Human Body by Robert K. Clark, page 203, Figure 12.19 "Specific Functions of the Central Lobes"

Specific functions of the central lobes	
Lobe	**Function**
Frontal	Motor area, controls skeletal muscle.
Parietal	Sensory area, integrates the senses of touch, pain, etc.
Occipital	Visual area, integrates visual stimuli.
Temporal	Olfactory and auditory areas, integrates sound and smell.

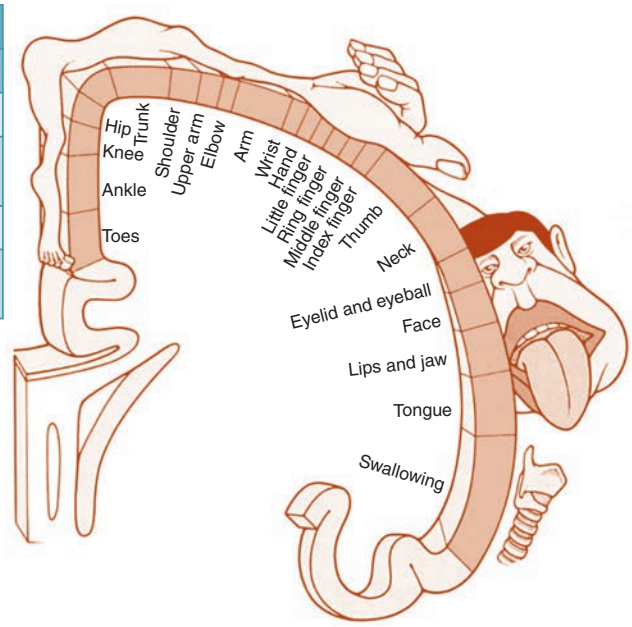

Figure 6.5 *(Continued)*

Table 6.2 Lobes of the Brain and Their Functions

Lobe	Functions
Frontal: precentral gyrus, prefrontal cortex, and Broca's area	■ Precentral gyrus: primary motor cortex for voluntary muscle activation of the contralateral side of the body ■ Prefrontal cortex: controls emotions, abstract thinking, and judgment ■ Broca's area: controls the motor (expressive) aspect of speech for the left hemisphere
Parietal: postcentral gyrus	■ Primary sensory cortex; integrates sensations from the contralateral side of the body for pain and temperature, touch, proprioception, and combined sensations; important for short-term memory
Occipital: primary visual cortex	■ Primary visual cortex: receives and processes visual stimuli and associative visual cortex ■ Associative visual cortex: gives meaning to visual information by processing visual stimuli
Temporal: primary auditory cortex, auditory cortex, and Wernicke's area	■ Primary auditory cortex: receives and associative processes auditory stimuli; important for long-term memory ■ Associative auditory cortex: processes auditory stimuli ■ Wernicke's area: controls the comprehension (receptive) aspect of speech
Limbic: oldest part of the brain	■ Instincts, emotions, preservation of individual, feeding, aggression, and endocrine sexual responses

Spinal Cord

See **Figure 6.6**, **Figure 6.7**, and **Figure 6.8**.

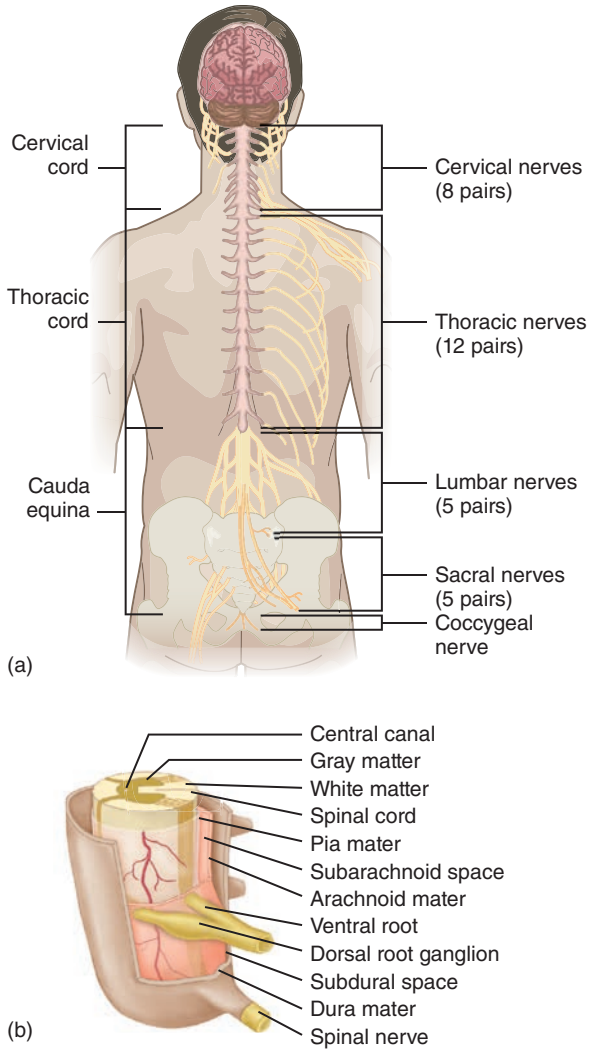

Figure 6.6 Spinal cord and its protective structures

Anatomy and Physiology: Understanding the Human Body by Robert K. Clark, page 214, Figure 12.25 a, b "The spinal cord and its protective structures"

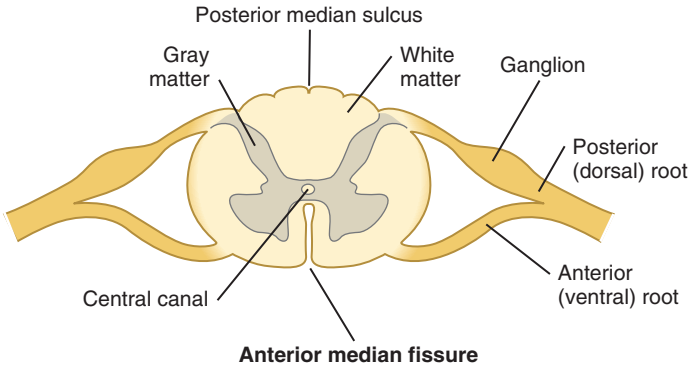

Figure 6.7 Spinal nerve roots
Anatomy and Physiology: Understanding the Human Body by Robert K. Clark, page 215, Figure 12.27 "A transverse section of the spinal cord showing spinal nerve roots"

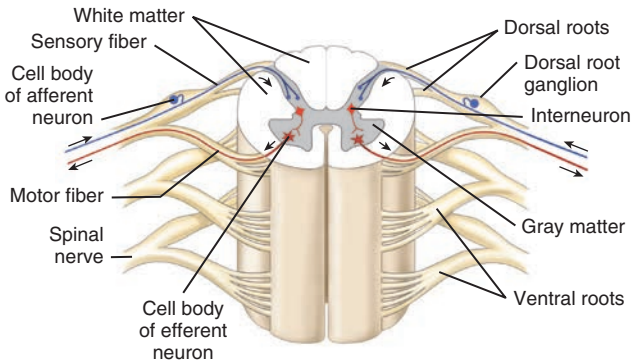

Figure 6.8 Spinal cord and dorsal root ganglia
Human Biology: Fifth Edition by Daniel D. Chiras, page 181, Figure 10-8 "The Spinal Cord and Dorsal Root Ganglia"

Table 6.3 Spinal Cord

- The spinal cord (SC) is a cylindrical mass of nerve tissue that is situated in the vertebral canal it is protected by bone and surrounded by meninges.
- The SC is a continuation of the medulla oblongata. It starts at the foramen magnum in the skull and ends at the conus medullaris (L1–L2).
- The SC contains gray matter (cell bodies and unmyelinated axons) and white matter (myelinated ascending and descending tracts).
- The gray matter is situated in the center of the cord (in shape of letter H) and is made of cell bodies and dendrites of neurons. The white matter is arranged in tracts around the gray matter.
- The gray matter contains two anterior (ventral) horns and two posterior (dorsal) horns. Anterior horns contain efferent (motor) neurons. Posterior horns contain afferent (sensory) neurons.

(continued)

Table 6.3 Spinal Cord *(continued)*

- The SC is divided into thirty-one segments with thirty-one pairs of spinal nerves (SNs): eight cervical, twelve thoracic, five lumbar, five sacral, and one coccygeal. Each SN has an anterior root and a posterior root. The anterior root has motor fibers and posterior root has sensory fibers. There is no posterior root for C1.
- In the cervical spine, the nerve roots exit above the corresponding vertebral body (C8 exits below C7 and above T1). In the thoracic/lumbar spine, the nerve roots exit below the corresponding vertebral body.
- The SC gives rise to the C4–T1 nerve roots (which supply the upper extremities) and the L1–S5 nerve roots (which supply the lower extremities).
- The SC is a pathway for motor impulses from the brain and sensory impulses to the brain.
- The SC mediates the stretch reflexes and the defecation and urination reflexes.

Ascending (Sensory) Tracts

Table 6.4 Sensory (Afferent) Tracts

- Dorsal columns convey sensations of proprioception, kinesthesia, vibration, stereognosis, barognosis, graphesthesia, two-point discrimination, and tactile localization.
- Spinothalamic tracts convey sensations of pain and temperature and crude touch.
- Spinocerebellar tracts convey sensations of proprioception (from muscle spindles and GTO), and touch and pressure receptors.
- Spinoreticular tracts convey sensations of deep and chronic pain.

Descending (Motor) Tracts

Table 6.5 Motor (Efferent) Tracts

- Corticospinal (or pyramidal) tracts function in voluntary motor control.
- Vestibulospinal tracts control muscle tone, antigravity muscles, and postural reflexes, head stabilization.
- The rubrospinal tract assists in motor function.
- The reticulospinal tracts modifies pain impulses, automatic postural responses.
- The tectospinal tract assists in head turning in response to visual stimuli.

Autonomic Nervous System

Table 6.6 Sympathetic Nervous System

- Thoracolumbar division of autonomic nervous system (ANS): prepares the body to cope with stressful situations (fight or flight); has afferent and efferent nerve fibers
- Sympathetic nervous system (SNS) effects: increased heart rate (HR) and blood pressure (BP); constriction of peripheral blood vessels; dilation of the pupils; dilation of the bronchioles; slowing of peristalsis; secretion of epinephrine and norepinephrine by adrenal medulla

Table 6.7 Parasympathetic Nervous System

- Craniosacral division of ANS: conserves and restores homeostasis; has afferent and efferent nerve fibers
- Parasympathetic nervous system (PNS) effects: decreased HR and BP; dilation of peripheral blood vessels; constriction of the pupil; constriction of the bronchioles; increasing of peristalsis and glandular activity

Brain Meninges and Ventricles

See **Figure 6.9** and **Figure 6.10**.

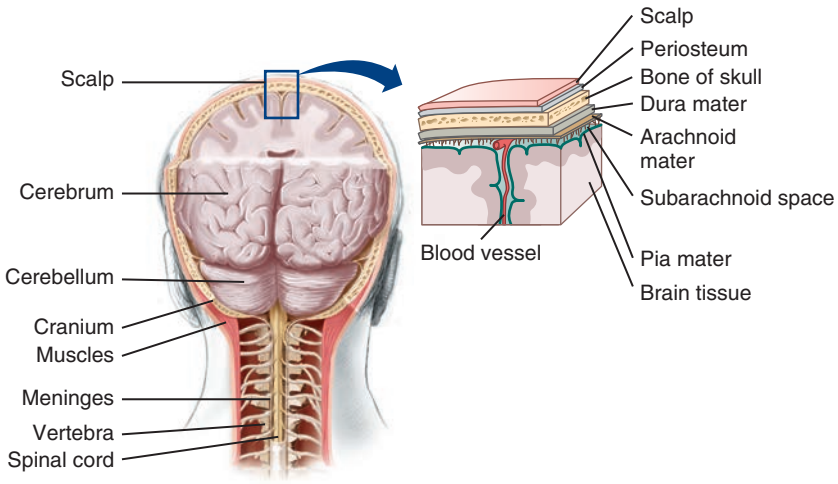

Figure 6.9 Brain meninges

Anatomy and Physiology: Understanding the Human Body by Robert K. Clark, page 190, Figure 12.5 "In addition to the bone, the central nervous system is protected by meninges"

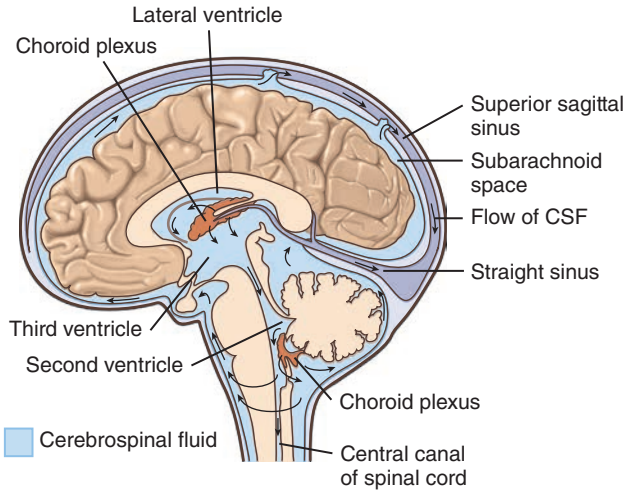

Figure 6.10 Brain ventricles

Anatomy and Physiology: Understanding the Human Body by Robert K. Clark, page 191, Figure 12.6 "The location and flow of cerebrospinal fluid"

Table 6.8 Brain Meninges and Ventricles

Meninges	Ventricles Filled with Cerebrospinal Fluid
Dura mater: outside, tough, and fibrous membrane	Lateral ventricles: large and irregularly shaped; communicate with third ventricle
Arachnoid: middle, delicate, and vascular membrane	Third ventricle: located posterior and deep; communicates with fourth ventricle
Subarachnoid space: contains cerebrospinal fluid (CSF) and major arteries	Fourth ventricle: located in pons and medulla; communicates with subarachnoid space.
Pia mater: inside, thin, and vascular membrane covering the brain surface	

Role of Cerebrospinal Fluid

Table 6.9 Role of Cerebrospinal Fluid (CSF)

- CSF protects the brain and helps in the exchange of nutrients and waste products.
- CSF is produced in the choroid plexus in ventricles.
- CSF normal pressure: 100–180 mm H_2O (9–14 mmHg).
- Total CSF volume: 125–150 mL.

Brain Blood Supply

Table 6.10 Brain Blood Supply

Carotid system: supplies the frontal, parietal, and parts of temporal lobe	The carotid system originates from the aortic arch that becomes the right and left common carotid arteries (which then divide and form the internal and external carotid arteries). The internal carotid artery enters the cranium and forms the anterior and middle cerebral arteries.
Vertebrobasilar system: supplies the brain stem, cerebellum, temporal, occipital lobes, and part of thalamus	The vertebrobasilar system originates from the subclavian artery and vertebral artery (which unite and form the basilar artery). The basilar artery forms the right and left posterior cerebral arteries.
Circle of Willis: connects the carotid and vertebrobasilar systems	The circle of Willis consists of the anterior and posterior communicating arteries.

Muscle Sensory Receptors and Their Functions

Table 6.11 Sensory Receptors and Their Functions

Sensory Receptors	Functions
Muscle spindles: situated in the belly of the muscle and parallel to the muscle fibers	Monitor changes in muscle length and the velocity of these changes; monitor position, movement sense, and motor learning
Golgi tendon organ: situated at the musculotendinous insertion of the muscle	Monitors tension within the muscle; provides a protective mechanism to the muscle

SECTION 6-2

Neurologic Data Collection

Patient Arousal Levels

Table 6.12 Patient's Arousal Levels[1]

Arousal Level	Description
Alert	Patient is aware of his or her environment, paying attention to the therapist and able to cooperate with treatment.
Coma	Patient is totally unresponsive to stimuli and cannot be awakened. Patient is not able to express himself or herself. Patient can be monitored with the Glasgow Coma Scale (includes three activities; eye opening, best motor response, verbal response).
Lethargic	Patient is drowsy and ready to sleep. Patient has difficulty concentrating on tasks and needs stimulation to keep awake.
Obtunded	Patient has diminished arousal and awareness to his or her environment. Patient may require repeated stimulation to notice the therapist.
Stupor (semi-coma)	Patient has decreased responsiveness to his or her environment and cannot interact with the therapist. Patient needs noxious (unpleasant) stimulation to be aroused.

Memory and Amnesia Terms

Table 6.13 Memory and Amnesia Terms[2]

- **Memory:** mental registration, retention and recollection of past experiences, knowledge, ideas, and sensations.
- **Short-term (immediate) memory:** immediate recollection of experiences, knowledge, ideas, and sensations that occurred in the immediate past (seconds to minutes). The capacity of short-term memory is approximately seven items.
- **Long-term memory:** recollection of experiences, knowledge, ideas, and sensations that occurred in the distant past (days, months, years). The capacity of long-term memory is unlimited.
- **Amnesia:** significant loss of memory. It can be caused by cerebral vascular accident (CVA), seizure, trauma, alcoholism, intoxication, senility, or an unknown cause.
- **Anterograde (post-traumatic) amnesia:** amnesia for events that occurred after the onset of amnesia. It involves amnesia of new learned material that was acquired after the causative event. This is a more common type of amnesia.
- **Retrograde amnesia:** amnesia for events that occurred prior to the onset of amnesia. It involves amnesia of prior learned material that was acquired prior to the causative event. This is a less common type of amnesia.

Orientation Terms

Table 6.14 Orientation Terms[1,3]

- Orientation: cognitive adaptation of an individual that is assessed within an unfamiliar environment (e.g., hospital, skilled nursing facility) to determine accurate awareness of person, place, time, and situation.
- Assessed using three or four domains.
- Three domains consist of the individual knowing: person (their name), place (hospital, skilled nursing, rehab unit), and time (day of the week).
- Four domains consist of the individual knowing: person (their name), place (hospital, skilled nursing, rehab unit), time (day of the week), and situation (the condition or event that brought them to the hospital, nursing home, etc.).
- If an individual is NOT oriented to one or more of the domains, it is documented in the medical record as the domains that were correctly identified listed in parentheses, (e.g., "oriented x 2/4 [person, place]").

Ranchos Los Amigos Levels of Cognitive Functioning

Table 6.15 Levels of Cognitive Functioning[3]

I. No response: Patient is unresponsive to any stimuli.
II. Generalized response: Patient responds inconsistently and nonpurposefully to stimuli. Responses such as total-body movements or vocalization may be the same regardless of the stimulus.
III. Localized response: Patient specifically but inconsistently responds to stimuli. Patient may follow uncomplicated commands in an inconsistent, delayed manner such as squeezing the hand or closing the eyes.
IV. Confused—agitated: Patient is in a high level of activity. Patient exhibits bizarre, nonpurposeful behavior relative to stimuli and environment. Patient is unable to cooperate directly with the treatment. Patient exhibits the following cognitive deficits: (1) very limited gross attention span; (2) confabulation; (3) incoherent and inappropriate verbalization; (4) impairment in short- and long-term memory; and (5) inability to discriminate among persons or objects.
V. Confused—inappropriate: Patient is able to respond somewhat consistently to simple commands. Patient responds in a nonpurposeful, random, or fragmented way to complex commands or unstructured activities. Patient exhibits gross attention in regard to the environment but is highly distractible and cannot focus. Patient is able to perform previously learned tasks with structure. Patient's cognitive deficits include (1) difficulty with complex and unstructured activities, (2) inability to learn new information, (3) inability to focus on a specific task, (4) impaired memory, (5) confabulation, and inappropriate verbalization.
VI. Confused—appropriate: Patient demonstrates goal-directed and appropriate behavior but is dependent on external input or instruction. Patient consistently follows simple commands and demonstrates carry over for relearned tasks (such as self-care activities). Patient's cognitive deficits are related to incorrect responses due to memory problems. Past memories have more depth and detail than more recent ones.

(continued)

Table 6.15 Levels of Cognitive Functioning *(continued)*

VII. Automatic—appropriate: Patient appears to demonstrate appropriate behavior in familiar settings. Patient is oriented to environment. Patient performs daily routines automatically mostly in a robot-like manner. Patient demonstrates carry over for new learning activities but at times has difficulty remembering them. Patient is able to initiate social and recreational activities but needs organization. Patient's cognitive deficits are minimal confusion and impaired judgment.

VIII. Purposeful—appropriate: Patient recalls and integrates past and recent events. Patient is oriented and reactive to environment. Patient demonstrates independent carryover for new learning. Patient exhibits the following cognitive deficits: (1) decreased abstract reasoning; (2) decreased tolerance to stress; (3) judgment difficulties in emergency or unusual situations; and (4) decreased premorbid abilities.

Terms of Cognitive–Perceptual Deficits

Table 6.16 Cognitive–Perceptual Deficits[1]

Agnosia: inability to recognize familiar objects with one sensory modality, although the patient is able to recognize the same object with another sensory modality.

Anosognosia: denial, neglect, and lack of awareness of the presence or severity of a person's own neurologic dysfunction (such as paralysis in stroke).

Apraxia: inability to produce purposeful movements, although there is no sensory or motor loss. Patient has intact sensation, strength, coordination, and comprehension.

Figure–ground discrimination deficit: inability to pick out an object from the background on which it is embedded.

Form constancy deficit: inability to pick out an object from an array of similarly shaped objects.

Homonymous hemianopsia: blindness in the outer half of the visual field of one eye and the inner half of the visual field of the other eye. Patient cannot receive information from either the right or the left of the visual environment.

Ideational apraxia: inability to produce purposeful movements on his or her own or on command.

Ideomotor apraxia: inability to produce purposeful movements on command but can produce them on his or her own.

Position in space deficit: inability to determine and interpret spatial concepts such as up or down, in or out, in front or behind, or under or over.

Right/left discrimination deficit: inability to identify the right and left sides of one's own body or that of the examiner.

Somatognosia: inability to identify own or other person's body parts and the relationship of one body part to another. Somatognosia is also an impairment in the body scheme.

Spatial-relation deficit: inability to perceive the relationship between self and one or more objects.

Topographical orientation deficit: inability to understand and remember the relationship of one place to another.

Unilateral neglect: inability to register and integrate visual stimuli and perceptions from one side of the environment (usually the left side). Patient ignores stimuli occurring in that side of personal space. The deficit is not attributed to any sensory problem.

Speech and Communication Functions and Impairments

Table 6.17 Speech and Communication Functions and Impairments[1]

Speech and Communication Functions	Impairments
Expressive function: assessment of fluency of speech and speech production	■ Broca's aphasia (nonfluent, expressive, or motor aphasia): speech is interrupted, uncoordinated, difficult to produce, and with awkward articulation. It is the result of a lesion involving the third frontal convolution of the left hemisphere. ■ Verbal apraxia: inability to volitionally articulate as a result of a lesion in the cortical dominant hemisphere. ■ Dysarthria: speech production difficulty caused by motor impairments related to respiration, phonation, articulation, and jaw and tongue movements. It is the result of a lesion in the CNS and PNS.
Receptive function: assessment of comprehension	■ Wernicke's aphasia (fluent or receptive aphasia): auditory comprehension is impaired while speech is spontaneous and flowing smoothly. It is the result of a lesion in the posterior first temporal gyrus of the left hemisphere.
Dysfunction of all language modalities	■ Global aphasia: severe aphasia with impairments in comprehension and speech production, reading comprehension, and writing.

Sensory Function: Sensory Receptors

Table 6.18 Sensory Receptors: Function and Testing

Sensory Receptors	Function and Testing
Barognosis (combined cortical sensations)	Function: ability to recognize different gradations of weight in similar size or shape objects Testing: The physical therapy assistant (PTA) places different weights with the same size (shape), one at a time, in the patient's tested hand. The patient, with eyes closed, is asked to indicate if the weight is "heavier" or "lighter" than the previous one (or comparing bilaterally).
Graphesthesia (combined cortical sensations)	Function: ability to recognize numbers, letters, or symbols traced on the skin Testing: The PTA traces (with a pencil) numbers, letters, or symbols on the patient's tested hand. The patient, with eyes closed, is asked to identify the figures drawn on the skin.
Kinesthesia (deep sensations)	Function: sensation and awareness of active or passive movement Testing: The PTA moves the patient's limb. The patient, with eyes closed, is asked to identify the direction of movement (up or down, in or out) while the limb is in motion. The patient, with eyes closed, may also duplicate the movement with the opposite limb.

(continued)

Table 6.18 Speech and Communication Functions and Impairment *(continued)*

Sensory Receptors	Function and Testing
Pain (superficial sensations)	Function: ability to recognize sharp or dull sensation in response to sharp or dull stimuli Testing: The PTA applies a disposable safety pin or a paper clip to patient's skin. The patient, with eyes closed, is asked to indicate when the stimulus is felt.
Proprioception (deep sensations)	Function: position sense and the awareness of the joints at rest Testing: The PTA positions the patient's limb. The patient, with eyes closed, is asked to identify the limb's position (up or down, in or out).
Stereognosis (combined cortical sensations)	Function: ability to recognize by touch or manipulation of the shape of familiar objects Testing: The PTA gives the patient one object (such as a coin, a key, or a pencil). The patient, with eyes closed, is asked to name the object.
Touch (superficial sensations)	Function: ability to differentiate between touch and nontouch in response to slight touch or no touch Testing: The PTA applies a cotton ball (or a piece of tissue) to the patient's tested skin. The patient, with eyes closed, must respond to PTA ("yes" or "no") to indicate when the stimulus was applied.
Two-point discrimination (combined cortical sensations)	Function: ability to differentiate between one or two blunt points applied to the skin simultaneously (the smallest distance between two stimuli) Testing: The PTA applies simultaneously two stimuli (the rounded part of two paper clips) to the patient's tested skin. The patient, with eyes closed, is asked to differentiate between one or two stimuli. When two stimuli are perceived by the patient, the PTA needs to measure the distance between the stimuli. Consideration must be given to acute perception of stimuli in the distal upper extremities (UEs) as compared with lower extremities (LEs).

Sensory Function: Dermatomes

Dermatomes represent sensory distribution of the cutaneous nerves corresponding to the spinal segments providing their innervation. As part of a sensory assessment, dermatomes are evaluated first as superficial sensations, then as deep or combined (cortical) sensations. Dermatome testing is performed in a distal to proximal direction. It is generally not necessary to test every segment of each dermatome; testing of general body areas is sufficient.

Table 6.19 Dermatomes*

Upper-Extremity Dermatomes
C1: top of the head
C2: temple, forehead, occiput
C3: neck, posterior cheek
C4: superior part of chest above axilla (clavicle area)
C5: lateral aspect of the arm, deltoid muscle region
C6: anterior arm, lateral side of hand to thumb, and index finger

(continued)

Table 6.19 Dermatomes *(continued)*

C7: lateral arm and forearm to index, long, and ring fingers
C8: middle arm and forearm to long, ring, and little fingers
Trunk Dermatomes
T1: medial side of forearm to base of little finger
T2: axillary region
T4: nipple level
T6: xiphoid process level
T10: umbilicus level
T12: anterior superior iliac crest level
Lower-Extremity Dermatomes
L1: lower abdomen and groin region
L2: anterolateral thigh (back and front of thigh to knee)
L3: anteromedial thigh, leg, upper buttock
L4: medial buttock, lateral thigh, medial leg, dorsum of foot, large toe
L5: posterior lateral thigh, lateral leg, dorsum of foot, medial half of sole, first to third toes
S1: lateral plantar surface of foot, posterior thigh and leg
S2: posterior thigh and leg
S3: groin, medial thigh to knee
S4–S5: perineum, genitals, lower sacrum

* For the dermatome chart, see **Figure 6.11**.

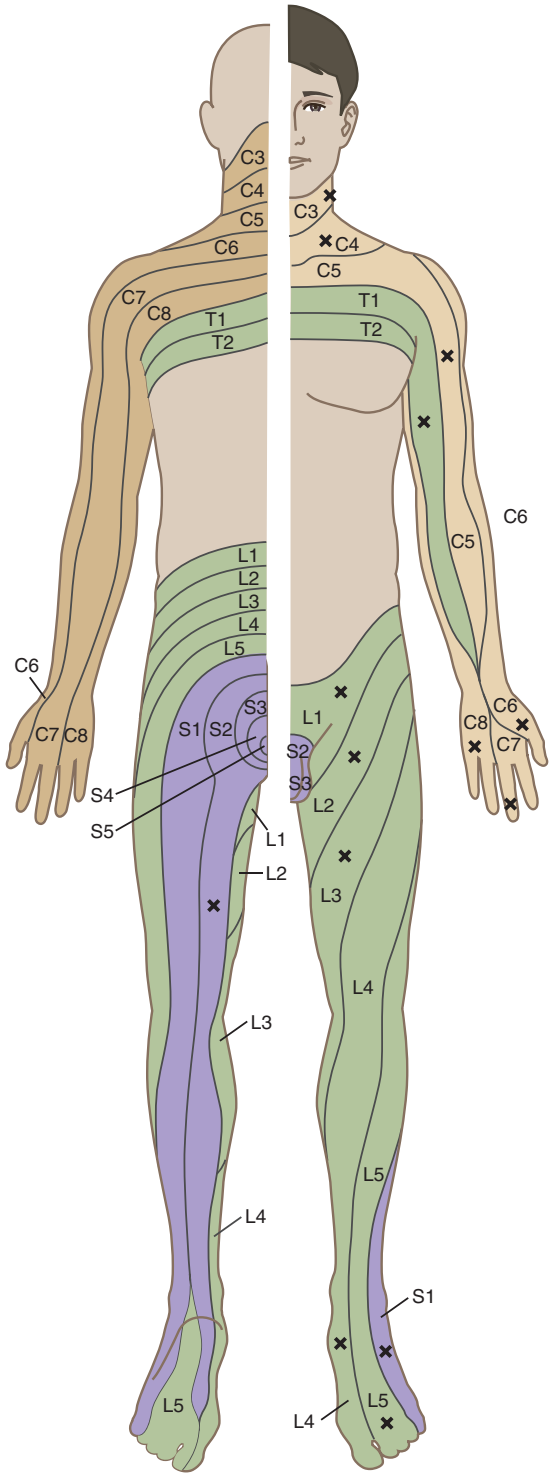

Figure 6.11 Map of dermatomes (specific skin regions to test within each dermatome indicated with an X).

Motor Function: Tonal Abnormalities

Table 6.20 Hypertonia and Hypotonia

- **Clonus:** Cyclical, spasmodic fluctuation of muscle contraction and relaxation in response to a repeated stretch of a spastic muscle. Usually spastic muscles react to a large and quick stretch by increasing their resistance. Clonus is common in plantarflexors and jaw and wrist muscles of upper motor neuron (UMN) lesions.
- **Cogwheel rigidity:** Condition in which tremor coexists with rigidity. It is common in Parkinson's disease. When the PTA moves the patient's extremity passively, it feels like a cogwheel (by letting go, then increasing the resistance to movement).
- **Decerebrate rigidity:** Sustained contraction and posturing of the trunk and extremities in full extension. It indicates a grave condition, in which a lesion is present in the brain stem between the superior colliculi and the vestibular nuclei.
- **Decorticate rigidity:** Sustained contraction and posturing of the trunk and lower extremities in extension and upper extremities in flexion. It is less grave than decerebrate rigidity, with a lesion being present in the corticospinal tract at diencephalon (above superior colliculus).
- **Dystonia:** Prolonged involuntary muscular contractions causing repetitive twisting or writhing of body parts and fluctuations in muscle tone (with increased or decreased muscular tone). This condition can be found in conjunction with CNS lesions (commonly in basal ganglia), neurodegenerative disorders (Wilson's disease or Parkinson's disease), or metabolic disorders (amino acid or lipid). Dystonia can also be found in torticollis, and the primary idiopathic dystonia can be inherited.
- **Flaccidity:** Decreased or absent muscular tone (hypotonia). The extremities are easily moved passively (floppy) without any resistance. This condition is common in conjunction with lower motor neuron (LMN) lesions affecting the anterior horn cell or peripheral nerve and in UMN lesions of the cerebellum or pyramidal tract.
- **Lead-pipe rigidity:** Constant rigidity. It is not dependent on the velocity of passive movement.
- **Rigidity:** Resistance to passive movement involving agonist and antagonist muscles. It is characterized by stiffness and inability to bend or be bent. This condition is caused by a lesion in basal ganglia. It is common in Parkinson's disease.
- **Spasticity**: Increased tone or resistance of muscles. It causes stiff and awkward movements. This condition is a result of an UMN lesion.

Motor Function: Myotatic Reflexes (Stretch Reflexes)

Table 6.21 Stretch Reflexes[4]

Nerve Root	Site and Testing
C5–C6	Biceps: Patient sitting with arm flexed and supported. Tap over the biceps tendon in the cubital fossa. Normal response: elbow flexion.
C7–C8	Triceps: Patient sitting with arm supported in abduction and elbow flexed. Tap over the triceps tendon (above the olecranon). Normal response: elbow extension.

(continued)

Table 6.21 Stretch Reflexes *(continued)*

Nerve Root	Site and Testing
L2–L4	Quadriceps (patellar): Patient sitting with knee flexed (and foot unsupported). Tap over the quadriceps tendon between the patella and tibial tuberosity. Normal response: knee extension.
L5–S2	Medial Hamstrings: Patient prone with knee half-flexed and supported. Tap over the hamstring tendon at the knee. Normal response: knee flexion.
S1–S2	Achilles (ankle): Patient prone with foot over the end of the table. Tap the tendon above its insertion on the calcaneus. Normal response: foot plantarflexion.

Motor Function: Grading Scale for Muscle Stretch Reflex

Table 6.22 Grading Scale for Muscle Stretch Reflex[1,4]

0 Absent: no visible muscle contraction.

1+ Hyporeflexia: slight muscle contraction with little or no joint movement.

2+ Normal: slight muscle contraction with slight joint movement.

3+ Hyperreflexia: brisk (visible) muscle contraction with moderate joint movement.

4+ Abnormal: strong muscle contraction. Patient (client) can have clonus and/or the reflex can spread to the contralateral side.

Motor Function: Babinski's Reflex

Table 6.23 Babinski's Reflex Testing[1,4]

Normal response (negative Babinski sign): no reaction or flexion (plantarflexion) of the great toe when the lateral border of the sole of the foot is stimulated (stroked).

Abnormal response (positive Babinski sign): extension (dorsiflexion) of the great toe, and fanning of the other toes, when the lateral border of the sole of the foot is stimulated (stroked). An abnormal response indicates a lesion of the corticospinal (pyramidal) tract. It is a normal reflex in infants younger than the age of 6 months.

Motor Function: Cranial Nerve Functions and Impairments

Table 6.24 Cranial Nerves: Functions and Impairments

Cranial Nerve (CN)	Functions and Impairments
CN I: olfactory (sensory)	Function: smell Impairment: anosmia (loss of the sense of smell)
CN II: optic (sensory)	Function: vision and pupillary reflexes Impairments: blindness and absence of pupillary reflexes (when shining the light in the eye)
CN III: oculomotor (motor and sensory) Muscles: medial, superior, and inferior rectus; inferior oblique; levator palpebrae superioris	Function: elevates upper eyelids; constricts pupil; moves eyes up/down Impairments: ophthalmoplegia (paralysis of ocular muscles with eye deviation); severe ptosis (difficulty raising the eyelids); mydriasis (abnormal pupil dilation)
CN IV: trochlear (motor and sensory) Muscle: superior oblique	Function: depresses the adducted eye Impairments: weakness in depression of ipsilateral adducted eye; diplopia (double vision)
CN V: trigeminal (motor and sensory) Muscles: masseter; temporalis; pterygoids; mylohyoid; tensor tympani; palatini; anterior belly of digastric	Function: sensation from face, cornea, and muscles of mastication Impairments: loss of facial sensation and corneal reflex; weakness and atrophy of muscles of mastication; deviation of open jaw to ipsilateral side
CN VI: abducent (motor and sensory) Muscle: lateral rectus	Function: abduction of the eye Impairments: diplopia; convergent strabismus (the eye deviates by turning inward); paralysis of ipsilateral eye muscle
CN VII: facial (motor and sensory) Muscles: buccinator; stapedius; stylohyoid; platysma; occipitalis; posterior belly of digastric	Function: facial expression; articulation; winking; food and drink ingestion; nasal and lacrimal secretions; salivary secretions; taste Impairments: paralysis of ipsilateral upper and lower facial muscles; loss of lacrimation; dry mouth and decreased salivation; loss of taste ipsilateral in the anterior two thirds of the tongue
CN VIII: vestibulocochlear (sensory)	Function: hearing; equilibrium Impairments: nerve deafness; disequilibrium; vertigo (sensation of having objects moving around the person); nystagmus (involuntary cyclical movements of the eyes)

(continued)

Table 6.24 Cranial Nerves: Functions and Impairments *(continued)*

Cranial Nerve (CN)	Functions and Impairments
CN IX: glossopharyngeal (motor and sensory) Muscles: stylopharyngeus; superior pharyngeal constrictor	Function: elevates the pharynx; salivary secretions; taste; sensations in the root of the tongue, tonsils, uvula, and soft palate Impairments: minimal dysphagia (difficulty swallowing); partial dry mouth; loss of taste ipsilateral in the posterior third of the tongue; loss of gag reflex; anesthesia in the tonsillar region
CN X: Vagus (motor and sensory) Muscles: palate; pharyngeal constrictors; laryngeal intrinsics	Function: taste; swallowing; phonation; slowing of the heart rate; constriction of bronchioles; increased peristalsis; digestive secretions; sensations to auditory meatus; sensations to pharynx and larynx; visceral sensations Impairments: dysphagia; hoarseness; paralysis of soft palate with deviation of velum and uvula to the contralateral side; anesthesia of pharynx and larynx on the ipsilateral side; anesthesia of ipsilateral auditory meatus
CN XI: spinal accessory (motor and sensory) Muscles: SCM; trapezius	Function: swallowing; phonation; movements of head and shoulder Impairments: muscular weakness in shrugging the shoulders on the ipsilateral side; muscular weakness in turning the head to the opposite side
CN XII: hypoglossal (motor and sensory) Muscles: styloglossus; hyoglossus; genioglossus; tongue intrinsics	Function: movements of the tongue Impairments: atrophy of the ipsilateral muscles of the tongue; tongue deviation to the ipsilateral side on protrusion

Motor Function: Cerebellar Dysfunction Characteristics

Table 6.25 Cerebellar Dysfunction Characteristics[1]

Cerebellar Dysfunction	Characteristics
Ataxia: uncoordinated movements; a combination of cerebellar and sensory dysfunction	Can be observed in the patient's gait, posture, and patterns of movement such as dysmetria and movement decomposition.
Dysarthria: speech articulation dysfunction (also called scanning speech)	Speech is hesitant and slow, with inappropriate pauses and lengthened syllables. The melodic quality of speech is distorted. The patient demonstrates normal word selection and grammar.

(continued)

Table 6.25 Cerebellar Dysfunction Characteristics *(continued)*

Cerebellar Dysfunction	Characteristics
Dysdiadochokinesia: impaired ability to perform rapid alternating movements	The patient is unable to perform rapid forearm supination and pronation. As speed increases, the patient's movements become irregular with rhythm and range deficits.
Dysmetria: inability to judge the distance or range of a movement	The patient is unable to reach an object because of either overestimating or underestimating the distance where the object is located.
Hypotonia: decrease in muscle tone due to cerebellar dysfunction	The patient demonstrates reduced resistance to passive movement. The patient's muscles are soft and flaccid.
Intention (kinetic) tremor: involuntary oscillatory movement of a limb during voluntary motion; intention tremor absent at rest	The patient demonstrates involuntary tremor when trying to reach a target. The tremor increases when the limb is close to the target or when the movement speed increases.
Movement decomposition (dyssynergia): inability to perform a smooth movement at once.	When asked to complete a movement, the patient performs a series of component parts of the movement.
Postural (static) tremor: involuntary oscillatory movement of the body during standing (static) posture	The patient demonstrates involuntary postural tremor back and forth when trying to maintain a standing posture. This tremor may also be observed in a limb held against gravity.

Motor Function: Basal Ganglia Dysfunction Characteristics

Table 6.26 Basal Ganglia Dysfunction Characteristics[1]

Basic ganglia Dysfunction	Characteristics
Akinesia: inability to initiate movement	The patient is unable to start any movement. The patient needs a large amount of concentration and effort to start any limb movement. Akinesia can be found in the late stages of Parkinsonism.
Athetosis; slow, involuntary, twisting movements	The patient demonstrates slow and involuntary twisting or writhing in the upper extremities (mostly hands), neck, tongue, face, and trunk. These movements can be present in combination with spasticity. Athetosis can be found in the athetoid type of cerebral palsy.
Bradykinesia: decrease in size and speed of a movement	The patient demonstrates a slow, shuffling gait, decreased movement, difficulty initiating the movement, or difficulty changing the direction of movement. The patient may also demonstrate decreased arm swing in gait and difficulty stopping when the movement is started. Bradykinesia can be found in Parkinson's disease.

(continued)

Table 6.26 Basal Ganglia Dysfunction Characteristics *(continued)*

Basic ganglia Dysfunction	Characteristics
Chorea: involuntary, rapid, and jerky movements	The patient demonstrates involuntary, rapid, jerky irregular movements of the extremities or facial muscles. Chronic (hereditary) chorea is characteristic of Huntington's disease.
Resting tremor: involuntary, rhythmic, oscillatory movement occurring at rest	The patient demonstrates involuntary tremor in the hands in the form of "pill-rolling" movements (seems as though the patient is rolling a pill between the thumb and the first two fingers). The patient also may have involuntary pronation and supination of the forearm and jaw tremor. Resting tremor is characteristic of Parkinson's disease.
Rigidity: increased muscular tone (see **Table 6.20**)	The patient demonstrates stiffness and ability to bend tone or be bent. Cogwheel rigidity: alternate giving and increased resistance to passive movement. Lead-pipe rigidity: constant resistance to movement. Both are observed in basal ganglia disorders.

Motor Function: Characteristics of Upper Motor Neuron and Lower Motor Neuron Lesions

Table 6.27 UMN Versus LMN[1]

UMN Characteristics (CNS Lesions: Cortex, brainstem, corticospinal tracts, spinal cord)	LMN Characteristics (Cranial nerves and PNS Lesions: anterior horn cell, spinal roots, peripheral nerves)
Typical Pathologies: SCI; CVA; TBI; CP; MS; hydrocephalus	**Typical Pathologies**: polio; tumor of peripheral nerves; peripheral nerve trauma; muscular dystrophy; Guillain-Barré syndrome; Bell's palsy; trigeminal neuralgia
Hypertonicity (dependent on velocity); spasticity (especially in the anti-gravity muscles); contractures; abnormal posturing; deformity	Hypotonicity; flaccidity; proximal weakness (myopathy); distal weakness (neuropathy)
Involuntary muscle spasms in the flexor or extensor muscles	Fibrillation potentials (spontaneous depolarization of muscle fibers not visible through the skin); fasciculations (visible, spontaneous twitching of muscle groups)
Paralysis; paresis	Paralysis
Disuse atrophy (variable and widespread)	Neurogenic atrophy (rapid and severe)
Hyperreflexia; clonus; positive Babinski's sign	Hyporeflexia with diminished or absent deep tendon reflexes; floppy limbs
Dyssynergic patterns of voluntary movements	Weak or absent voluntary movements

Motor Function: Coordination Tests and Scoring

Table 6.28 Coordination Tests and Scoring[1]

Gross motor coordination tests: finger to nose; finger to therapist's finger; finger to finger; forearm supination and pronation; clapping; alternately touch nose to finger; heel on shin; foot tapping; alternate heel to knee; alternate heel to toe

Fine motor coordination tests: thumb to finger opposition; grasp and release test; standardized tests (i.e., Pegboard test, Hand Tool Dexterity Test)

Coordination Scoring

0 = unable

1 = severe impairment

2 = moderate impairment

3 = minimal impairment

4 = normal performance

Motor Function: Balance Tests and Scoring

Table 6.29 Balance Tests and Scoring[4]

- Standing static balance test (eyes open to eyes closed): patient stands in double limb stance; patient stands in single limb stance. Double and single limb stance can also be tested on less stable positions, i.e., foam square, pillows.
- Romberg static balance test (eyes open to eyes closed): patient stands with feet in normal stance position. This test can detect ataxia.
- Sharpened Romberg static balance test (eyes open to eyes closed): patient stands in a tandem heel to toe position. This test is more sensitive than the Romberg static balance test.
- Dynamic balance tests: patient stands, walks, turns, and stops; patient demonstrates tandem walking (placing the heel of one foot directly in front of the toe of the opposite foot); patient demonstrates walking sideways, backward, and cross-stepping. Additional activities can be added to assess ability to maintain balance while moving, i.e., carrying an object, counting, stepping over objects.
- Functional balance tests (See Appendix B for detail on each test.)
  1. Berg Balance Scale: measures skill on fourteen functional activities
  2. Functional reach test: patient stands without support and reaches forward as far as possible with shoulder at 90° flexion, elbow extended, and hand fisted without losing balance
  3. Tinetti POMA mobility test: measures skill on six functional activities such as sitting balance, standing on one leg, turning, ambulation, stepping over obstacles
  4. Timed get up and go test

Balance Scoring

Normal = patient maintains steady static balance without support and for dynamic balance can shift weight in all directions

(continued)

Table 6.29 Balance Tests and Scoring *(continued)*

Good = patient maintains static balance without support and for dynamic balance can pick objects off the floor

Fair = patient maintains static balance with handhold and for dynamic balance can maintain balance while turning the head and trunk

Poor = in static balance patient requires handhold and support and dynamically is unable to accept any challenge or to move without loss of balance

Motor Deficits Associated with Cerebral Vascular Accident: Abnormal Synergy Patterns

Table 6.30 CVA Synergy Patterns

- Upper-extremity flexion synergy: scapular retraction and elevation or hyperextension; shoulder abduction and external rotation; elbow flexion (strong component); forearm supination; wrist and finger flexion
- Upper-extremity extension synergy: scapular protraction; shoulder adduction (strong component) and internal rotation; elbow extension; forearm pronation (strong component); wrist and finger flexion
- Lower-extremity flexion synergy: hip flexion (strong component), abduction, and external rotation; knee flexion; ankle dorsiflexion and inversion; toe dorsiflexion
- Lower-extremity extension synergy: hip extension, adduction (strong component), and internal rotation; knee extension (strong component); ankle plantarflexion (strong component) and inversion; toe plantarflexion

Brunnstrom's Spasticity Patterns

Table 6.31 Brunnstrom's Spasticity Patterns

- Head rotation to the unaffected side and lateral flexion to the affected (hemi) side
- Shoulder adduction and internal rotation
- Scapula retraction and depression
- Elbow flexion and forearm pronation (can also be supination)
- Wrist flexion and ulnar deviation and fingers/thumb flexion and adduction
- Pelvis elevation and backward rotation
- Hip extension, adduction, and internal rotation
- Knee extension and foot plantarflexion and inversion
- Toes flexion and adduction

Motor Deficits Associated with Cerebral Vascular Accident: Brunnstrom's Stages of Recovery

Table 6.32 Brunnstrom's Six Stages of Recovery

Stage 1: Patient starts to recover from hemiplegia. Patient exhibits the following: flaccidity; hyporeflexia; no voluntary movement of the affected upper and lower extremities.

Stage 2: Patient exhibits the following: beginning of spasticity; hyperreflexia; strong synergy patterns of the affected upper and lower extremities; minimal voluntary movement of the affected areas (including upper and lower extremities).

Stage 3: Patient exhibits the following: severe spasticity; voluntary movement of the affected upper and lower extremities only in synergy patterns.

Stage 4: Patient exhibits the following: spasticity begins to decrease; synergy begins to decrease; beginning of voluntary movement without synergy.

Stage 5: Patient has the capability to progress in the recovery process. If progress continues, patient exhibits the following: minimal synergy patterns; more complicated learned movement (motor) patterns without synergy; coordination deficits.

Stage 6: Patient has the capability to progress to normal. If progress continues, patient exhibits no spasticity, and motor control and coordination are restored to normal.

Cerebral Vascular Accident: Gait Deficits

Table 6.33 CVA Gait Deficits

Hip

- Retraction (caused by trunk and limb spasticity)
- Hiking (caused by weak abdominals)
- Trendelenburg limp (caused by weak abductors)
- Circumduction (caused by hamstrings spasticity, foot drop, and/or decreased ROM in hip/knee flexion)
- Scissoring (caused by adductors spasticity)
- Poor proprioception
- Exaggerated hip flexion (because of the flexor synergy)

Knee

- Increased flexion in stance (caused by hamstrings spasticity and/or weak quadriceps)
- Hyperextension in stance (caused by plantarflexion contracture and/or weak quadriceps)
- Inadequate knee flexion (caused by inadequate hip flexion and/or spastic quadriceps)
- Inadequate knee extension (caused by spastic hamstrings)
- Poor proprioception

(continued)

Table 6.33 CVA Gait Deficits *(continued)*

Ankle and Foot

- Equinus gait when the heel does not touch the ground (caused by spasticity or contracture of gastrocnemius and soleus)
- Foot drop (paralysis of dorsiflexors)
- Unequal step length (caused by spastic toe flexors and pain on flexed toes)
- Equinovarus (caused by spastic posterior tibialis and/or gastrocnemius and soleus)
- Exaggerated dorsiflexion (caused by flexor synergy)

Traumatic Spinal Cord Injury: Mechanisms of Injury

Table 6.34 Traumatic SCI: Mechanisms of Injury

- *Flexion injury* is the most common mechanism of injury in SCI, causing high percentages of lumbar or cervical SCI at levels T12 to L2 and C4 to C7. Flexion injuries can cause the following: fractures of the anterior vertebral body, spinal processes, pedicles, and laminae; tearing of the posterior spinal ligaments; disk disruptions; and dislocation of the anterior vertebral body.
- *Flexion–rotation injury* can cause the following: fractures of the posterior pedicles, laminae, and articular facets; dislocations or subluxations of faucet joints; and tearing of the posterior and interspinous ligaments.
- *Compression injury* can cause the following: concave fractures of the spinal endplates; comminuted fractures; teardrop fractures; ruptures of the intervertebral disk.
- *Hyperextension injury* can cause the following: fractures of the spinous processes, faucets, and laminae; avulsion fractures of anterior aspect of vertebrae; tearing of the anterior longitudinal ligament; disk rupture.

* Spinal areas of greatest frequency of injury: C5–C7 and T12–L2

Spinal Cord Injury Syndromes

Table 6.35 SCI Syndromes

- *Anterior cord syndrome* (ACS) can produce the following: loss of motor function below the level of lesion (caused by damage to the corticospinal tract); loss of the sense of pain and temperature below the level of lesion (caused by damage to the spinothalamic tract); and preservation of the proprioception, kinesthesia, and vibratory senses below the level of lesion. ACS can be caused by flexion injury of cervical region with damage of the anterior spinal cord and/or anterior spinal artery.
- *Brown-Sequard syndrome* can produce the following: ipsilateral loss of sensation of the dermatome corresponding to the level of lesion; contralateral loss of the sense of pain and temperature of several dermatomes below the level of lesion; and ipsilateral loss of motor function (characterized by decreased DTRs, clonus, and positive Babinski sign), proprioception, kinesthesia, and vibratory sense. Brown-Sequard syndrome can be caused by hemisection of the spinal cord with damage on one side of spinal cord (from gunshots or stabbing attacks).

(continued)

Table 6.35 SCI Syndromes *(continued)*

- *Cauda equina injury* (lower motor neuron injury) typically produces an incomplete lesion with a potential for regeneration.
- *Central cord syndrome* (CCS) can produce the following: severe motor loss in the upper extremities; less severe motor loss in the lower extremities; mild and varying degrees of sensory impairments; and preservation of sacral tracts and bowel, bladder, and sexual functions. Patients may be able to ambulate with some distal upper-extremity weakness (especially after surgeries to relieve cervical compression). CCS can be caused by hyperextension injury of the cervical spine (from motor vehicle accidents) or congenital narrowing of the spinal canal.
- *Posterior cord syndrome* (PCS) can produce the following: loss of proprioception, two-point discrimination, and stereognosis below the level of lesion; and preservation of motor function, sense of pain, and light touch. PCS can be caused by tabes dorsalis due to late-stage syphilis. PCS is very rare.
- *Sacral sparing* can produce the following: incomplete lesion with varying innervation from the intact sacral segments; preserved perianal sensation; and preserved contraction of the external anal sphincter.

Classification of Spinal Cord Injury

Table 6.36 SCI Classification[3,5]

The American Spinal Injury Association[3,5] classifies SCI injuries as follows:

1. Tetraplegia: complete paralysis of all upper and lower extremities and trunk, including the respiratory muscles due to lesion of the cervical spinal cord
2. Paraplegia: complete paralysis of both lower extremities and part of the trunk due to lesion of the thoracic or lumbar spinal cord or cauda equina

SCI is also classified by the American Spinal Injury Association into the following categories:

1. ASIA A: Complete with no sensory or motor function in the lowest sacral segments (S4 and S5)
2. ASIA B: Incomplete with sensory function but not motor function preserved below the neurologic level (including sacral segments S4 and S5)
3. ASIA C: Incomplete with motor function preserved below the neurologic level, and more than half of key muscles below the neurological level have a muscle grade less than 3
4. ASIA D: Incomplete with motor function preserved below the neurological level, and at least half of key muscles below the neurological level have a muscle grade of 3 or more
5. ASIA E: Normal with normal motor and sensory functions

Levels of lesion are also classified as follows:

1. Neurologic level of lesion: the most caudal segment of the spinal cord with normal motor and sensory function on the right and left sides of the body
2. Motor or sensory level of lesion: the most caudal segment of spinal cord with bilateral motor and sensory normal function
3. Motor level: determined by MMT testing of a key muscle (on right or left) at a myotome adjacent to the suspected level of impairment
4. Sensory level: determined by testing light touch and pin prick (on right or left) at a key dermatome

Data from Umphred D, Lazaro RT. Neurorehabilitation for the Physical Therapist Assistant (2nd ed). Thorofare: SLACK Incorporated; 2014. American Spinal Injury Association. Standard neurological classification of spinal cord injury. Available at: http://asia-spialinjury.org/wp-content/uploads/2016/02/International_Stds_Diagram_Worksheet. pdf. Accessed March 2016.

Traumatic Spinal Cord Injury: Functional Capabilities and Assistance

Table 6.37 SCI Functional Capabilities and Assistance[1,3]

Most Distal Nerve Root Segments Innervated: C1, C2, C3 Levels

- Requirements: full-time attendant; mechanical ventilator or phrenic nerve stimulator during the day; environmental control units to activate light switches, call buttons, and electrical appliances, to turn pages of books, and for speaker phone
- Patient function and assistance: totally dependent on assistance with activities of daily living (ADLs) and transfers; independent when using a power wheelchair (with an electrically controlled reclining back or tilt in space) that has a portable mechanical ventilator, and a mouthstick or sip-and-puff controls; has wheelchair and bed skills
- Key muscles: face and neck muscles and cranial innervation
- Available movements: talking, sipping, blowing, and mastication

Most Distal Nerve Root Segment Innervated: C4 Level

- Requirements: full-time attendant; power tilt-in-space wheelchair (for pressure relief); arm supports (orthotics, flexor hinge hand splint) and adapted eating equipment for a small degree of self-feeding; environmental control units to activate light switches, call buttons, and electrical appliances to turn pages of books and for speaker phone
- Patient function and assistance: totally dependent on assistance with ADLs, transfers, coughing, glossopharyngeal breathing, and skin inspection; can use head or mouth stick (or sip-and-puff, or hand splint) for typing on the computer keyboard and is able to play table games (such as cards or checkers), paint, or draw; independent when using a power wheelchair with head, mouth, chin, or sip-and-puff controls; has wheelchair and bed skills
- Key muscles: diaphragm and trapezius
- Available movements: respiration and elevation of scapula

Most Distal Nerve Root Segment Innervated: C5 Level

- Requirements: part-time attendant; equipment setup; mobile arm supports, deltoid aid, and adapted utensils and splints for self-feeding; adapted equipment for limited self-care activities such as grooming and washing; hand splints or typing sticks for typing on the computer keyboard; power tilt-in-space wheelchair for pressure relief; sliding board
- Patient function and assistance: dependent on some assistance and setup for ADLs, dressing, transfers with sliding board and overhead swivel bar, skin inspection, and coughing with manual pressure to diaphragm; can drive a van with hand controls; has bed and wheelchair skills; independent when using a manual wheelchair with hand-rim projections and a power wheelchair with arm controls; can self-feed and can do pressure relief
- Key muscles: biceps, brachialis, brachioradialis, deltoid, infraspinatus, rhomboids, and supinator
- Available movements: elbow flexion and supination, shoulder abduction to 90° and external rotation, and limited shoulder flexion

Most Distal Nerve Root Segment Innervated: C6 Level

- Requirements: side rails on the bed; universal cuff and adapted utensils for self-feeding; adaptive equipment for dressing and grooming (button hook, zipper pulls); adaptive equipment for bowel and bladder and self-care (in the shower); hand controls and U-shaped cuff for steering wheels; adaptive equipment for self-preparation of occasional light meals

(continued)

Table 6.37 SCI Functional Capabilities and Assistance *(continued)*

- Patient function and assistance: dependent on very little assistance for ADLs; can independently (with adaptive equipment) self-feed, dress (uses momentum), perform self-care and bowel and bladder care, transfer (with sliding board), do skin inspection, cough (with pressure to abdomen), drive, prepare light meals, and play wheelchair sports; cannot tie shoes; has bed and wheelchair skills; can use the manual wheelchair with hand-rim projections all the time, and the power wheelchair for long distances and in the community
- Key muscles: ECR, infraspinatus, latissimus dorsi, pectoralis major (clavicular portion), pronator teres, serratus anterior, and teres minor
- Available movements: shoulder flexion, adduction, extension, and internal rotation, abduction and upward rotation of scapula, forearm pronation, and wrist extension (tenodesis grasp)

Most Distal Nerve Root Segment Innervated: C7 Level

- Requirements: adaptive equipment for dressing (button hook) and self-care (shower chair, hand-held shower nozzle, and bathroom handles); bowel and bladder care adaptive equipment (digital stimulator, raised toilet seat, urinary drainage device); sliding board; wheelchair-accessible kitchen; hand controls for the car; adaptive kitchen tools
- Patient function and assistance: independent with ADLs, self-feeding, dressing, self-care, transfers (with or without sliding board), bowel and bladder care, manual coughing, light housekeeping, and driving; is able to get in and out of the car; has bed and wheelchair skills; independent when using a manual wheelchair with friction surface hand rims
- Key muscles: EPL, EPB, FCR, triceps, and extrinsic finger extensors
- Available movements: elbow extension, finger extension, and wrist flexion

Most Distal Nerve Root Segments Innervated: C8 to T1 Levels

- Requirements: some adaptive equipment for self-care (tub seat, grab bars); adaptive equipment for housekeeping; hand controls for the car
- Patient function and assistance: independent with ADLs, light housekeeping, meal preparation, transfers, and driving; can work (in an architectural-barriers free environment); has bed and wheelchair skills; independent with a manual wheelchair with standard hand rims
- Key muscles: FCU, FPL, FPB, and intrinsic and extrinsic muscles of finger flexors
- Available movements: all movements of the muscles of the upper extremities, fine coordination, and strong grasp

Most Distal Nerve Root Segments Innervated: T4 to T6 Levels

- Requirements: standing table or standing frame; bilateral knee ankle foot orthoses (KAFOs), reciprocating gait orthoses (RGOs) for limited ambulation
- Patient function and assistance: independent with bed skills, ADLs, wheelchair skills, transfers, and routine housekeeping; can negotiate curbs and perform the "wheelie" in a manual wheelchair; can participate in wheelchair sports; can perform physiological standing at a standing table (standing frame) using KAFOs; may ambulate for short distance with KAFOs or RGOs
- Key muscles: long muscles of the back (sacrospinalis and semispinalis) and the top half of the intercostal muscles
- Available movements: stronger trunk control musculature, pectoral muscles improvement (for lifting), and increased respiratory reserve musculature

(continued)

Table 6.37 SCI Functional Capabilities and Assistance *(continued)*

Most Distal Nerve Root Segments Innervated: T9 to T12 Levels

- Requirements: bilateral KAFOs, RGOs, crutches, or walker
- Patient function and assistance: independent with household ambulation when using bilateral KAFOs or RGOs and crutches (or walker); uses wheelchair only for energy conservation
- Key muscles: intercostal and lower abdominal
- Available movements: improvement with trunk control and endurance

Most Distal Nerve Root Segments Innervated: L2, L3, and L4 Levels

- Requirements: bilateral KAFOs or AFOs (L3-L4) and crutches
- Patient function and assistance: able to perform independently functional ambulation when using bilateral KAFOs and crutches; uses wheelchair only for energy conservation
- Key muscles: iliopsoas, quadratus lumborum, rectus femoris, gracilis, and sartorius
- Available movements: hip adduction and flexion, and knee extension

Most Distal Nerve Root Segments Innervated: L4 and L5 Levels

- Requirements: bilateral AFOs and crutches (or canes)
- Patient function and assistance: able to perform independently functional ambulation when using bilateral AFOs and crutches (or canes); uses wheelchair only for convenience and energy conservation
- Key muscles: extensor digitorum, lower back musculature, quadriceps, medial hamstrings (weak), and anterior and posterior tibialis
- Available movements: very good trunk control, hip flexion and knee extension, and weak knee flexion

Classification of Multiple Sclerosis

Table 6.38 MS Categories[1,3]

- Relapsing-remitting MS: the most common type of MS; periods of relapses with acute worsening of the disease and periods of remission with partial or complete disappearance of the disease
- Secondary-progressive MS: starts as relapsing-remitting MS and then progresses with or without relapses and remissions
- Progressive-relapsing MS: commonly seen in patients who develop the disease after 40 years of age; steady progressive type that starts with acute, clear signs and symptoms that steadily worsen; may or may not have episodes or remission
- Primary-progressive MS: a rare form of MS with late onset (after age 40), which progresses constantly without periods of remission

Classification of Amyotrophic Lateral Sclerosis

Table 6.39 ALS Categories[3]

- ALS is a rapidly progressing neurodegenerative disease process that affects the respiratory system, which results in death due to respiratory compromise. This progressive decline typically occurs within 2–5 years after initial diagnosis.
- There are three phases with a total of six stages (see **Box 6-1**).
- Rehabilitation focus initially is on preservation of the cardiovascular system and musculoskeletal system. In the end stages, caregiver training focuses on transfers, respiratory care, and integumentary checks as the patient becomes more confined to bed.

BOX 6-1 Amyotrophic lateral sclerosis stages summary
ALS—Summary of the Stages

Phase I: Independent

Stage 1: Patient presents with mild weakness without limitations in function.

Stage 2: Patient exhibits definite weakness in some muscle groups.

Stage 3: Patient's muscle weakness affects ADLs, especially in the extremities, although independence is still demonstrated and compensation is observed. Respiratory function is beginning to be compromised.

Phase II: Partially Independent

Stage 4: Patient able to perform most ADLs with adaptations but fatigues quickly. Mobility is primarily through the use of a wheelchair.

Stage 5: Both upper and lower extremities demonstrate severe weakness, limiting the individual's ability to function independently.

Phase III: Dependent Final Stage

Stage 6: Patient is bed dependent and requires maximum assistance for all activities.

Reproduced from Neurorehabilitation for the PTA by Darcy A. Umphred and Roland T. Lazaro, page 380; Box 13-1 "Summary of the Stages of ALS."

Classification of Disability Associated with Parkinson's Disease

Table 6.40 Hoehn and Yahr Classification[1]

Stage	Character of Disability
I	Mild symptoms: unilateral disease
II	Bilateral involvement. Balance not impaired.

(continued)

Table 6.40 Hoehn and Yahr Classification *(continued)*

Stage	Character of Disability
III	Mild to moderate bilateral disease with some postural instability. Some activities restricted, but patient can live independently and continue some forms of employment.
IV	Severe disability. Able to stand and walk unassisted.
V	Confined to bed or wheelchair unless aided.

SECTION 6-3

Types of Neurologic Interventions

Motor Function Interventions: Postural Strategies to Regain Balance

Table 6.41 Balance Strategies[1]

Ankle Strategy: response to small perturbations
Muscles are activated in a distal to proximal sequence. Patient maintains balance by using the ankle musculature (dorsiflexors and plantarflexors). Patient shifts the center of mass forward or backward while keeping the lower extremities relatively rigid. If loss of balance is in a forward direction gastrocnemius is activated followed by the hamstrings and finally the paraspinals. If loss of balance is in a backward direction the anterior tibials are activated followed by the quads and abdominal muscles.
Hip Strategy: response to a rapid or large perturbation
Muscles are activated in a proximal to distal sequence. Patient maintains balance by using the hip and lower trunk musculature. If loss of balance occurs in a forward direction the abdominals are activated first followed by the quads. If loss of balance occurs in a posterior direction the paraspinals are activated first followed by the hamstrings.
Stepping Strategy: response to a large force
Results in center of mass moving outside limits of stability. Patient takes a step (forward, backward, or to the side) to realign the center of mass within the base of support and regain balance.

Motor Function Interventions: Developmental Motor Skills (Essential Functional Skills)

Table 6.42 Developmental Motor Skills[1]

Mobility: ability to move from one position to another. Examples include rolling, supine to side lying and back, side lying to sit and back, sitting to standing and back.
Stability (or static postural control): ability to maintain static postural stability and orientation. It is also the same as static balance (or equilibrium)—the ability to maintain the center of mass over the base of support without any motion. Examples include prone on elbows, half-kneeling, kneeling, quadruped, plantigrade, and standing.
Controlled mobility (or dynamic postural control): ability to maintain dynamic postural stability and orientation. It is also the same as dynamic balance (or equilibrium)—the ability to maintain the center of mass over the base of support during motion. Examples include weight shifting while the body is in motion and reaching while the body is in motion.
Skill: ability to consistently perform coordinated movement sequences while interacting with others or for functional activities in the home, community, and work. Patients with skill deficits have poorly coordinated movements and lack of control, precision, and consistency. Examples include reaching and manipulation using upper extremities as well as walking and talking.

Motor Function Interventions: Restore Movement and Functional Mobility (Using Developmental Sequence Postures)

Table 6.43 Interventions Using the Developmental Sequence Postures[1]

Prone on Elbows Posture (Figure 6.12)

- Places weight bearing throughout the shoulders and elbows
- Improves control of the upper trunk, upper extremity, neck, and head
- Increases strength in shoulder stabilizers musculature
- Increases range of motion (ROM) into spinal extension
- Produces a wide base of support and a low center of gravity

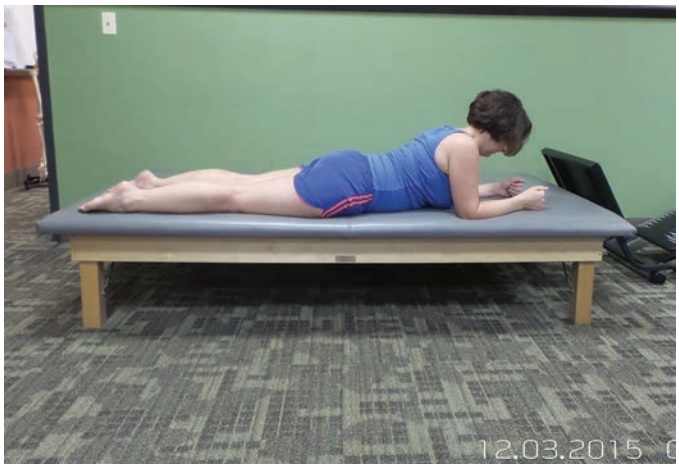

Figure 6.12 Prone on elbows

Quadruped Posture (Figure 6.13)

- Places weight bearing throughout the shoulders, elbows, wrists, knees, and hips
- Improves control of the upper trunk, lower trunk, upper and lower extremities, neck, and head
- Increases strength in the shoulders and hip stabilizers
- Decreases extensor tone at the knees
- Increases ROM in extension at the wrists and fingers
- Produces a wide base of support and a low center of gravity

(continued)

Table 6.43 Interventions Using the Developmental Sequence Postures *(continued)*

Figure 6.13 Quadruped

Kneeling and Half-Kneeling Posture (Figures 6.14, 6.15, 6.16)

- Places weight bearing throughout the knees and hips and ankles (in half-kneeling)
- Improves control of the upper/lower trunk, lower extremity, head, and neck
- Increases strength in hip stabilizers
- Decreases extensor tone at the knees
- Improves balance reactions
- Produces a narrow base of support and a high center of gravity in kneeling
- Produces a wide base of support and a high center of gravity in half-kneeling

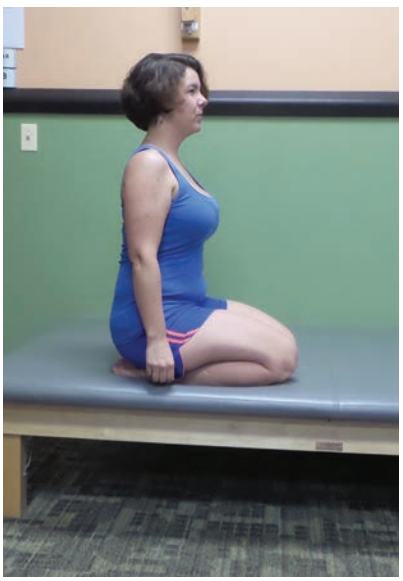

Figure 6.14 Short kneeling

(continued)

Table 6.43 Interventions Using the Developmental Sequence Postures *(continued)*

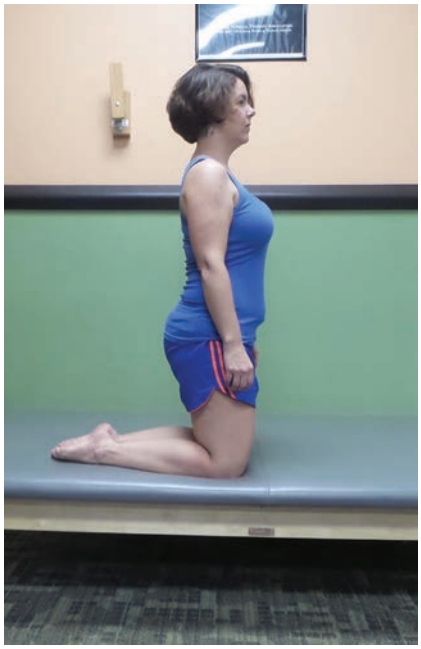

Figure 6.15 Tall kneeling

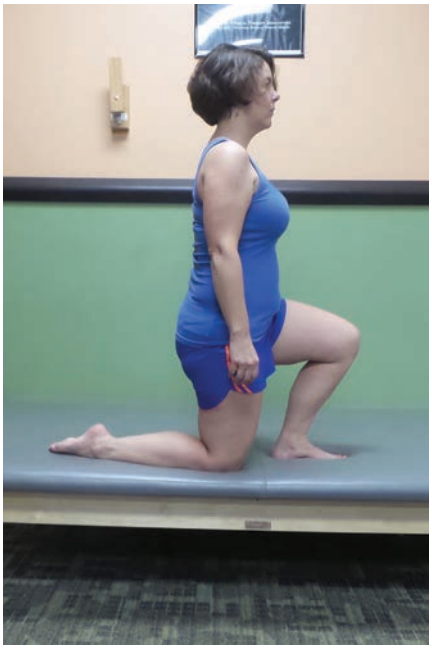

Figure 6.16 Half-kneeling

(continued)

Table 6.43 Interventions Using the Developmental Sequence Postures *(continued)*

Bridging Posture (Figure 6.17)

- Places weight bearing throughout the feet and ankles
- Improves control of the lower extremities (if bilateral) and trunk
- Increases strength in the hip stabilizers
- Is a lead-up activity for bed mobility
- Produces a wide base of support and a low center of gravity

Figure 6.17 Bridging

Sitting Posture (Figure 6.18)

- Places weight bearing throughout the upper extremities
- Improves control of the head, neck, upper and lower trunk, and lower extremities
- Improves balance reactions
- Is a functional posture
- Produces a medium base of support and center of gravity

(continued)

Table 6.43 Interventions Using the Developmental Sequence Postures *(continued)*

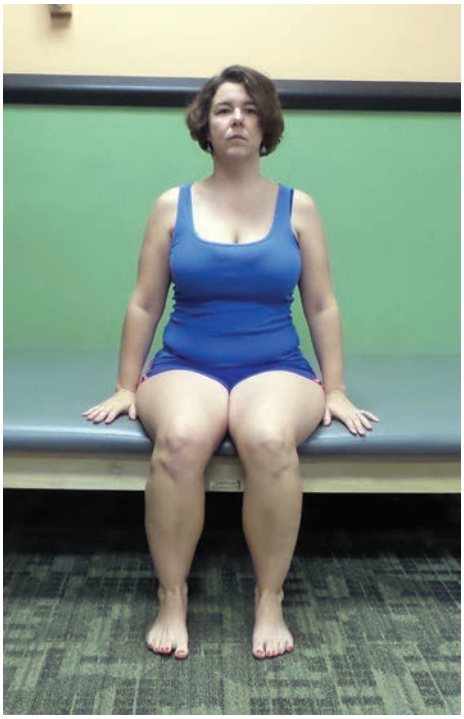

Figure 6.18 Sitting

Modified Plantigrade Posture (Figure 6.19)

- Places weight bearing throughout the joints in the upper and lower extremities
- Improves control of the head, neck, upper and lower trunk, and upper and lower extremities
- Improves balance reactions
- Increases ROM in extension at the wrists and fingers
- Is a functional posture
- Produces a wide base of support and a high center of gravity

(continued)

Table 6.43 Interventions Using the Developmental Sequence Postures *(continued)*

Figure 6.19 Plantigrade

Standing Posture (Figure 6.20)

- Places weight bearing throughout the lower extremities
- Improves control of the head, neck, upper and lower trunk, and lower extremities
- Improves balance reactions
- Is a functional posture
- Produces a narrow base of support and a high center of gravity

(continued)

Table 6.43 Interventions Using the Developmental Sequence Postures *(continued)*

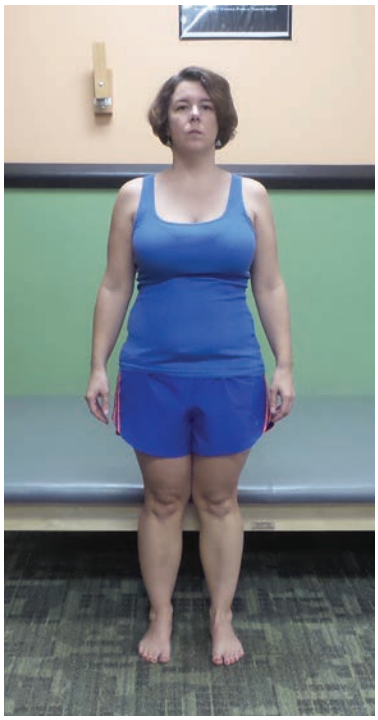

Figure 6.20 Standing

Motor Function Interventions: Basic Motor Learning Strategies

Table 6.44 Basic Motor Learning Strategies[1]

Cognitive ("What to Do" Decision) Stage of Learning the Skill

The PTA can do the following:

- Explain the purpose of the skill.
- Demonstrate the skill, accentuating the correct performance.
- Ask the patient to explain the task, its components, and its requirements.
- Point out the similarities of the learned task to other tasks.
- Use knowledge of performance feedback by focusing on errors as they become consistent. (PTA does not concentrate on large numbers of random errors.)
- Use knowledge of results feedback by focusing on successful performance.
- For feedback, ask the patient to watch the correct movement.

(continued)

Table 6.44 Basic Motor Learning Strategies *(continued)*

- Ask the patient to evaluate his or her performance.
- Use feedback after each trial in the early learning.
- Use variable feedback later.
- Organize the initial practice of the task.
- Stress controlled movement.
- Provide adequate rest periods.
- Use manual guidance (physically assisting the learner to perform the task; does not overuse assistance in later stages).
- Break complex tasks into simple components.
- Use repeated practice of the same task.
- Use serial or random practice (when a variety of tasks are practiced randomly across trials) of related skills.
- Use mental practice.
- Avoid stressors and mental fatigue.
- Structure the environment by reducing extraneous stimuli and distractors.
- Emphasize a closed environment before moving the patient into an open environment.

Associative ("How to Do" Decision) Stage of Learning the Skill

The PTA can do the following:

- Use knowledge of performance feedback by focusing on errors as they become consistent. (PTA does not concentrate on large numbers of random errors.)
- Use knowledge of results feedback by focusing on successful performance and stressing the relevance of the task to the function.
- Emphasize proprioceptive feedback (the patient's own feeling of the movement).
- Assist the learner to improve self-evaluation and decision-making skills.
- Encourage the patient to self-assess achievements.
- Use variable feedback: summed feedback—feedback use after a set number of trials; faded feedback—feedback given at first after every trial and then less frequently; bandwidth feedback—feedback given when the performance is outside a given error range.
- Avoid excessive augmented feedback.
- Encourage consistency of performance.
- Focus on variable practice order of related skills.
- Progress toward an open environment.
- Change the environment.
- Prepare the learner for the home, community, and work environments.

Autonomous ("How to Succeed" Decision) Stage of Learning the Skill

The PTA can assess need for conscious attention and automaticity of movements:

- Select appropriate feedback: the learner demonstrates appropriate self-evaluation and decision-making skills; when errors are evident, use occasional knowledge of performance feedback or knowledge of results feedback.

(continued)

Table 6.44 Basic Motor Learning Strategies *(continued)*

- Organize practice: stress consistency in variable environments; practice in open environments; use massed practice when the rest time is much less than the practice time.
- Structure the environment: vary environments; help the patient to be ready for the home, community, and work environments; focus on competitive aspects of the task.

Neurologic Facilitation Techniques

Table 6.45 Neurologic Facilitation Interventions[1]

- **Agonist reversals (AR):** slow, resisted concentric contraction of agonist muscles moving through the range, followed by a holding contraction in the range position and then an eccentric contraction while moving slowly back to the initial starting position. AR is a proprioceptive neuromuscular facilitation (PNF) technique.
- **Approximation (AP):** compression of joint surfaces to facilitate extensor muscular contractions and provide joint stability. It can be applied manually, during upright positions, in weight-bearing positions, and in PNF extensor patterns. AP can be applied mechanically using weights, belts, or weighted vests, or while bouncing on a Swiss ball. AP can also be applied to the shoulders or pelvis in upright weight-bearing positions such as in sitting, standing, or kneeling. AP is contraindicated in inflamed joints. AP is a PNF technique.
- **Contract–relax (CR):** strong, isotonic contraction (rotation) of the antagonists (restricting muscles) in a limited ROM, followed by an isometric contraction that is held for 5–8 seconds. Next, voluntary relaxation takes place, followed by active contraction of the agonist muscles into the newly acquired ROM. CR is a PNF technique.
- **Hold–relax (HR):** strong, isometric contraction of the antagonists (restricting muscles) in the limited ROM, followed by a voluntary relaxation and passive range of motion (PROM) of the agonists into the newly gained range. HR is a PNF technique.
- **Hold–relax active contraction (HRAC):** strong, isometric contraction of the antagonists (restricting muscles) in the limited ROM, followed by a voluntary relaxation and active range of motion (AROM) of the agonists into the newly gained range. HRAC is a PNF technique.
- **Joint traction (JT):** manual distraction (or mechanical distraction using ankle or wrist cuffs) to facilitate joint motion and enhance joint awareness. JT can be used in PNF flexor extremity patterns with pulling movements. This technique is contraindicated in patients with hypermobile or unstable joints. JT is a proprioceptive facilitation technique.
- **Manual contacts (MCs):** manual contacts with deep pressure (grip) over the muscles to facilitate muscular contraction. MCs are applied in the direction opposite to the desired motion. MCs guide the direction of movement, provide sensory awareness, and are cues to movement. MC is a proprioceptive facilitation technique.
- **Maximal resistance (MR):** the maximum resistance tolerated by the patient applied in PNF patterns to stronger muscles to create an overflow pattern of the weaker muscles. The overflow is the spread of muscular response from the stronger muscles to the weaker ones. MR is a PNF technique.
- **Muscle positioning (MP):** performed in the midrange for greatest muscular tension; in short ranges for weak contractile force; and in the lengthened range for strong muscular contraction that is enhanced by the stretch mechanism. MP is a PNF technique.
- **Quick stretch (QS):** short stretch applied to a weak muscle in the lengthened range using the diagonal PNF patterns to facilitate the agonist muscular contraction. An example of QS is tapping over the muscle belly or the tendon. QS is a proprioceptive facilitation technique.

(continued)

Table 6.45 Neurologic Facilitation Interventions *(continued)*

- **Repeated contractions (RCs):** repeated isotonic contractions with quick stretches and resistance performed through the range or part of the range at a point of weakness. RC is a PNF technique.
- **Resistance:** resistance applied to weak muscles. Resistance can be manual (graded); body weight and gravity using upright positions; mechanical (weights, cuffs, vests); or isokinetic. Resistance is a proprioceptive facilitation technique.
- **Resisted progression (RP):** stretching, approximation, and tracking light resistance applied manually (or using a T-band) to the patient's pelvis during locomotion. This technique should not disrupt the patient's coordination, momentum, and velocity. Indications for RP are improved timing and control of the lower trunk or pelvis muscles during locomotion and increased endurance. RP is a PNF technique.
- **Rhythmic initiation (RI):** voluntary muscular relaxation, followed by passive movements, active assisted and active resistive movements (using light resistance), and finally active movements. Indications for RI: spasticity, rigidity (as in PD), difficulty initiating movement (as in PD), aphasia, and inability to relax. RI is a PNF technique.
- **Rhythmic stabilization (RS):** alternating resisted isometric contractions of first the agonist and then the antagonist muscles without any motion allowed. Indications for RS are to increase muscular strength and coordination. RS is a PNF technique.
- **Slow reversals (SRs):** isotonic contractions of first the agonist muscles and then the antagonist muscles using graded resistance. The resistance is applied first to the stronger muscles, progressing to the weaker muscles. At the end, the limb is moved through the full ROM. SR is a PNF technique.
- **Timing for emphasis (TE):** resistive (strong) isometric contractions causing overflow from strong to weak muscles within a synergistic pattern. Motion is allowed only in the weaker muscles. TE is a PNF technique.

Proprioceptive Neuromuscular Facilitation Diagonal Patterns

Table 6.46 Description and Performance of PNF Terminal Positions (Shoulder, Forearm, Wrist, Fingers, Hip, Knee, Ankle)

UE D1 extension: extension, abduction, internal rotation (scapular depression, abduction, and downward rotation); pronation; ulnar extension of wrist; and abduction and extension of fingers including thumb abduction

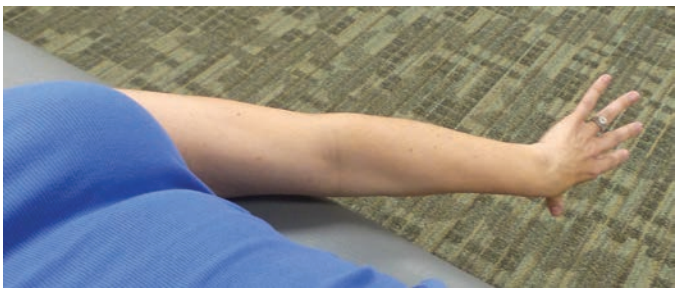

Figure 6.21 UE D1extension

(continued)

Table 6.46 Description and Performance of PNF Terminal Positions (Shoulder, Forearm, Wrist, Fingers, Hip, Knee, Ankle *(continued)*

UE D1 flexion: flexion, adduction, external rotation (scapular elevation, abduction, and upward rotation); supination; wrist radial flexion; and fingers flexion and adduction including thumb adduction

Figure 6.22 UE D1 flexion

UE D2 extension: extension, adduction, internal rotation (scapular depression, abduction, and downward rotation); pronation; ulnar extension of wrist, and flexion and adduction of fingers including thumb opposition

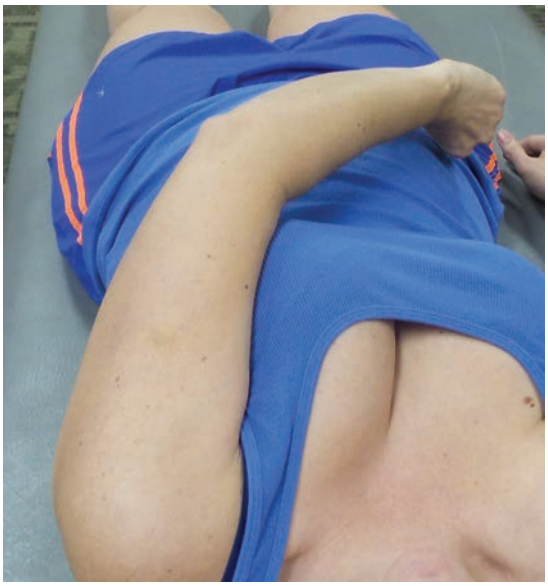

Figure 6.23 UE D2 extension

(continued)

Table 6.46 Description and Performance of PNF Terminal Positions (Shoulder, Forearm, Wrist, Fingers, Hip, Knee, Ankle *(continued)*

UE D2 flexion: flexion, abduction, external rotation (scapular elevation, adduction, and upward rotation); supination; radial extension of wrist; and fingers abduction and extension including thumb extension

Figure 6.24 UE D2 flexion

LE D1 extension: extension, abduction, internal rotation (posterior rotation of pelvis); knee extension; and ankle plantarflexion and eversion

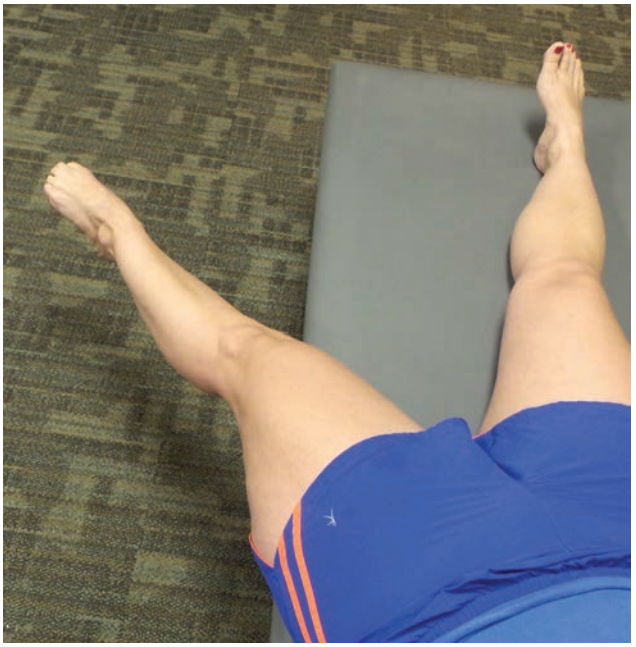

Figure 6.25 LE D1 extension

(continued)

Table 6.46 Description and Performance of PNF Terminal Positions (Shoulder, Forearm, Wrist, Fingers, Hip, Knee, Ankle *(continued)*

LE D1 flexion: flexion, adduction, external rotation (anterior rotation of pelvis); knee flexion; and ankle dorsiflexion and inversion

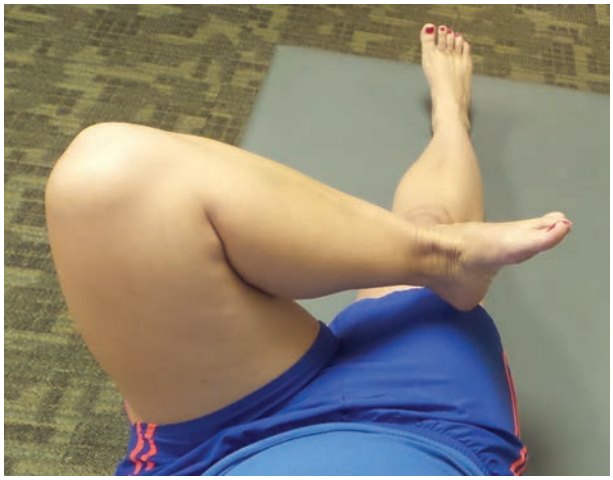

Figure 6.26 LE D1 flexion

LE D2 extension: extension, adduction, external rotation (depression of pelvis); knee extension; and ankle plantarflexion and inversion

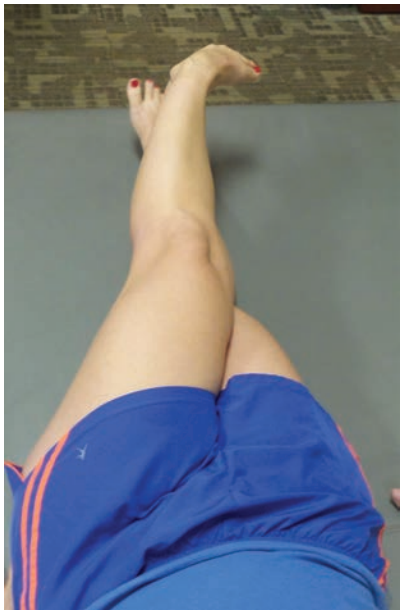

Figure 6.27 LE D2 extension

(continued)

Table 6.46 Description and Performance of PNF Terminal Positions (Shoulder, Forearm, Wrist, Fingers, Hip, Knee, Ankle *(continued)*

LE D2 flexion: flexion, abduction, internal rotation (elevation of pelvis); knee flexion; and ankle plantarflexion (or ankle dorsiflexion) and eversion

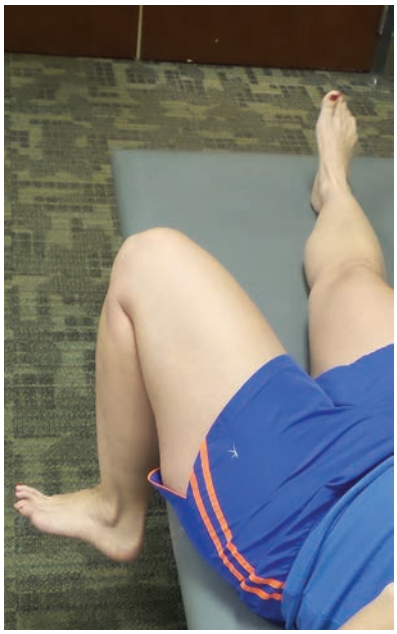

Figure 6.28 LE D2 flexion

Neurologic Inhibition Techniques

Table 6.47 Inhibition Interventions[1]

Firm Manual Contacts (FMCs)

- Applied to midline abdomen, back, palms, lips, or soles of feet.
- Indications: patients with paresthesia or peripheral nerve injury; TBI.
- FMC is a sensory stimulation technique producing inhibition.

Inhibitory Pressure (IP)

- Deep maintained pressure to tendons.
- Prolonged positioning in extreme lengthened range: prolonged weight-bearing quadruped or kneeling position; prolonged weight bearing on extended wrists, arms, or fingers; modified plantigrade positioning; pressure over calcaneus to decrease plantarflexion tone; tactile deep maintained pressure over acupressure points to decrease pain; firm, maintained pressure using cones in the hands or inhibitory splints or casts for lower leg or wrists.
- IP inhibits muscular tone. It can also be used in combination with relaxation techniques (deep breathing or relaxing environment). IP is a sensory stimulation technique producing inhibition.

(continued)

Table 6.47 Inhibition Interventions *(continued)*

Neutral Warmth (NW)

- Wrapping body or body parts using Ace wraps or towel wrap; applying snug-fitting clothes such as gloves, socks, and/or tights; using tepid baths; using air splints. NW is used to decrease muscular tone, reduce pain, and produce relaxation and a calming effect.
- Indications for NW: patients with increased sympathetic activity; patients with high arousal levels; spasticity.
- Precaution for NW: Do not overheat (can increase tone).
- NW is a sensory stimulation technique producing inhibition.

Prolonged Icing (PI)

- Immersion in cold water or ice chips; ice towel wraps or ice packs; ice massage. PI is used to decrease muscular tone, reduce muscular spasms, and decrease metabolism of the tissue.
- Precaution for PI: Monitor the patient carefully for SNS effects such as increased arousal, fight or flight response, or protective withdrawal mechanism.
- PI is a sensory stimulation technique producing inhibition.

Prolonged Stretch (PS)

- Slow, maintained stretch applied at the maximum available lengthened range to inhibit muscular contraction and tone.
- Can be applied using positioning, inhibitory splinting, and/or casting; traction; or mechanical low-load weights.
- PS is a proprioceptive facilitation technique producing inhibition.

Rhythmic Rotation (RRo)

- Relaxation is achieved with slow, repeated rotation movements (either passive or active) of a limb at the point of limitation. As muscular relaxation is obtained, the limb is moved slowly into the new range. When tension is observed, more rhythmic rotation movements are necessary.
- RRo is a PNF technique producing inhibition.

Slow Stroking (SS)

- Applied to paravertebral spinal region; causes generalized inhibition and a calming effect. SS is applied by alternating firm strokes (using a flat hand) downward on the paravertebral muscles for 3–5 minutes while the patient is lying prone (or sitting and resting forward on a tabletop).
- Indications for SS: increased SNS activity; increased arousal.
- Precaution for SS: Patients with large amounts of body hair can be less responsive to the calming effect and may become irritated.
- SS is a sensory stimulation technique producing inhibition.

Slow Vestibular Stimulation (SVS)

- Slow repetitive rolling or rocking movements applied through passive or active-assisted techniques. Examples of SVS include sitting and rocking; rolling side lying; using a rocking chair; using the therapy ball, a bolster, equilibrium board, or a swing; riding a wheelchair.

(continued)

Table 6.47 Inhibition Interventions *(continued)*

- Indications for SVS: patients with hypertonia or hyperactivity; high arousal; combative-stage TBI. SVS can be combined with deep breathing exercises, imagery relaxation techniques, and quiet environment.
- SVS is a vestibular stimulation technique producing inhibition.

Vestibular Stimulation (VS) of Head and Body

- Use of fast spinning in a chair; spinning in a hammock; prone on a scooter board; or equilibrium board, wobble boards, or therapy ball.
- Indications for VS: hypotonia; children with hyperactivity; coordination problems; akinesia and bradykinesia (in PD).
- VS is a vestibular stimulation technique producing inhibition.

Locomotion Training

Table 6.48 Locomotion Training Sequence[1]

A. Activities to prepare for locomotion using instruction and training
   1. Bridging (focus on lower trunk, hip and pelvis, and LEs)
   2. Quadruped (focus on the trunk, proximal and intermediate UEs, and proximal LEs)
   3. Sitting (focus on upper trunk, pelvis, and proximal and intermediate UEs)
   4. Sit to stand
   5. Kneeling/half-kneeling (focus on trunk, pelvis, proximal and distal LEs, and reciprocal control of LEs)
   6. Modified plantigrade (focus on trunk, UEs, and proximal, intermediate, and distal control of LEs)
   7. Standing (focus on trunk and LEs)

B. Activities at the parallel bars using instruction and training
   1. Moving from sitting to standing and back
   2. Standing balance training
   3. Stepping, sidestepping, and cross-stepping
   4. Training in an appropriate gait pattern
   5. Using the appropriate gait pattern to ambulate forward and to turn
   6. Training to transfer with the assistive device from sitting to standing and back
   7. Standing and weight-shifting balance training with assistive device
   8. Gait training with the appropriate assistive device: forward and turning

C. Indoor locomotion activities using instruction and training
   1. Walking forward and backward
   2. Resisted progression
   3. Sidestepping and cross-stepping
   4. Braiding
   5. Stair climbing
   6. Falling techniques for patients who ambulate independently with assistive devices for the long term

D. Outdoor locomotion activities using instruction and training
   1. Opening doors and passing through thresholds that go outdoors
   2. Climbing curbs
   3. Negotiating ramps, stairs, and sloped surfaces
   4. Walking on even and uneven surfaces
   5. Walking and crossing at stoplights
   6. Entering and exiting buildings in the community
   7. Entering and exiting vehicles
   8. Using elevators and revolving doors

Constraint-Induced Movement Therapy as a Form of Functional Training

Table 6.49 Constraint-Induced Movement Therapy (CIMT) as a Form of Functional Training

CIMT[6] forces the use of the affected extremity by restraining the unaffected extremity. For example, for a patient having hemiplegia of the right (involved) upper extremity, the therapist constrains the patient's left (uninvolved) upper extremity in a sling. Then the patient uses his or her right (involved) upper extremity repetitively and intensively for 2 weeks.

- CIMT is becoming more widely used in the United States. It was developed by Dr. Edward Taub[7] (a professor of psychology) at the University of Alabama in Birmingham. Taub developed CIMT on the principle of "learned non-use." His idea of "learned non-use" includes three principles[7–9]: constraining the unaffected limb, forced use of the affected limb, and massed practice.
- To start CIMT, a patient (client) needs to be able to extend his or her wrist and move his or her arm and fingers. In addition, patients (clients) need to demonstrate basic head and trunk stability during upright positioning.
- Research has shown that CIMT helps patients (clients) by improving functional use of their affected extremity much more than the regular therapy.[6–9] The results of a 2003 study proved that plastic changes occurred in the motor cortex of patients with TBI who received CIMT intensively (7 hours daily) for 2 weeks.[7] Other studies have shown that CIMT can produce a use-dependent cortical reorganization of the brain in patients (clients) who had CNS injury-related paresis of the upper limb (including chronic hemiparesis from stroke).[8–10]
- CIMT has been found to help children with cerebral palsy use their affected (hemiparetic) upper extremities. These studies[8, 9] suggested that CIMT leads to recruitment of a large number of neurons adjacent to those originally involved in the control of the stroke-affected limb. The research conclusion supports the effectiveness of CIMT in a clinical setting by providing a neurophysiological basis[7, 8] for the therapy-induced effects on the brain's neural network.
- CIMT is a form of "functional training" or "task-oriented training" therapy. It can be applied to patients (clients) who have experienced CVA, TBI, and CP. Tasks considered significant for daily function, such as standing, walking, grasping, and releasing, are emphasized with this technique. Motor learning strategies are used to enhance function.
- Physical therapy goals using functional training based on CIMT may consider the following issues:
  - Training the patient early to avoid learned non-use
  - Considering the patient's history, health status, age, and experience when designing stimulating and interesting activities
  - Involving patient in goal setting and decision-making
  - Structuring the practice using task-related training
  - Structuring the patient's practice as context specific
  - Maintaining focus on the therapist's role as training coach (minimizing hands-on therapy)
  - Monitoring recovery closely
  - Documenting progress using valid and reliable functional outcome measures
  - Being cautious about timetables and predictions (because the recovery may be longer)

SECTION 6-4

Clinical Impairments and Activity Limitations of Neurologic Conditions

Clinical Impairments and Activity Limitations: Cerebral Vascular Accident

Table 6.50 (Cerebral Vascular Accident) CVA Impairments and Activity Limitations*

Sensory Deficits
■ Impaired sensation in the contralateral upper and lower extremity
■ Impaired proprioception
■ Loss of superficial touch and pain and temperature
■ Numbness
■ Thalamic pain syndrome (continuous and severe pain contralaterally; pain can be triggered by noise, bright lights, or light touch)
■ Homonymous hemianopsia
■ Left hemisphere lesion has right-side hemisensory loss
■ Right hemisphere lesion has left-side hemisensory loss
Motor Deficits
■ Flaccidity and hyporeflexia (immediately after CVA; does not last long)
■ Spasticity (on the opposite side of the lesion)
■ Hyperreflexia (such as clonus and positive Babinski sign)
■ Synergies
■ Primitive reflex patterns (STNR, ATNR, STLR, TLR)
■ Associated reactions: Souques—elevation of hemi UE elicits fingers' extension and abduction; Raimiste—resistance to abduction or adduction in noninvolved UE or LE elicits abduction or adduction response in the opposite UE/LE
■ Paresis or weakness: in Middle Cerebral Artery (MCA) syndrome, UE is more affected than LE; in Anterior Cerebral Artery (ACA) syndrome, LE is more affected than UE
■ Incoordination and balance deficits
■ Apraxia (ideomotor and ideational)
■ Left hemisphere lesion: difficulty planning and sequencing movements; apraxia (ideational or ideomotor)
■ Right hemisphere lesion: difficulty sustaining a movement
Gait Deficits
■ Trendelenburg gait (weak abductors)
■ Scissoring (spastic adductors)
■ Insufficient pelvic rotation during swing
■ Circumduction (weak hip flexors during swing)
■ Backward leaning of trunk
■ Exaggerated hip flexion synergy
■ Excessive knee flexion during stance (weak knee extensors)
■ Knee in hyperextension as a compensation for weak knee extensors or spastic quads
■ Foot drop

(continued)

Table 6.50 (Cerebral Vascular Accident) CVA Impairments and Activity Limitations *(continued)*

- Equinus gait (heel does not touch down)
- Varus foot (weight is borne on the lateral side of the foot)
- Unequal step length (hemi leg does not advance through the end of stance into toe-off)
- Decreased cadence and uneven timing

Communication Deficits

- Broca's or expressive aphasia: speech is impaired; left frontal lobe lesion
- Wernicke's or receptive aphasia: auditory comprehension is impaired; left lateral temporal lobe
- Global aphasia: speech and comprehension are impaired; typical of large left hemisphere lesion
- Dysarthria: motor speech deficit caused by impairments of respiration, articulation, phonation, or sensory feedback
- Left hemisphere lesion has the following: speech and language impairments for the dominant hemisphere (right-handed patients); nonfluent or Broca's aphasia; fluent or Wernicke's aphasia; global aphasia; memory impairments related to language

Perceptual Deficits

- Unilateral neglect: ignores stimuli from the left side
- Anosognosia: denial of dysfunction
- Somatoagnosia: cannot comprehend relationship of one body part to another
- Right and left discrimination: cannot identify right and left sides of body
- Pusher syndrome: lateral lean toward the hemiplegic side
- Right hemisphere lesion has the following: visual perceptual impairments; left-side unilateral neglect; agnosia; visual–spatial impairments; disturbances of body image and body scheme; memory impairments related to spatial–perceptual information

General Cognitive Deficits

- Attention: deficits in areas of sustained attention, divided attention, selective attention, and alternating attention
- Memory: short- and long-term memory
- Confabulation: use of inappropriate words or fabricated stories
- Perseveration: continued repetition of words, thoughts, or acts unrelated to current activity
- Dementia: general decline in higher brain functions such as in judgment, memory, consciousness, communication, and behavior

Left Hemisphere Lesion Cognitive Deficits

Patient may be as follows:

- Slow
- Hesitant
- Cautious
- Insecure
- Fearful

(continued)

Table 6.50 (Cerebral Vascular Accident) CVA Impairments and Activity Limitations *(continued)*

- Aware of impairments
- Disorganized in problem solving
- Anxious about his or her poor performance
- Having difficulty with processing delays
- Having difficulty with expression of positive emotions
- Having memory impairments typically related to language
- Having difficulty processing verbal cues and verbal commands.

Right Hemisphere Lesion Cognitive Deficits

Patient may be as follows:

- Impulsive
- Indifferent
- Quick
- Having poor judgment
- Underestimating the problems
- Overestimating the abilities
- Experiencing difficulty grasping the overall organization or pattern, problem solving, and synthesizing information
- Unaware of impairments
- Unable to self-correct
- At risk for safety
- Having rigidity of thought
- Having difficulty with abstract reasoning
- Having difficulty with perception of emotions and expression of negative emotions
- Having difficulty processing visual cues
- Having memory impairments related to spatial–perceptual information

Affective Deficits

- Emotional lability: pathological crying and laughing; changing easily and quickly from laughing to crying
- Irritability
- Agitation
- Increased frustration
- Depression: not psychological, but rather stemming from a direct impairment caused by CVA

Bladder and Bowel Deficits

- Urinary incontinence (due to bladder hyperreflexia or hyporeflexia)
- Bowel incontinence
- Diarrhea
- Constipation
- Bowel impaction

(continued)

Table 6.50 (Cerebral Vascular Accident) CVA Impairments and Activity Limitations *(continued)*

Indirect Impairments

- Deep venous thrombosis (DVT)
- Pressure sores (decubitus ulcers)
- Decreased ROM
- Contracture
- Deformity
- Shoulder subluxation and pain
- Chronic regional pain syndrome (CRPS)
- Deconditioning

* This is a basic guide; the PTA should also consider the results of the physical therapist's (PT's) initial examination and evaluation.

Clinical Impairments and Activity Limitations: Parkinson's Disease

Table 6.51 Parkinson's Disease (PD) Impairments and Activity Limitations

- Rigidity: cogwheel rigidity (jerky resistance to passive movement); lead-pipe rigidity (constant, uniform resistance to passive movement)
- Akinesia (difficulty initiating movement); bradykinesia (difficulty maintaining movement; slowness); hypokinesia (movements reduced in speed, amplitude, and range); freezing episodes (sudden stop during movement); micrographia (abnormally small handwriting)
- Resting tremor: pill-rolling tremor (hand tremor at rest); postural tremor (tremor in sitting or standing against gravity)
- Postural instability (weak trunk extensor muscles cause a flexed, stooped posture with increased neck, trunk, hips, and knees flexion); back pain (as a result of stooped posture)
- Communication and swallowing deficits: dysarthria (decreased voice volume, monotone speech, distorted articulation, and uncontrolled rate of speech); mutism (not speaking or speaking in whispers); sialorrhea (excessive drooling due to increased salivation and decreased swallowing); dysphagia (impaired swallowing; can cause choking or aspiration pneumonia)
- Gait deficits: loss of reciprocal arm swing and decreased stride length; festinating gait (progressive increase in speed with shortening of stride); propulsive festinating gait (increase in speed forward; most common); retropulsive festinating gait (increase in speed backward; less common); plantarflexion contracture gait (with narrow base of support)
- Visual deficits: blurred vision; difficulty reading (cannot be corrected by glasses); decreased blinking (can produce irritation of the eyes)
- Cognitive deficits: bradyphrenia (slowing of thought processes); deficits in learning new skills; deficits in reasoning, abstract thinking, memory, and judgment; dementia (may occur in patients with PD who are 80 years or older)
- Indirect impairments: fatigue (weakness and lethargy); masked face (infrequent blinking and lack of facial expression); kyphosis (caused by contractures in hip and knee flexors, hip rotators, adductors, plantarflexors, neck flexors, shoulder adductors, internal rotators, and elbow flexors); scoliosis (caused by leaning to one side); orthostatic hypotension (caused by Levodopa side effects); pulmonary deficits (airway obstruction due to decreased respiratory movements; may be caused by kyphosis)

Clinical Impairments and Activity Limitations: Multiple Sclerosis

Table 6.52 Multiple Sclerosis (MS) Impairments and Activity Limitations

Motor Deficits

- UMN deficits: spasticity (can be mild to severe)
- Paresis
- Brisk deep tendon (stretch) reflex (DTR)
- Clonus
- Positive Babinski sign
- Involuntary spasm of flexor and extensor musculature
- Exaggerated cutaneous reflexes
- Flexion/extension synergy patterns

Other Motor Deficits

- Slow and stiff movements
- Weak musculature
- Balance and coordination deficits such as asthenia, ataxia, dysmetria, dyssynergia, dysdiadochokinesia, dizziness, intention tremor, and trunk musculature weakness (all with cerebellar involvement)
- Fatigue
- Difficulty walking
- Staggering gait with loss of balance
- Dysarthria (slurred or unarticulated speech)
- Dysphonia (harsh or hoarse speech)
- Dysphagia (difficulty swallowing)

Sensory Deficits

- Paresthesia (pins and needles or numbness)
- Acute, intense, or burning pain (such as trigeminal neuralgia and headache)
- Lhermitte's sign for MS symptoms (flexion of the neck produces a sudden electric shock running down the spine and lower extremities)
- Chronic pain
- Optic neuritis (inflammation of optic nerve)
- Scotoma (dark spot in the center of the visual field)
- Nystagmus
- Lateral gaze palsy (incomplete eye adduction)
- Diplopia (double vision)

Cognitive and Affective Deficits

- Impaired memory, attention, and concentration
- Decreased problem solving and judgment
- Depression

(continued)

Table 6.52 Multiple Sclerosis (MS) Impairments and Activity Limitations *(continued)*

- Anxiety
- Emotional lability
- Euphoria
- Bipolar affective disorder (alternative periods of depression and mania)

ANS Deficits

- Bowel deficits (such as constipation, bowel impaction, incontinence, or diarrhea)
- Bladder deficits (such as incontinence, urinary frequency and urgency, urinary hesitancy, excessive and frequent urination at night)
- Sexual deficits (such as impotence, vaginal dryness, or loss of libido)

Clinical Impairments and Activity Limitations: Traumatic Brain Injury

Table 6.53 Traumatic Brain Injury (TBI) Impairments and Activity Limitations

Motor Deficits

- Hemiparesis
- Quadriparesis (tetraparesis)
- Abnormal DTRs
- Clonus
- Positive Babinski sign
- Ataxia, hypotonia, coordination and balance deficits (with cerebellar involvement; patient may have bilateral deficits)
- Flaccidity
- Spasticity
- Hypertonicity
- Rigidity (can be decorticate and/or decerebrate rigidity)
- Muscular atrophy, decreased muscular power and/or endurance
- Abnormal synergy patterns

Sensory Deficits

- Sharp and dull discrimination
- Temperature
- Light touch
- Pressure
- Kinesthesia
- Proprioception
- Stereognosis
- Barognosis
- Tactile localization
- Dysphagia

(continued)

Table 6.53 Traumatic Brain Injury (TBI) Impairments and Activity Limitations *(continued)*

Perceptual Deficits

- Homonymous hemianopsia
- Somatognosia
- Right and left discrimination
- Anosognosia
- Figure–ground discrimination
- Position in space deficit
- Agnosia
- Apraxia (ideomotor or ideational)

Integumentary Deficits

- Postures that aggravate or relieve pain
- Pressure areas

Arousal, Mentation, and Cognition Deficits

- Anterograde (post-traumatic) amnesia
- Retrograde amnesia
- Emotional lability
- Decreased level of consciousness (coma, vegetative state, or persistent vegetative state)
- Attention deficits
- Memory loss
- Altered orientation
- Impaired safety awareness
- Decreased problem solving, reasoning, and judgment
- Perseveration
- Disinhibition
- Impulsiveness
- Aggressiveness
- Irritability
- Apathy
- Sexual inappropriateness
- Egocentricity

Speech and Communication Deficits

- Broca's or Wernicke's aphasia
- Global aphasia
- Dysarthria
- Impaired reading comprehension
- Impaired written expression

Clinical Impairments with Mild Traumatic Brain Injury or Concussion

Table 6.54 **Mild TBI or Concussion**[11,12]

- Most TBIs that occur each year are mild TBIs or concussions.
- Symptoms might appear within hours or may be delayed. Most symptoms occur within 7–10 days and resolve within a few weeks, although in some cases can last up to 3 months.
- Repeated mild TBIs or mild concussions lead to longer recovery periods and potential for long-term problems.

Physical Symptoms

- Dizziness
- Headache
- Nausea, vomiting
- Visual disturbance
- Fatigue
- Problems with bright lights
- Slurring of speech

Cognition

- Disorientation
- Short- or long-term memory problems
- Deficits in attention and focus on tasks
- Slowed information processing

Social and Emotional Problems

- Anxiety
- Irritability
- Easily distracted
- Emotional lability
- Personality changes

Sleep Disturbances

- Sleeping more or less than usual
- Difficulty falling asleep

Clinical Impairments and Activity Limitations: Traumatic Spinal Cord Injury

Table 6.55 Spinal Cord Injury (SCI) Impairments and Activity Limitations

- *Areflexia* (spinal shock) occurs immediately after injury. It is characterized by absence of motor function, appearance of flaccidity, loss of sensation and reflex activity below the level of lesion, delayed plantar reflex, loss of DTRs, and loss of bulbocavernous and cremasteric reflexes. It can last from several days to several weeks. Areflexia is resolved when the bulbocavernous reflex returns.
- *Motor and sensory impairments* depend on the type of clinical syndrome and the level of lesion (see also **Tables 6.34** and **6.35**). Motor impairments can include the following: hypotonia; flaccidity; spasticity; decreased muscular strength, power, and endurance; hypertonia; muscular substitution; gait and balance deficits; functional deficits; and community and work dysfunctions. Sensory impairments can include the following: loss or decreased superficial, deep, and combined sensations; and pain (traumatic pain after traumatic injury; nerve root pain caused by damage to nerve roots; spinal cord dysesthesia with painful sensations below the level of the lesion; musculoskeletal pain above the level of lesion, most commonly in the shoulder).
- *Autonomic dysreflexia* (hyperreflexia) can occur mostly in lesions above the T6 level in patients having tetraplegia and high-level paraplegia. It is a medical emergency. The PTA needs to take the following steps:
  1. Bring the patient to a sitting position.
  2. Call EMS or a nurse (in hospital/skilled nursing facility).
  3. Examine the bladder drainage system (catheter) for internal/external blockage.
  4. Release the clamped catheter.
  5. Examine the patient for bowel impaction.
  6. Look for other possible causes and manage if indicated.
- Symptoms of autonomic dysreflexia include the following: sudden and marked increase in systolic and diastolic BP; bradycardia; headache; profuse sweating; increased spasticity; restlessness; constricted pupils; flushing above the level of the lesion; blurred vision; constriction below the level of the lesion; nasal congestion; and piloerection (goose bumps). Causes may include bladder distension due to urinary retention (most common), bladder infection or irritation, kidney stones, kidney dysfunction, bowel distention, pressure sores, noxious cutaneous stimuli i.e., tight clothing, sharp objects, and environmental temperature changes.
- *Postural hypotension* (orthostatic hypotension) is a decrease in blood pressure while the patient is trying to assume an erect position. The cause is prolonged immobilization, especially with cervical and upper thoracic SCI. Symptoms include dizziness and a feeling of fainting. A related problem with postural hypotension in SCI is pitting edema of the feet, ankles, and legs.
- *SNS deficit* is impaired temperature control due to damage to the spinal cord. Because of hypothalamic dysfunction, the patient loses the ability to sweat or shiver. Symptoms include the following: diaphoresis (excessive sweating as a compensatory mechanism); spotty areas of localized sweating below the level of lesion; and body temperature dependent on the environmental temperature.
- *Respiratory deficit* depends on the level of lesion and the residual respiratory muscle function. Respiratory impairment is life threatening to the patient with SCI. The effects of respiratory deficit can include decreased ability to cough, altered breathing pattern, and patient's vulnerability to increased secretions, atelectasis (collapsed lungs), and pulmonary infections.
- *Bladder and bowel deficits* can cause the following: urinary tract infections (UTIs); reflexive or spastic bladder (can empty only to a certain fullness pressure) occurring in UMN lesions at the T11–T12 level or higher; flaccid or nonreflexive bladder (can empty only by compressing the lower abdomen) occurring in LMN lesions at the T12 level or lower; reflexive or spastic bowel occurring with UMN lesions; and flaccid or nonreflexive bowel occurring with LMN lesions.

(continued)

Table 6.55 Spinal Cord Injury (SCI) Impairments and Activity Limitations *(continued)*

- *Sexual deficits* can cause the following: decreased erectile capacity mostly with LMN and complete SCI lesions; decreased ejaculation mostly with UMN lesion, higher-level cord lesions, and complete SCI lesions; decreased female sexual response in LMN lesions (and intact response in UMN lesions); and unimpaired fertility. Patients with UMN and incomplete SCI lesions have greater erectile capacity than LMN and complete lesions. Patients with LMN, lower-level cord, and complete lesions have a higher incidence of ejaculation compared to patients with UMN, higher-level cord, and incomplete lesions.
- *Indirect impairments* may include the following: atelectasis and pneumonia (patients with paralyzed or weak muscles of inspiration); decubitus ulcers; DVT; contractures (most common: hip flexion—adduction and internal rotation contractures; shoulder flexion/extension—internal rotation and adduction contractures); heterotopic ossification (abnormal bone formation in the tendons, connective tissue between muscle, aponeurosis, or peripheral part of the muscle; commonly affects areas close to the hips and knees); osteoporosis (below the level of the lesion); and renal calculi.

Clinical Impairments and Activity Limitations: Guillain-Barré Syndrome (Polyneuritis)

Table 6.56 Guillain-Barré Syndrome Impairments and Activity Limitations

Motor Deficits

- Paresis or paralysis: symmetrical distribution; progresses from lower extremities to upper extremities, and from distal to proximal; can produce tetraplegia with respiratory failure
- Flaccidity: LMN lesion; demyelination of cranial and peripheral nerves
- Decreased muscular strength, power, and endurance

Sensory Deficits

- Paresthesia (tingling and burning sensations)
- Anesthesia (of distal extremities in a long gloves and stocking pattern)
- Hyperesthesia
- Pain (muscular ache)
- Burning pain

Functional Deficits

- Impaired gait and balance
- Decreased ADLs
- Decreased home or work management and integration in the community

Autonomic Deficits

- Tachycardia
- Blood pressure fluctuations
- Arrhythmia

Clinical Impairments and Activity Limitations: Amyotrophic Lateral Sclerosis

Table 6.57 Amyotrophic Lateral Sclerosis (ALS) Impairments and Activity Limitations

Motor Deficits
■ Muscular weakness ■ Hyporeflexia ■ Hypotonicity ■ Atrophy ■ Fasciculations ■ Muscle cramps ■ Spasticity ■ Hyperreflexia ■ Cervical extensor weakness ■ Dysarthria ■ Anarthria (loss of motor power to speak distinctly) ■ Dysphagia ■ Sialorrhea (excess secretion of saliva)
Sensory Deficits
■ Spared for the most part ■ Some patients may have paresthesia or focal pain in the limbs
Functional Deficits
■ Decreased walking ability ■ Decreased ADLs ■ Deconditioning ■ Impaired postural control and balance ■ Decreased home or work management and integration in the community
Respiratory Deficits
■ Respiratory muscle weakness ■ Dyspnea on exertion first and then at rest ■ Fatigue ■ Recurrent sighing ■ Morning headache due to hypoxia ■ Difficulty sleeping in supine position ■ Weak cough
Cognitive Deficits
■ Depression ■ Anxiety ■ Dementia (frontotemporal dementia)

SECTION 6-5

Neurologic Interventions

American Physical Therapy Association (APTA) Guide to Physical Therapist Practice: Suggested Neuromuscular Interventions

Table 6.58 Therapeutic Interventions[13]

Refer to Section 4.2 for a review of basic exercise interventions. See Section 6-3 for detail on therapeutic interventions specific to patients with neurologic diagnoses.

- Balance, coordination, and agility training: perceptual training; posture awareness training; standardized, programmatic, complementary exercise approaches task-specific performance training; sensory training or retraining; task specific performance training; vestibular training
- Body mechanics and postural stabilization: body mechanics training; postural control training; postural stabilization activities, standing frame and tilt table
- Gait and locomotion training: developmental activities training; gait training; implement and device training; perceptual training; standardized, programmatic, complementary exercise approaches for wheelchair training
- Neuromotor development training: developmental activities training; motor training, motor control, motor learning; movement pattern training; neuromuscular education or reeducation, inhibitory and facilitatory techniques

Table 6.59 Functional Training in Self-Care and Home Management Including ADL and IADL[13]

- ADL training: bathing; bed mobility and transfer training; developmental activities; dressing; eating; grooming; toileting
- Devices and equipment use and training: assistive and adaptive device and equipment training during ADLs and IADLs; orthotic, protective, or supportive device or equipment training during ADLs and IADLs
- Functional training programs: simulated environments and tasks; task adaptation; travel training
- IADL training: caring for dependents; home maintenance; household chores; shopping; structured play for infants and children; yard work
- Injury prevention or reduction: injury prevention education during self-care and home management; injury prevention or reduction with use of devices and equipment; safety awareness training during self-care and home management

Table 6.60 Prescription, Application, and (as Appropriate) Fabrication of Devices and Equipment: Adaptive, Assistive, Orthotic, Protective, Supportive, and Prosthetic[13]

- Adaptive devices: environmental controls; hospital beds; raised toilet seats; seating systems
- Assistive devices: canes; crutches; long-handled reachers; walkers; power devices; static and dynamic splints; wheelchairs (refer to Section 4-5 for wheelchair management and mobility training)
- Orthotic devices: braces; casts; splints; shoe inserts
- Protective devices: braces; cushions; helmets; protective taping
- Supportive devices: compression garments; corsets; elastic wraps; neck collars; serial casts; slings; supplemental oxygen; supportive taping

Table 6.61 Functional Training in Self-Care and in Domestic Education, Work, Community, Social and Civic Life[13]

- Devices and equipment use and training: assistive and adaptive device and equipment training during IADLs; orthotic, protective, or supportive device or equipment training during IADLs
- Functional training programs: simulated environments and tasks; task adaptation; task training; travel training
- IADL training: community service training involving instruments; school and play activities training including tools and instruments; work training with tools
- Injury prevention or reduction: injury prevention education during work at job, school, or play; community and leisure integration or reintegration; injury prevention or reduction with use of devices and equipment; safety awareness training during work at job, school, or play; community and leisure integration and reintegration
- Leisure and play activities and training

Table 6.62 Manual Therapy Techniques[13]

- Manual traction
- PROM
- Massage: therapeutic massage
- Soft tissue mobilization

Table 6.63 Biophysical Agents and Modalities[13]

Biophysical and Modalities
For a review of commonly applied biophysical agents, including indication for use, see Table 4.3 of this text.

Table 6.64 Patient/Client-Related Instruction[13]

- Instruction, education, and training of patients/clients and caregivers regarding current condition: pathology; pathophysiology—disease, disorder, or condition; impairments, functional limitations, or disabilities
- Enhancement of performance
- Health, wellness, and fitness
- Plan of care
- Risk factors for pathology; pathophysiology—disease, disorder, or condition; and impairments, functional limitations, or disabilities
- Transitions across settings
- Transitions to new roles

Table 6.65 Airway Clearance Techniques[13]

Breathing Strategies
■ Active cycle of breathing or forced expiratory techniques
■ Assisted cough/huff techniques
■ Autogenic drainage
■ Paced breathing
■ Pursed lip breathing
■ Techniques to maximize ventilation: maximum inspiratory hold
■ Staircase breathing
■ Manual hyperinflation
Positioning
■ Positioning to alter work of breathing
■ Positioning to maximize ventilation and perfusion
■ Pulmonary postural drainage
Manual and Mechanical Techniques
■ Assistive devices
■ Chest percussion, vibration, and shaking
■ Chest wall manipulation
■ Suctioning
■ Ventilatory aids

Clinical Practice Guidelines—Neurological Disorders

Clinical Practice Guidelines (CPGs), developed by APTA sections, other organizations, societies, and health care organizations, are based on a systematic review of the evidence and provide therapists with resources to help guide clinical decision-making.[14] The Academy of Neurologic Physical Therapy, a Section of the APTA, provides access to CPGs relevant to the management of patients with neurologic diagnoses. Examples of topics addressed by the Academy of Neurologic Physical Therapy include Vestibular Hypofunction; Locomotion – Chronic CVA, SCI, TBI; Use of AFOs and FES post stroke; Concussion[15]. A full listing and links to the published CPGs can be found at https://www.neuropt.org/practice-resources/anpt-clinical-practice-guidelines.

Cerebral Vascular Accident Interventions

Table 6.66 CVA Intervention Strategies[1,16]

Interventions to Improve Sensory Function
1. Encourage the patient to use the affected extremity.
2. Use sensory stimulation techniques (such as stroking, approximation, superficial, and deep pressure) for functional training.
3. Use feedback and encouragement with the stimulation techniques.

(continued)

Table 6.66 CVA Intervention Strategies *(continued)*

4. Use stimulation techniques encouraging the patient's extremities to cross the midline (reaching, PNF).
5. Provide visual, tactile, or proprioceptive stimuli on the affected side (maximizes the patient's attention to the affected side).
6. Do not use intense stimulation to produce withdrawal effects; use pressure splints for deep pressure and joint sensation sensory stimulations.
7. Use the patient and patient's family education for protection of the affected extremity (to prevent trauma to the affected side).

Interventions to Improve Flexibility and Joint Integrity

1. Use daily PROM and AROM exercises in all motions (the PT can also apply joint mobilization) to prevent contractures.
2. Use positioning (with resting splints).
3. Place the affected scapula in protraction and upward rotation to prevent impingement with overhead activities (do not use overhead pulleys).
4. Provide patient education for self-ROM (using the affected UE to horizontally abduct/adduct the unaffected UE to 90°; sitting and leaning forward toward the floor with bilateral UEs).
5. Use weight-shifting activities forward in a modified plantigrade position to stretch the affected plantarflexors.
6. Position the patient supine at the edge of the mat with the affected hip in abduction and extension, knee flexion, and foot placed flat on the floor (or stool) to break the scissoring synergy pattern.

Interventions to Improve Muscular Strength

1. Use strengthening exercises starting with gravity-eliminated powder boards or aquatics (for very weak patients) and continuing with free weights, elastic bands, and isokinetics.
2. Use functional activities and resistive exercises such as step-ups and stair climbing with ankle weights.
3. Use exercise precautions (Valsalva maneuver) with HTN and patients with cardiopulmonary dysfunctions.
4. Use eccentric exercises to decrease cardiovascular stress; use exercises in upright sitting position for HTN.
5. Use safety precautions for patients taking medications (see the safety precautions in Part I).
6. Decrease the risk of injury for older adults with CVA who have been immobilized for long periods of time by starting with concentric low-intensity exercises (instead of eccentric and high-intensity exercises), allowing enough rest periods, and monitoring for fatigue and delayed onset muscle soreness (DOMS).

Interventions to Decrease Spasticity

1. Use appropriate positioning (see the following positioning techniques).
2. Use rhythmic rotation and prolonged stretch.
3. Use slow rocking movements (rocking the patient's body over the elongated limb).
4. Use weight-bearing positioning in kneeling and quadruped positions.
5. Use rotational upper trunk movements in PNF diagonal patterns.
6. Ask the patient to perform side sitting on the affected side to stretch the spastic flexor muscles.
7. Use reciprocal inhibition to reduce tone in the agonist muscles.
8. Use ice wraps or ice packs to decrease neural firing rates.
9. Use relaxation techniques.
10. Use air splints for the affected upper extremity with the patient in a quadruped position with elbow extended.

(continued)

Table 6.66 CVA Intervention Strategies *(continued)*

Interventions to Improve Postural Control and Functional Mobility

1. Rolling: Focus on rolling toward the unaffected side to challenge the affected side. Use the hands' "prayer position" to assist the movement.
2. Supine to sit and back: Focus on rising from the affected side.
3. Sitting: Focus on achieving a symmetrical posture of spine and pelvis and feet flat. Provide verbal and tactile cues to help symmetry. Use the upper extremities in front or at the sides for support in early sitting. Use gentle bouncing on a therapy ball to promote pelvic and trunk alignment. Focus on lateral weight shifts to the affected side to challenge the patient. Scooting-in sitting helps with putting pants on. Coming to the end of the seat to place the feet back under the body helps with transitional movements.
4. Bridging: to develop trunk and hip extensor control for bedpan, pressure relief, scooting, and sit to stand transfers. Include weight shifts and placing hips to the side while bridging. In the beginning, stabilize the foot to achieve the affected left extremity hook-lying position. Use more difficult tasks, such as the patient placing the unaffected foot on a ball while bridging.
5. Sit to stand and sitting down transfers: Ask the patient to use momentum to shift the body forward. Have the patient's feet well back to allow ankle dorsiflexion and assist with forward rotation. Have the patient's hands in prayer position or place the hands in a clasp together on a therapy ball while the patient is moving forward. In the beginning, elevate the patient's seat to decrease hip/knee extension; later lower the seat. Practice small-range movements such as partial squats with the patient against a wall.
6. Standing modified plantigrade: early standing posture to develop postural and extremity control, thereby assisting the quads in extension.
7. Standing: first using a high table or wall support for stabilization, then weight shifting in all positions, and finally reaching in all directions and stepping.
8. Transfers: to both sides, focusing on the affected side. Use different surfaces and heights.

Interventions to Improve Upper-Extremity Function

1. Extended-arm weight-bearing with the hand placed on a support surface: promotes stabilization and decreases flexion synergy.
2. Approximation: for stimulation of the shoulder and scapula stabilizers and elbow extensors.
3. Quadruped position: offers maximal challenge.
4. Reaching: to improve scapular protraction, upward rotation, and elbow, wrist, and finger extension. Beginning reaching starts in side-lying position; advanced reaching includes independently lifting and reaching forward and standing and reaching to pick an object from a shelf.
5. Grasp and manipulation: begins with voluntary gross grasp and release. Voluntary release is more difficult than grasp. The patient needs positioning, stretching, and inhibitory techniques to decrease flexion and increase extension. Use task training such as reaching for an object off a shelf; practice advanced wrist and finger extension with activities such as using utensils to eat, writing, drinking from a cup, or picking up coins.

Interventions to Improve Lower-Extremity Function

1. To activate hip extensors and abductors, dorsiflexors, and knee extensors: Use PNF LE D1 extension; use supine PNF LE D1 flexion; sitting, crossing, and uncrossing the affected LE; standing; step ups; bridging to promote hip extension with knee flexion; lower trunk rotation in side-lying, kneeling, or standing position to decrease retraction and elevation for pelvic control; pelvic shifts while sitting on a therapy ball; hip abduction in hook-lying, supine, side-lying, modified plantigrade, and standing positions.
2. To break up knee hyperextension in standing position: Use foot slides in supine hook-lying position and in sitting; use partial squats.

(continued)

Table 6.66 CVA Intervention Strategies *(continued)*

Interventions to Improve Balance

1. Weight shifts first in sitting, then in standing; symmetrical weight bearing in sitting and standing.
2. Shifting toward the affected side in sitting and standing.
3. Weight bearing on the affected hip in sitting and on the affected foot in standing with prohibited unaffected lower-extremity movement or weight bearing.
4. Decrease base of support: sitting—lower extremity uncrossed to crossed; standing—from wide to narrow and tandem; standing on one lower extremity.
5. Change support surfaces: sitting on mat to therapy ball; standing on floor to dense foam.
6. Use sensory inputs: feet on firm surface or foam.
7. Use upper-extremity position and support.
8. Use upper-extremity movements.
9. Use lower-extremity movements.
10. Use trunk movements.
11. Use destabilizing functional activities.
12. Perform dual task training.
13. Change environments: open and closed.
14. Use postural strategies: ankle, hip, medial lateral hip.
15. Use stepping strategies.

Interventions to Improve Locomotion

1. Gait training: Progress the patient from parallel bars and use of assistive devices to no assistive devices; may use an overhead harness and partial body weight support. Maintain the natural rhythm of walking and speed. Encourage the patient to take even steps using verbal cues and/or foot markers placed on the floor. The patient should progress from smaller steps to longer steps, increased distance, and faster speeds. The patient should walk in different environments.
2. Analysis of gait abnormalities.
3. Practice of functional locomotion skills: walking forward, backward, sideward; sidestepping, braiding, step up, step down, lateral step up; stair climbing, step over step; walking on ramps, curbs, uneven terrain, over and around obstacles; crossing the street; stepping on and off an elevator and escalator.
4. Dual-task activities: carrying a tray while walking; walking and talking; bouncing a ball while walking; holding a ball while walking.
5. Treadmill, cycle ergometer, and isokinetic training.
6. Use of orthotics to improve safety. Use the dorsiflexor assist on a temporary basis in the early stages. Use a posterior leaf spring Ankle foot orthosis (AFO) to control for foot drop. Use a solid ankle AFO for maximum stabilization. An AFO set in 5° dorsiflexion limits knee hyperextension; an AFO set in 5° PF stabilizes the knee during midstance.

Interventions to Improve Motor Learning

1. The patient learns the skill in the cognitive stage. The therapist gives simple, clear, verbal instructions, trying not to overload the patient; the patient practices the learned skill or learned component parts of the skill. During this process, correct performance is reinforced, with interventions being provided for errors. Patient's active participation is important. The patient practices skills first on the unaffected side, then on the affected side. The patient can also use mental practice. The patient examines his or her performance; if the patient cannot examine himself or herself accurately, the therapist helps the patient in proper decision making.

(continued)

Table 6.66 CVA Intervention Strategies *(continued)*

2. Feedback may be either intrinsic, occurring naturally as part of the movement response, or extrinsic, as provided by the therapist. Visual inputs, such as patient looking at the movement, are important in early interventions. Proprioception stimulations such as manual contacts, tapping, stretching, antigravity postures, and vibration are important in later learning to enhance the learned skill. In later training, the therapist limits immediate feedback and provides increased sensory stimulations. Pain and fatigue should always be avoided.
3. The patient needs constant practice and repetition for motor learning and recovery. In the beginning, in the hospital, the patient needs adequate rest periods due to decreased endurance. Later, the patient needs variable practice using random practice order to improve performance and for better retention. The learning environment is important, with a closed environment with reduced distractions being offered in the beginning and an open environment with interferences toward the end. Patient motivation needs to be considered by making the therapy session a positive experience and having the patient and family become involved in goal setting.

Table 6.67 Strategies for Right CVA

- Use verbal cues.
- Do not use demonstration or gestures.
- Give frequent feedback.
- Focus on slowing down and controlling movements.
- Focus on the patient's safety.
- Avoid environmental and spatial clutter.
- Do not overestimate the patient's ability to learn.

Table 6.68 Strategies for Left CVA

- Develop an appropriate communication base using words, gestures, and demonstration.
- Assess the patient's level of understanding.
- Give frequent feedback and support.
- Do not underestimate the patient's ability to learn.

Table 6.69 Intervention Strategies for Flaccid, Spastic, and Relative Recovery Stages

Flaccid Stage

The PTA must concentrate on the following interventions:

- Bed mobility turning from supine to side lying and sitting and back
- Pressure splints to provide sensory input and stabilization of the affected extremity and decrease edema
- Use of arm slings / cuff to prevent shoulder subluxation and improve shoulder function
- Use of an arm board or lap tray to provide support for the upper extremity
- Preparation for sitting up

(continued)

Table 6.69 Intervention Strategies for Flaccid, Spastic, and Relative Recovery Stages *(continued)*

- Preparation for standing up (focus on lower-extremity control)
- Trunk balance
- Stimulation and facilitation techniques to increase tone and voluntary movements

Spasticity Stage

The PTA must concentrate on the following interventions:

- Rehabilitation of patient in the sitting and standing positions as much as possible
- Some treatments started in the flaccid stage in supine position continue in the sitting and standing positions
- Inhibition techniques to decrease spasticity
- Weight bearing on the involved extremity
- Sitting
- Standing
- Progression to treatment in prone lying and kneeling positions
- Gait training with an assistive device
- Working for independent control of affected extremity
- Facilitation techniques for voluntary movement

Relative Recovery Stage

The PTA must concentrate on the following interventions:

- Treatments to improve the patient's gait, balance, and coordination
- Dissociation of mass patterns of movement
- ADLs

Table 6.70 CVA Positioning Techniques

Position the Patient with CVA in Supine Position

- Trunk in midline with head and neck in neutral and symmetrical positions
- A small pillow or towel under the scapula to assist with scapular protraction
- Affected upper limb positioned (on a pillow) in external rotation and abduction with the elbow extended, wrist neutral, and fingers extended
- Hip forward (pelvis protracted) and in neutral position (in regard to rotation), with a small towel under the knee to prevent hyperextension
- Foot and ankle in neutral position (if there is PF, use a splint)
- Nothing placed against the soles of the feet

Position the Patient with CVA in Side-Lying Position on the Unaffected Side

- Head/neck in neutral and symmetrical position; trunk straight in midline position
- Small pillow placed under the unaffected rib cage to elongate the affected side

(continued)

Table 6.70 CVA Positioning Techniques *(continued)*

- Affected scapula protracted and affected shoulder placed well forward on a supporting pillow
- Elbow extended, wrist neutral, and fingers extended
- Thumb abducted
- Affected hip forward and pelvis protracted
- Affected knee flexed and supported on a pillow

Position the Patient with CVA in Side-Lying Position on the Affected Side

- Head/neck in neutral and symmetrical position; trunk straight in midline position
- Affected upper scapula protracted
- Affected shoulder well forward with elbow extended
- Forearm supinated; wrist neutral
- Fingers extended; thumb abducted
- Affected hip in extension
- Affected knee flexed (another position may be hip and knee in slight flexion with protraction of pelvis)

Position the Patient with CVA Sitting in the Wheelchair (or Chair)

- Head and neck in neutral and symmetrical position
- Spine in extension and aligned in midline position
- Equal weight bearing on both buttocks
- Affected shoulder protracted and forward with elbow supported on a lapboard (or a trough)
- Wrist in neutral position with finger extended and thumb abducted
- Both lower extremities flexed to 90° and in neutral position with regard to rotation

Parkinson's Disease Interventions

Table 6.71 PD Intervention Patterns[1,16]

Interventions to Improve Motor Learning

1. Structured instruction: task-specific learning; structured activities; simple tasks; many repetitions of one activity until learning is achieved; do not overload the patient with new tasks until the initial task is learned
2. Visual cues: brightly colored floor markings during gait training; improve stride length and velocity; decrease shuffling gait
3. Rhythmic auditory stimulation: music or a metronome to increase gait cadence; music for marching in place

Interventions to Improve Relaxation

1. Slow rhythmic rotational movements of the extremities and trunk: PNF diagonal patterns to incorporate rotation; gentle trunk rocking to reduce rigidity; hook-lying position, lower trunk rotation, and rolling in side-lying position; rhythmic initiation; diaphragmatic breathing during PNF diagonal patterns such as PNF D2 flexion and PNF D2 extension
2. Interventions to improve flexibility: PROM and AROM exercises

(continued)

Table 6.71 PD Intervention Patterns *(continued)*

3. PNF diagonal patterns: PNF D2 for bilateral upper-extremity flexion to improve trunk extension and decrease thoracic kyphosis; PNF D1 LE extension to decrease lower-extremity flexed and adducted positions
4. PNF hold–relax or contract–relax technique
5. Light and gentle stretching: hip and knee flexors, ankle plantarflexors, and elbow flexors
6. Prone daily positioning to prevent contracture (early in the disease)
7. Weights to stretch hip and knee flexion contractures (later in the disease)

Interventions to Strengthen Muscles

1. Aquatic exercises: walking pool program; supervised aerobic pool program
2. Aerobic training exercise program: individualized; established by the PT
3. Strength training that focuses on antigravity muscles
4. HEP of daily exercises with moderate duration and intensity: standing corner–wall stretches are effective for kyphotic and forward head posture; overhead flexion and abduction with a cane; modified plantigrade exercises holding lightly at the kitchen countertop; group exercises to increase patient's motivation; patient should not overdo activities and become fatigued
5. Functional training exercises: rhythmic initiation for strengthening exercises; segmental rotation of upper and lower trunk during bed mobility activities; PNF D1 upper-extremity and lower-extremity flexion patterns for movement initiation; anterior and posterior pelvic tilts on a therapy ball to improve pelvic mobility; weight shifting; PNF D2 flexion and D2 extension of upper extremity to increase upper trunk extension; modified wall squats to strengthen hip and knee extensors; modified plantigrade with upper limbs extended on a wall; lateral side stepping; quadruped creeping to teach the patient how to get up from falling; half-kneeling and kneeling as transitional activities

Interventions to Improve Gait

1. Gait training techniques to increase speed, broaden base of support, lengthen stride, improve stepping, facilitate heel to toe pattern, and improve trunk rotation and arm swing
2. Techniques to decrease kyphotic and forward head posture during gait: gait training with an overhead harness instead of an assistive device; walking on a motorized treadmill using an overhead harness
3. Visual (e.g., floor markings) and auditory cues: to walk faster, take larger steps, or swing arms
4. Marching in place with music techniques: to improve step height and increase speed
5. Highlighting of lower trunk rotation during gait: braiding technique of side stepping with alternate crossed stepping
6. Use of different gait training surfaces and techniques: from tile flooring to carpet and outside grass; from eyes open to eyes closed; from closed environment to open environments; from straight flooring to curbs, ramps, and stairs
7. Reduction of freezing episodes during gait: encourage rotational movements or stepping over obstacles

Interventions to Improve Balance

1. Dynamic stability training: weight shifting, reaching, trunk rotation combined with reaching, sitting on a therapy ball
2. Balance-challenging techniques: arms to side, arms folded across chest, feet together, feet apart, arms overhead, single leg raises, stepping, marching in place, functional reach; change the support surface by adding foam or asking the patient to close his or her eyes; as a safety precaution do not use manual displacement because it can cause increased rigidity

(continued)

Table 6.71 PD Intervention Patterns *(continued)*

3. Standing exercises: toe-offs, heel rises, chair rises, modified wall squats, single-limb stance with side kicks, marching in place; as a safety precaution allow the patient to maintain light touch support during standing exercises

Interventions to Improve Cardiopulmonary Function

1. Diaphragmatic breathing exercises
2. Deep breathing training to increase vital capacity
3. Upper-extremity exercises: wrist cuff weights, ergometer, PNF UE bilateral D2 flexion and extension
4. Lower-extremity resistance exercises: ergometer and/or daily walking program; aquatic therapy
5. The PT's individualized aerobic exercise program (based on ACSM guidelines for frequency, intensity, duration, and progression)

Interventions to Promote Patient, Family, and Caregiver Education

1. One-on-one instruction
2. Group sessions
3. Printed materials
4. Computer or video presentations
5. Supportive and positive attitude
6. Support groups

Multiple Sclerosis Interventions

Table 6.72 MS Intervention Strategies[1,16]

Interventions to Increase Muscular Strength

1. Use the PT's individualized exercise program for each patient: PT considers the frequency, intensity, type, and time duration of exercise.
2. Avoid exercise fatigue in the patient.
3. Have the patient perform exercises in the morning.
4. Use moderate exercise intensity.
5. Use resistance exercises: free weights, elastic bands, and weight and isokinetic machines.
6. Use circuit training: different stations alternating upper- and lower-extremities exercises.
7. Provide adequate rest periods between exercises.
8. Use slow progression of exercises.
9. Avoid overworking of the patient.
10. Have the patient exercise in a cool environment: prevent overheating; use cooling suits or vests; use aquatic exercises.
11. Do not use free weights with patients having proprioception, incoordination, or tremors.
12. Use written instructions or diagrams with patients having cognitive or memory deficits.
13. Include functional strengthening activities: closed-chain exercises and balance training.
14. Use group exercises to improve the patient's motivation.

Interventions to Increase Flexibility

Use stretching and ROM exercises:

1. Stretch the pectoralis and latissimus dorsi for forward posture deficits.

(continued)

Table 6.72 MS Intervention Strategies *(continued)*

2. Stretch hip flexors, adductors, hamstrings, and heel cords for patients confined to a wheelchair.
3. Stretch hip and knee extensors and plantarflexors for patients confined to bed.

Interventions to Improve Cardiopulmonary Function[1]

1. Use the PT's individualized aerobic exercise program. The PT needs to test the patient prior to exercise; be cautious with medications' effects and the patient's fatigue.
2. The individualized aerobic exercise program is recommended three times per week, 10-minute sessions, at 50–75% or 50–65% peak VO_2. Recommended exercises are cycling, walking, swimming, water aerobics, or circuit training. Patient education is important for understanding, self-monitoring, safety, and modifications of exercise program.

Interventions to Improve Sensory Deficits

1. Instruct the patient to use adequate lighting all of the time to compensate for visual deficits: use bright light at night; reduce clutter.
2. Give the patient an eye patch for one eye for a double-vision deficit. The eye patch should be used when driving, watching television, or reading; it should not be used all the time.
3. Instruct the patient in skin care, protection, and pressure relief for superficial sensations deficits to prevent decubitus ulcers. The patient should keep the skin clean and dry, inspect the skin daily, and wear comfortable clothes that are soft and not tight. He or she should do push-ups in the chair every 15 minutes and be repositioned in bed every 2 hours. Pressure-relieving devices such as special mattresses, cushions, cuffs, or boots may also be used. The patient should avoid activities that can traumatize skin during transfers, avoid skin contact with hot water or hot objects, and be aware of and seek immediate medical attention for skin blisters or open sores.

Interventions to Decrease Spasticity

1. Use cold packs, ice packs, or cool wraps. Use caution with patients with intact sensations who may develop ANS responses such as increased heart and respiratory rate and nausea.
2. Use ROM exercises early in the disease process.
3. Use stretching exercises: intermittent static stretching for 30–60 seconds for 5–10 repetitions. Use serial casts or air splints. Use stretching as a HEP for the patient and caregiver; teach the patient and caregiver proper stretching techniques. Prevent ballistic stretching. Emphasize stretching the quadriceps, adductors, and plantarflexors, and hamstrings and hip flexors for patients in a wheelchair.
4. Reduce extensor tone. Use lower trunk rotation in side-lying or hook-lying position. The patient may be placed in a hook-lying position, with a therapy ball under the lower legs, and the PTA gently rocking the ball back and forth; the patient may also move from quadruped to side-sitting position.
5. Reduce hypertonicity using inhibitory techniques.
6. Use a positioning schedule for a patient confined to bed or a wheelchair.

Interventions to Decrease Pain

1. Instruct the patient in daily stretching exercises to decrease pain.
2. Use massage and ultrasound to relieve pain.
3. Use postural retraining exercises and orthotic and adaptive devices to decrease pain.
4. Use a soft collar to limit neck flexion for Lhermitte's sign pain.
5. Use aquatic therapy (cooler water) for pain from dysesthesia.
6. Have the patient wear stockings and gloves (neutral warmth technique) for chronic pain relief; be careful that patient is not hot.

(continued)

Table 6.72 MS Intervention Strategies *(continued)*

Interventions to Decrease Fatigue

1. Instruct the patient to avoid heat caused by strenuous activities or environmentally.
2. Use energy conservation: modification of tasks or the environment; use of crutches, walkers, or orthotics; breaking down difficult activities into small parts.
3. Use activity pacing. An activity can be interspaced throughout the day with periodic rest periods. The patient needs to set priorities and limit activities to the most important and enjoyable ones.
4. The PTA should work with the rehabilitation team to help the patient.

Interventions to Increase Balance and Coordination (Especially for Patients with Ataxia)

1. Increase postural stability: joint approximation for shoulders, hips, head, and spine; rhythmic stabilization technique.
2. Promote dynamic postural control: weight shifting, reaching, and stepping activities; aquatic therapy in 85°F water.
3. Promote functional activities: bridging, sit to stand, and scooting activities; real-life functional tasks such as reaching, turning, or bending while sitting or standing; practice transfers from sit to stand and back.
4. Use challenging balance activities: change balance surfaces; decrease base of support; eyes open and eyes closed; use platform training.
5. Stabilize movements. Use light-weight cuffs for ankles or wrists to reduce tremors of limbs and trunk in ambulation; use weighted canes or walkers in ambulation; use a soft collar for head and neck tremors. Take care not to fatigue the patient.
6. Use Frenkel's exercises.

Interventions to Improve Ambulation

1. Use stretching and strengthening exercises: stretch iliopsoas and hamstrings regularly especially if sitting in wheelchair; strengthen mostly hip flexors, ankle dorsiflexors, quadriceps, and hip abductors.
2. Use aquatic exercises, which can reduce tone and fatigue and control ataxia.
3. Use the motorized treadmill (and an overhead harness).
4. Use orthotic devices as necessary: AFO for foot drop and knee hyperextension control; rocker shoes for ankle mobility.
5. Use assistive devices as necessary: walker or crutches to help with fatigue, strength, sensory deficits, and balance.
6. Use wheeled mobility devices for later in the disease: three- or four-wheeled scooters; manual or power wheelchair for postural support and fatigue. Prevent sacral sitting with kyphosis; use gel-cushioned seating, footrests, lap belt, and heel loops.
7. Teach transfers and wheelchair mobility (use transfer board or hydraulic lift).

Interventions to Improve Functionality

1. Use functional mobility training: bed mobility, transfers, gait training.
2. Work with Occupational therapist (OT)/ Certified occupational therapist assistant (COTA) in ADLs.
3. Use adaptive equipment training: raised seats, transfer board, wrist rests for writing or typing, long-handled shoe horns, button hooks, Velcro closures, socks aids; voice amplification for speech; computer-assisted communication system for speech.

Interventions to Improve Speech and Swallowing

1. Use diaphragmatic breathing.
2. Use coughing techniques.

(continued)

Table 6.72 MS Intervention Strategies *(continued)*

3. Use upright positioning with slight forward head position and chin parallel to the patient's lap (to avoid aspiration and help with swallowing).
4. Use oral motor exercises to improve function of the mouth (for lip closure, tongue movements, and jaw control).

Interventions to Improve Cognitive Function

1. Use a memory book to log daily events and reminders.
2. Structure the environment (labeling the furniture for immediate use).
3. Give written directions for functional tasks or HEP (such as transfers, positioning, ambulation, self-stretching and strengthening).
4. Assist the caregiver/family to help the patient with directions and cueing.

Traumatic Brain Injury Interventions

Table 6.73 TBI Intervention Strategies[1,16]

Rancho Los Amigos (RLA) Levels 1, 2, and 3

1. Prevent contracture development. Use positioning: position the head in neutral, with rolls placed behind the neck and parallel to the head for support and to prevent lateral flexion and rotation. Position the trunk with normal alignment, with rolls behind the shoulders and hips to prevent rotation. Position the upper extremity with a cone or towel in hand to prevent finger flexion. Position the lower extremity with hips and knees in slightly flexed position and a roll between legs to prevent adduction or IR. Turn the patient every 2 hours. Position the patient correctly in a wheelchair/chair: use a reclining wheelchair or tilt-in-space wheelchair; position the head and pelvis in the wheelchair/chair. Prevent foot drop by using boots. Use gentle PROM.
2. Decrease abnormal tone. Use PROM and positioning by maintaining the head and neck in neutral position. Discourage primitive posturing that increases tone. Keep the entire body in proper alignment. Use serial casting for plantarflexion contracture.
3. Maintain skin integrity and prevent decubiti development through frequent position changes (turning every 2 hours).
4. Maintain respiratory status. Prevent respiratory complications through postural drainage, percussion, vibration, and suctioning to keep the airway clear.
5. Use sensory stimulation to improve arousal and elicit movements. Stimulate the auditory, olfactory, visual, tactile, gustatory, kinesthetic, and vestibular systems. After such stimulation, monitor the patient for changes in BP, HR, and respiration. Watch for diaphoresis. Document the patient's motor responses such as grimacing, head turning, vocalization, or changes in posture.
6. Teach the family about the recovery stages, performing ROM exercises, positioning, and sensory stimulation; work with a social worker (SW) to provide support and guidance.
7. Promote early return of functional mobility skills through upright positioning for improved arousal and proper body alignment. Support the patient's neck and head in upright posture; a tilt table may be used to allow weight bearing through the lower extremities.

RLA Level 4

1. Provide consistency through use of team-determined behavioral modification techniques. All team members should be consistent, especially when addressing inappropriate behaviors.
2. Use the same therapist for treatments.

(continued)

Table 6.73 TBI Intervention Strategies *(continued)*

3. Establish a daily routine.
4. Use calm, comforting, and focused behavior.
5. Provide structure and orientation.
6. Do not expect carry-over. The patient learns functional tasks; use charts or graphs to progress the patient with new skills.
7. Expect the patient to be self-centered and do not attempt to change the patient's attitude.
8. Provide safe and functional choices for therapy. Allow the patient to have control over the treatment, but in a safe way, such as asking whether he or she wants to walk or to play with the ball; either choice would be helpful in allowing the patient to have some control without making wrong choices.
9. Provide close supervision in a closed environment to maintain the patient's safety.
10. Teach the family about the patient's aggressive behaviors, so that they will understand and accept them as temporary and short-term behaviors. Teach the family to exhibit consistency.

RLA Levels 5 and 6

1. Continue the interventions from level 4 and focus on maximizing the patient's motor abilities. Watch for mental and physical fatigue signs, such as irritability and decreased performance.
2. Use specific and clear feedback in plain words; do not overwhelm the patient with feedback.
3. Provide verbal and physical assistance.
4. Allow rest periods.
5. Teach compensatory techniques such as dressing with one hand if hemiparesis is present in one upper extremity.
6. Involve the patient in task-specific training.
7. Break down complex tasks into component parts.
8. Provide structure and prevent overstimulation: Provide a daily schedule; use memory logs; work with the patient in a closed, reduced-stimulus environment.
9. Restore movement and functional mobility by using developmental sequence postures.
10. Use relaxation techniques.
11. Teach and emphasize safety with the patient and the patient's family.
12. Teach the family how to assist the patient with functional mobility (such as bed mobility, transfers, gait training, wheelchair mobility), PROM, and strengthening exercises.

RLA Levels 7 and 8

1. Physical therapy general goals are geared toward increasing the patient's independence through weaning from structure and using open environments (instead of closed).
2. The patient should be involved in decision making.
3. The patient needs assistance with behavioral, cognitive, and emotional reintegration (through honest feedback and preparation for community reentry).
4. Promote independence in functional tasks through mobility skills, and ADLs (using real-life environments).
5. Promote improvement of postural control, symmetry, and balance.
6. Encourage the patient to have an active lifestyle and show him or her how to increase cardiovascular endurance.
7. Provide emotional support, and encourage socialization, behavioral control, and motivation.
8. Provide patient and family education about patient compensation for impairments or disabilities; ensure that the family is acquainted with the community resources for TBI.

Spinal Cord Injury Interventions

Table 6.74 SCI Intervention Strategies[1,16]

Improve Respiratory Capacity

1. Teach deep breathing exercises, glossopharyngeal breathing, and strengthening exercises to respiratory muscles (especially diaphragm breathing by using manual contacts below the xiphoid process or weights).
2. Assist coughing: manual contacts over epigastric region by pushing quickly inward and upward while the patient is trying to cough.
3. Use respiratory hygiene with postural drainage, percussion, vibration, and suctioning.
4. Use abdominal support. Use an abdominal corset to support the abdominal contents and assist the diaphragm to rest; it decreases the possibility of orthostatic hypotension.
5. Stretch the pectoral muscles.

Maintain ROM and Prevent Contracture

1. Use PROM daily; watch for contraindicated trunk and hip motion in paraplegia such as SLR more than 60° and hip flexion more than 90° and head/neck motion in tetraplegia.
2. Use positioning. Increase the patient's tolerance to prone positioning; position the ankles at a 90° angle.
3. Use splinting—mostly for wrists, hands, and fingers in the early interventions and for ankles and hips later.
4. Use selective stretching to preserve function (e.g., keeping tight long finger flexors for tenodesis grasp or tight lower trunk for stability).

Maintain Skin Integrity, Free of Decubiti and Other Injury

1. Use a positioning program: prone positioning; gradual upright positioning when the patient is medically stabilized using an abdominal corset and elastic stockings and monitoring vital signs.
2. Use pressure-relieving devices (e.g., cushions, gel cushion, ankle boots).
3. Perform patient education for pressure relief, and pressure relief activities (push-ups) and daily skin inspection (using a long-handled or adapted mirror).
4. Provide prompt treatment of pressure sores.

Improve Strength of All Remaining Innervated Muscles

1. Use selective strengthening during the acute phase of treatment to reduce stress on the spinal segments.
2. Use resistive exercises: manually, or with cuff weights in straight planes or PNF patterns.
3. Strengthen the anterior deltoid, shoulder extensors, biceps, and lower trapezius with tetraplegia and all upper-extremity muscles with paraplegia; emphasize shoulder depressors, triceps, and latissimus dorsi for transfers and gait training.

Reorient the Patient to the Vertical Position

1. Use a tilt table and wheelchair.
2. Use an abdominal binder and elastic lower-extremity wraps to decrease venous pooling.
3. Check for signs and symptoms of orthostatic hypotension (e.g., lightheadedness, syncope, mental or visual blurring, sense of weakness).

(continued)

Table 6.74 SCI Intervention Strategies *(continued)*

Promote Early Return of Functional Mobility Skills and ADLs

1. Emphasize independent rolling using the head, neck, upper extremity, and momentum. Avoid use of adaptive devices such as bed rails or trapezes. When moving the patient from supine to prone, use flexion of the head and neck with rotation; when moving the patient from prone to supine, use extension of the head and neck with rotation. Use bilateral upper-extremities rocking when moving the patient from supine to prone. Cross the patient's ankles with the upper limb in the direction of the roll; use PNF D1 flexion and D2 extension patterns in early rolling.
2. Use bed mobility activities, such as the patient being prone on the elbows for head and neck control, prone on the hands for paraplegia, and supine on the elbows and pull-ups for tetraplegia. Strengthen the biceps and shoulder flexors for wheelchair training.
3. Train the patient to assume sitting for ADLs, transfers, self-ROM, and wheelchair training. For patients with tetraplegia, 100° SLR is required to assume a long sitting position and avoid posterior tilt and sacral sitting. Teach the patient to sit from supine on the elbows or prone on the elbows' positions.
4. Train the patient in quadruped positioning—a lead-up activity for ambulation. The patient can assume a quadruped position from being prone on the elbows by first moving backward on the elbows and then, when the hips are positioned over the knees, putting weight on each hand by extending the elbows. He or she can assume a quadruped position from a long sitting position by rotating the trunk, putting weight on each hand by extending the elbows, and using momentum and strength in the upper extremities and trunk to move in the quadruped position.
5. Train the patient in kneeling position to increase functionality in the trunk and pelvis and to promote upright control. This training is important for ambulation with crutches and KAFOs. The patient can assume a kneeling position from the quadruped position by moving the hands backward until the pelvis drops toward the heels while the therapist gives the patient mat crutches to start practicing.
6. Train the patient in transfers when the patient has good sitting balance. Start with mat transfers first using a sliding board and then without a sliding board; later, advance to other surface transfers. The patient needs to use momentum and muscle substitution depending on his or her functional levels for successful transfer. The patient should train for and practice components of transfers initially, before performing the entire transfer.
7. Teach wheelchair mobility in a customized wheelchair; the wheelchair prescription will be different for each patient depending on the level of injury. Special wheelchair considerations are needed: seat depth 1–2 inches back from the popliteal space, floor-to-seat height measurement considering the seat cushion, back height to allow functionality, fitted seat width and depth, heel loops on footrest, and removable armrests and detachable swing way leg rests.
8. Train the patient to use orthotic devices in ambulation, such as KAFOs, reciprocal gait orthosis (RGO), and AFOs.
9. Train the patient in ambulation using forearm crutches for patients with paraplegia. Use point, two-point, swing-to, or swing-through gait patterns as required.
10. Train the patient in locomotor techniques (where equipment is available).

Guillain-Barré Syndrome Interventions

Table 6.75 Guillain-Barré Syndrome Intervention Strategies[12,16]

Acute-Phase Interventions: Ascending Phase

1. Monitor the respiratory system. Use pulse oximetry to measure the oxygen saturation level in the arterial blood—it should normally be higher than 96%. Use pulmonary physical therapy as necessary to facilitate coughing and airway clearance.

(continued)

Table 6.75 Guillain-Barré Syndrome Intervention Strategies *(continued)*

2. Prevent indirect impairments. Use PROM exercises, positioning, specialty bed, gentle passive stretching, and skin care.
3. Prevent injury to denervated muscles. Use positioning and splinting and do not overuse the denervated muscles; do not overstretch. Provide light exercises using the water buoyancy in the Hubbard tank.

Subacute-Phase Interventions: Descending Phase

1. Provide muscle reeducation. Start with active assistive and active ROM exercises in straight planes and PNF patterns; continue with low- to moderate-intensity resistive exercises. Avoid overuse and fatigue with exercises; allow necessary resting periods between repetitions.
2. Provide functional training, including a gradual return to ADLs and locomotion. Teach energy conservation and activity pacing; avoid overuse and fatigue with activities.
3. Provide cardiovascular fitness and general aerobic conditioning.
4. Provide patient and family education and support.

Amyotrophic Lateral Sclerosis Interventions

Table 6.76 ALS Intervention Strategies[12]

Early-Stage Interventions

1. Patient education should focus on continuing with normal activities as long as possible. Promote the patient's health and wellness. Teach alternative means to accomplish functional activities as the disease progresses. Teach the patient to avoid overworking weakened denervated muscles through energy conservation and activity pacing; teach the patient to monitor fatigue. Teach the patient and family to use equipment and community resources as the disease progresses.
2. Use preventive treatments: AROM, AAROM, stretching, strengthening, and endurance exercises.

Middle-Stage Interventions

1. Continue interventions from the early stage.
2. Maintain the patient's respiratory status; use postural drainage and pectoral muscle stretching.
3. Maintain the patient's functional activities. Avoid overuse of denervated muscles, modify tasks and activities, and monitor the patient's fatigue. Teach wheelchair mobility. Make environmental modifications in the patient's home or work, such as installing grab bars in the bathroom or wheelchair ramps.
4. Consider the rate of disease progression, the area involved, the extent of the disease, the patient's acceptance and motivation, and available psychosocial resources.

Late-Stage Interventions

1. Prevent indirect impairments. Use PROM exercises, positioning, pressure-relieving devices such as a pressure-distributing mattress and gel cushions, a hospital specialty bed, skin care, and pulmonary physical therapy if needed.
2. Relieve pain, muscular spasms, and/or spasticity with modalities such as massage, stretching and PROM, and positioning. Provide family or caregiver education about using a daily PROM program to prevent adhesions, especially for the shoulder; transfer training; positioning; turning in bed; and skin care. Use a mechanical lift if necessary.

(continued)

Table 6.76 ALS Intervention Strategies *(continued)*

3. Address the patient's cervical muscular weakness and pain. Use an orthotic cervical collar—can be soft for mild to moderate weakness or rigid for moderate to severe weakness. Use a recliner chair; use a tilt-in-space or reclining wheelchair.
4. Address the patient's respiratory muscle weakness. Provide patient and caregiver education about energy conservation and activity pacing techniques, signs of aspiration, ways to avoid choking, and manual assisted coughing techniques. Use breathing exercises and positioning.
5. Address the patient's functional activities. Use adaptive equipment to help the patient with ADLs, including eating or feeding utensils. Use orthotic devices—especially for the ankles and knees—to assist with ambulation. Use a wheeled walker or forearm crutches to assist with ambulation.

Recent Advances in Neurological Physical Therapy: Virtual Reality

Table 6.77 Physical Therapy Using Virtual Reality

VR is a new form of physical therapy that offers the following benefits:

- Can improve the following aspects of the patient/client's functionality:
- Executive functioning
- Cortical reorganization
- Balance and trunk control
- Mobility
- Can enhance the patient/client's socialization
- Can increase the following aspects of the patient/client's psychological state:
- Sense of control
- Achievement
- Independence
- Can increase the patient/client's compliance and adherence to physical therapy
- Can be considered a form of pain diversion
- Can help the patient/client to enjoy physical therapy and engage in rehabilitation activities
- Creates a computer-generated interactive environment
- Presents true-life situations
- Is a form of "real-life" training
- Can be individualized to each patient/client
- Can be applied to individuals of all ages
- Can motivate the patient/client to learn different tasks
- Creates an objective measurement of physical therapy results (e.g., measuring the range of motion, the frequency of exercises, and the number of repetitions)
- Has a long-term impact on the patient/client's outcome
- Can be applied to remote locations as long as the patient/client has a computer

(continued)

Table 6.77 Physical Therapy Using Virtual Reality *(continued)*

- Provides for continuity of care
- Can lower the cost of physical therapy
- Affects the sensory system such as vision, hearing, proprioception, touch, balance, and coordination
- Affects the motor systems for training and retraining

Table 6.78 Research-Documented Physical Therapy Using VR

1. Stroke rehabilitation: used for physical therapy for hand, thumb, fingers, balance, and gait training and retraining.
2. Multiple sclerosis and Parkinson's disease: to increase patients' walking speed and stride length.
3. Traumatic brain injury: helping patients/clients to relearn and practice planning skills, activities of daily living, and driving skills.
4. Nonpharmacologic pain control and pain reduction. Pain levels decreased from severe to mild/moderate during physical therapy ROM exercises for patients with multiple blunt-force trauma injuries (e.g., multiple fractures and internal injuries) and for patients with burn injuries. Patients' range of motion increased by 1° after just 1 day of VR therapy and by 15° during the second day of VR therapy.
5. Children with cerebral palsy, attention-deficit/hyperactivity disorder (ADHD), and autism: to improve attention, social and communication behaviors, cognitive skills, postural control, safety, and motor skills.[16,17]
6. Trunk control, limb use, balance, mobility, and gross and fine motor movements.

SECTION 6-6

Physical Therapy Interventions for the Neurological Patient in Acute Care

Table 6.79 Types of General Neurological Impairments and Physical Therapy Interventions in Acute Care[1,3]

- Increased/decreased sensation: tactile input; positioning; splinting; prevention of injury; patient/family education regarding awareness of the involved area and use of compensatory strategies (such as visual)
- Fatigue: strengthening of large muscle groups to compensate for getting fatigue early in the task; patient/family education not to overexert (may cause exacerbation of condition)
- Pain management: limiting sensory input; positioning and turning the patient; maintaining ROM; use of various modalities; use of alternative medicine if necessary
- Decreased endurance: use of a decreased number of repetitions/sets while applying therapeutic exercises; monitoring the patient for fatigue; utilization of assistive devices to conserve energy; prioritization of tasks; breathing exercises for cardiovascular conditioning
- Decreased ROM: stretching exercises (gentle); use of bracing and casting as necessary; if the patient has pain with mobility training, use of pain management (modalities, soft-tissue therapy); preserving biomechanical alignment to increase functional outcomes
- Gait deficits: increasing gait distance gradually, with rest periods between ambulation; using assistive devices and stand-by assistance; using orthotic devices; using a wheelchair while gait training; using encouragement and maintaining ambulation for functional tasks
- Decreased balance: apply interventions for proprioception to improve balance; provision of patient/family education on preventing falls; promotion of functional independence; promotion of a safe environment
- Visual impairment: using an eye patch for diplopia; checking for additional visual impairments such as nystagmus and vestibulo-ocular reflex; application of physical therapy interventions while being aware not to cause nausea or impair patient's safety
- Altered levels of consciousness and potential for cognitive and behavioral problems: work closely with other disciplines to maintain overall care of patient; work closely with the PT as patient emerges from coma; use simple commands, maintain clear communication with patient; treat patient in quiet areas with minimal distraction; provide time for processing instructions.
- Impaired respiratory function: patient may use a ventilator or have weakened muscles of respiration and impaired cough function; may need strengthening of muscles of respiration, assisted cough technique, abdominal binder to improve diaphragm function, postural drainage.

Transient Ischemic Attack

Table 6.80 Characteristics of TIA

- Temporary interruption of blood supply to the brain
- Precursor to cerebral vascular accident (CVA): approximately 10–20% of patients having TIA will have a CVA within 90 days
- Can last less than 24 hours
- Causes: emboli, reduced cerebral perfusion (arrhythmias), decreased cardiac output, hypotension, excessive use of antihypertensive medications, cerebrovascular spasm (subclavian steal syndrome—shunting blood from the left vertebrobasilar artery toward an occluded left subclavian artery and into the left arm)

Cerebral Vascular Accident

Table 6.81 Types of CVA and Their Clinical Characteristics[1]

Anterior Cerebral Artery (ACA) Syndrome

- Contralateral hemiparesis (mainly the lower extremities)
- Contralateral hemisensory loss (mainly the lower extremities)
- Urinary incontinence
- Apraxia: inability to perform purposeful movements, although there is no sensory or motor impairments
- Abulia (akinetic mutism), slowness, delay, and lack of spontaneity
- Contralateral grasp reflex and sucking reflex

Middle Cerebral Artery (MCA) Syndrome

- Contralateral hemiparesis (involving mainly the upper extremities and face)
- Contralateral hemisensory loss (involving mainly the upper extremities and face)
- Broca's (nonfluent) aphasia: limited vocabulary and slow and hesitant speech
- Wernicke's (fluent) aphasia: impaired auditory comprehension and fluent speech (with normal rate and melody)
- Global aphasia: nonfluent speech with poor comprehension
- Perceptual deficits with unilateral neglect, depth perception, spatial relations, and agnosia (inability to recognize or comprehend sights, sounds, words or other sensory information)
- Limb-kinetic apraxia: inability to perform purposive movements, although there are no sensory or motor impairments
- Contralateral homonymous hemianopsia: blindness in one-half of the visual field
- Loss of conjugate gaze to the opposite side (the paired movements of the eyes as they track moving objects)
- Sensory ataxia (impairment of muscular coordination resulting from problems in conduction of sensory responses from muscles) of the contralateral limb
- Pure motor hemiplegia

Internal Carotid Artery (ICA) Syndrome

- Occlusion of the internal carotid artery with a massive infarction in the region of middle cerebral artery that supplies blood to the brain
- Effects ranging from edema to uncal herniation, coma, and death

Posterior Cerebral Artery (PCA) Syndrome

- Contralateral homonymous hemianopsia (visual cortex involved)
- Bilateral homonymous hemianopsia
- Visual agnosia
- Prosopagnosia (difficulty naming people)
- Dyslexia (difficulty reading) without agraphia (difficulty writing)
- Anomia (color naming) and color discrimination
- Memory defect
- Topographic disorientation

(continued)

Table 6.81 Types of CVA and Their Clinical Characteristics *(continued)*

Vertebrobasilar Artery Syndrome

Can produce a wide variety of symptoms with ipsilateral and contralateral signs such as locked-in syndrome (with quadriplegia and coma, but good cognition) or other syndromes.

Cerebellar Hemorrhage

- Ataxia and motor weakness
- Nystagmus
- Dizziness
- Nausea and vomiting
- Impairment in postural control

Table 6.82 Medical Interventions for CVA[1,12]

- Past medical history
- Physical examination
- Diagnostic testing: Lab values; Electrocardiogram (ECG); Scanning imaging (CT scan, MRI); Transcranial Doppler (TCD); Ultrasound for blood velocity test; MRA (magnetic resonance angiography for blood flow); Positron Emission Tomography (PET)
- Manage elevated BP, raise lowered BP.
- Manage cerebral edema, control intracranial pressure.
- Oxygen by mask or canula to maintain oxygenation.
- Thrombolytic and antithrombotic agents for management of ischemic stroke.
- Anticoagulation therapy (heparin, warfarin)
- Antiplatelet therapy (aspirin, ticlopidine)
- Surgery: endarterectomy; aneurysm repair.

Table 6.83 Physical Therapy Interventions for CVA

- Physical therapy starts when the patient is medically stabilized (approximately within 72 hours). The PT or PTA should continuously monitor the patient for risk of medical emergencies (such as hypertension, arrhythmia, DVT, or another stroke).
- Focus on positioning in bed, chair, and wheelchair to reduce risk of contractures.
- Provide early stimulation of the hemiparetic side to avoid learned non-use.
- Ensure early mobilization (gait training); consider strengthening of the involved lower extremity; consider the patient's previous deconditioning.
- Promote stability of the involved upper extremity; improve motor control of the affected region; prevent injury to the affected shoulder; watch for painful shoulder syndrome; use the FES protocol for shoulder subluxation.
- Promote skill acquisition to enable ADL and functional recovery
- Facilitate lifestyle changes, to include daily exercise.
- Consider the patient's individual goals.
- Provide patient and family education from an early stage.

Post Spinal Cord Injury: Interventions

- During the acute and subacute stage of rehabilitation the PT and PTA should consider the patient's need for assistive devices, mobility devices and orthotics.
- Prevent secondary complications i.e., pressure sores, contractures, respiratory dysfunction.
- Recognize that patients with SCI will require fracture stabilization and may have undergone closed or open reduction. Effectively manage the patient with stabilization orthotics including patients with a thoracolumbosacral orthosis (TLSO) or Halo vest.

Table 6.84 Post Spinal Cord Injury: Physical Therapy Interventions[1,3]

High Cervical Levels (C2–C3 and C4)
■ Breathing exercises ■ Inspiratory muscle training ■ PROM and positioning ■ Strengthening exercises ■ Patient/family/caregiver education ■ Monitoring for autonomic dysreflexia (see **Table 6.55**)
Lower Cervical Levels (C5 to T1)
■ Positioning ■ Weight shifting ■ Functional mobility training ■ Strengthening exercises that include the respiratory muscles ■ Patient/family/caregiver education ■ Monitoring for autonomic dysreflexia
High Thoracic Levels (T2–T6)
■ Positioning ■ Weight shifting ■ Functional mobility training that includes a standing program ■ Respiratory exercises ■ Patient/family/caregiver education ■ Monitoring for autonomic dysreflexia
Low Thoracic Levels (T7–T12)
■ Functional mobility training that includes a standing program ■ Respiratory exercises ■ Weight-shifting training ■ Patient/family/caregiver education
Lumbar Injury Levels (L1–L5)
■ Functional mobility training that includes gait training ■ Weight-shifting training ■ Patient/family/caregiver education

(continued)

Table 6.84 Post Spinal Cord Injury: Physical Therapy Interventions *(continued)*

Lumbar and Sacral Levels

- Functional mobility training that includes gait training
- Weight-shifting training
- Patient/family/caregiver education

Parkinson's Disease and Parkinsonism: Physical Therapy Interventions

Table 6.85 Parkinson's Disease and Parkinsonism: Physical Therapy Interventions

- Transfer training and bed mobility training (turning and reaching activities) facilitate patients' functional mobility and prevent falls.
- Gait reeducation with focus on step length and height, reciprocal arm swing.
- Flexibility and ROM exercises, i.e., Tai-Chi and yoga, can decrease ROM deficits, and preserve motion and ability to perform functional tasks. Examples of ROM exercises using PNF include PNF patterns (bilateral D2 flexion for the upper extremities to promote upper trunk extension and prevent kyphosis; D1 extension—hip extension, abduction, and IR) for the lower extremities to counteract flexion and adduction.
- Posture reeducation to minimize stooped and kyphotic posture.
- Therapeutic strengthening exercises can strengthen specific muscle groups and prevent deconditioning.
- Cardiopulmonary conditioning using bicycle or/and treadmill.
- Treadmill training for gait dysfunction can promote mobility for aerobic conditioning.
- Patient education to focus attention to the task can decrease the slowness of movement.
- Observe the patient for symptoms of depression; encourage, educate, and praise the patient regarding his or her efforts and ability to perform tasks.
- Physical therapy goals must be patient centered.
- Utilize cueing to assist and improve the patient's motor performance (by correcting deficits). Auditory cues are beneficial for akinesia; cues for the patient to take longer steps can assist with gait deficits.
- Teach balance exercises; can prevent falls and promote the patient's functional independence.

Traumatic Brain Injury: Medical and Physical Therapy Management

Table 6.86 Medical Management of Traumatic Brain Injury[12]

- Glasgow Coma Scale: used to determine level of consciousness. Tests the function of the brain stem and the cerebrum using the patient's eye, motor, and verbal responses. Scores from 13 to 15 indicate mild brain injury; 9 to 12 indicate moderate brain injury; and 8 and lower indicate severe brain injury.

(continued)

Table 6.86 Medical Management of Traumatic Brain Injury *(continued)*

- Diagnostic Testing: computed tomography (CT); magnetic resonance imaging (MRI); functional magnetic resonance imaging (fMRI); positron emission tomography (PET); neuropsychologic testing; assessment and monitoring of intracranial pressure (ICP); Visual/auditory/somatosensory evoked potential examinations.[1]
- Medical care interventions post TBI: resuscitation; management of respiratory dysfunction including intubation and ventilation as indicated; cardiovascular monitoring—management of BP; treatment of increased intracranial pressure (using pharmacological, mechanical, or surgical procedures); maintenance of fluid and electrolyte balance; maintenance of nutrition, and eye and skin care; prevention of contractures; postural drainage; patient's safety.

Table 6.87 Physical Therapy Management of Traumatic Brain Injury[1,12]

- The PT and PTA are part of the interdisciplinary team that is characterized by open communication between all members of the team and open mindedness.
- Recognize importance of positioning for patients with TBI to prevent untoward events. Patients with increased ICP should be positioned with head elevated to about 30 deg. Patients with a nasogastric feeding tube should not be allowed to lie flat and an elevated head position of 30 deg is also indicated.
- General physical therapy goals may include the following: increase the patient's physical function and alertness level; reduce the risk of secondary impairments; improve motor control; decrease the effects of abnormal tone; improve postural control; increase the patient's tolerance to activities and positions; emphasize mobility, joint integrity, and function.
- Interventional goals in acute care may include the following (depending on the Ranchos Los Amigos [RLA] level): decrease abnormal posturing and primitive reflexes; improve the patient's arousal level (using sensory stimulation); manage the effects of abnormal tone and spasticity; maintain joint integrity.
- Examples of interventions in acute care may include the following (depending on the RLA level): sensory stimulation; flexibility exercises (PROM and/or AROM); bed and wheelchair positioning; patient and family education; transition to sitting when medically stable; progress to tilt table and functional tasks in sitting and supported standing; developmental sequence postures.

SECTION 6-7

Pharmacology for Neurological Pathologies

Table 6.88 Common Medications for Neurologic Conditions[18]

*Classes of Drugs	Purpose of Medication	*Common Side Effects	PTA Implications
Sedative hypnotics			
Benzodiazepines ■ Temazepam (Restoril) ■ Triazolam (Halcion) ■ Flurazepam (Dalmane)	■ Calm the patient ■ Facilitate normal sedation and sleep	■ Next day effects of drowsiness and ↓ motor performance ■ Hangover feeling the next day ■ Anterograde amnesia	■ ↑ fall risk ■ Poor memory recall of: WB status/ precautions/contra-indications ■ ↑ full cooperation of patient (less anxious) ■ Potential drug tolerance ■ Potential addiction
Barbiturates ■ Amobarbital (Amytal) ■ Pentobarbital (Nembutal) ■ Phenobarbital (Solfoton)	■ CNS depressants ■ Sleep aids	■ Same as above	■ Same as above
Anti-Anxiety			
■ **Benzodiazepines** ■ Valium (diazepam) ■ Alprazolam (Xanax) ■ Clonazepam (Klonopin) ■ Lorazepam (Ativan)	■ Anti-anxiety	■ Same as above ■ Skeletal muscle relaxation ■ Rebound anxiety if stopped abruptly	■ Dizziness, drowsiness, lethargy, hypotension, drug dependence, drug tolerance, blurred vision, respiratory depression
■ **Other Anti-anxiety medications** ■ Buspirone (Buspar)	■ General anxiety disorders	■ Drowsiness ■ Personality changes ■ Nausea ■ Rashes ■ Sweating	■ Dizziness, drowsiness, fatigue, headache, blurred vision, tachycardia, myalgia, ataxia, paresthesia
Anti-Depressant			
Tricyclics ■ Amitriptyline (Elavil) ■ Doxepin (Sinequan) ■ Nortriptyline (Aventyl)	■ Treatment of depression	■ Sedation, ■ Orthostatic hypotension ■ Cardiac arrhythmias ■ Seizures	■ Drowsiness, confusion, tachycardia, orthostatic hypotension, hypotension, risk of seizures, increased fall risk,

(continued)

Table 6.88 Common Medications for Neurologic Conditions *(continued)*

*Classes of Drugs	Purpose of Medication	*Common Side Effects	PTA Implications
MAO inhibitors ■ Phenelzine (Nardil) ■ Tranylcypromine (Parnate)	■ Treatment of depression	■ CNS excitation ■ Agitation ■ Tremor ■ Confusion ■ Hypertension ■ edema	■ Risk for hypertensive crisis, dizziness, fatigue, drowsiness, orthostatic hypotension, weakness, anxiety, paresthesia, fall risk
Second Generation Drugs ■ Fluoxetine (Prozac) ■ Paroxetine (Paxil) ■ Sertraline (Zoloft)	■ Treatment of depression	■ Risk of seizures ■ Sedation ■ Anxiety ■ Insomnia ■ Nausea	■ Anxiety, tremor, myalgia, dizziness, palpitations
Antipsychotics			
■ Aripiprazole (Abilify) ■ Chlorpromazine (Thorazine) ■ Haloperidol (Haldol) ■ Thioridazine (Mellaril)	■ Severe forms of mental illness—e.g., schizophrenia, psychosis ■ Alzheimer's agitation and confusion	■ Dysphagia ■ Tardive Dyskinesia ■ Sedation ■ Parkinsonian-like symptoms ■ Restlessness ■ Dystonia/dyskinesia ■ Neuroleptic Malignant Syndrome (NMS): Catatonia, stupor, rigidity, tremors, fever ■ Blurred vision ■ Dry mouth ■ Constipation ■ Urinary retention ■ Orthostatic hypotension	■ ↑ fall risk, orthostatic hypotension, sedation, blurred vision ■ Enhanced participation ■ Monitor for dyskinesia or other motor changes and notify medical staff immediately
Antiepileptic			
First-Generation Medications ■ Phenobarbital (Solfoton) ■ Amobarbital (Amytal)	■ Controls seizure activity in the brain for either partial seizures or general seizures ■ Same as above	■ Sedation ■ Nystagmus ■ Ataxia ■ Behavioral changes ■ GI irritation	■ Be aware of the patient's seizure plan if one is in place ■ Monitor for any changes in mm weakness, GI issues, behavioral changes

(continued)

Table 6.88 Common Medications for Neurologic Conditions *(continued)*

*Classes of Drugs	Purpose of Medication	*Common Side Effects	PTA Implications
■ Secobarbital (Seconal) ■ Clonazepam (Klonopin) ■ Diazepam (Valium) ■ Lorazepam (Ativan) ■ Phenytoin (Dilantin) ■ Carbamazepine (Tegretol) ■ Valproic acid (Depakote) **Second-Generation Medications** ■ Gabapentin (Neurontin) ■ Levetiracetam (Keppa) ■ Topiramate (Topomax) ■ Zonisamide (Zonegran)	■ Gabapentin is sometimes used for neuropathic pain syndromes	■ Dizziness ■ Headaches ■ Hirsutism ■ Dyskinesia ■ Akinesias ■ Temporary hair loss ■ Weight gain or loss ■ Impaired platelet function ■ Sedation ■ Fatigue ■ Dizziness ■ Ataxia ■ Generalized weakness ■ Loss of appetite	■ Beware of extra -pyramidal symptoms ■ Clinical environment triggers: lights, sounds, smells ■ Consider medication dosing and appointment scheduling if possible ■ Monitor for medication toxicity and report this immediately to a medical professional
Parkinson Disease			
■ Levodopa (Sinemet CR) ■ Bromocriptine (Parlodel) ■ Pergolide (Permax) ■ Amantadine (Symmetrel) ■ Benztropine (Cogentin) ■ Pramiperoxole (Mirapex)	■ Dopaminergic replacement therapy ■ Levodopa crosses the blood-brain barrier to transform into dopamine ■ Dopamine agonist medications (Pergolide, Bromcriptine) to decrease on-off effects (can be used alone or in combination with L-Dopa)	■ GI issues (carbidopa given with levodopa to ↓ GI issues) ■ Cardiac arrhythmias ■ Postural hypotension ■ Dyskinesia ■ ↓ effectiveness of L-dopa with prolonged use ■ On-off phenomenon Off= spontaneous reduction of L-dopa = worsening of symptoms; On = restored movement after taking L-dopa ■ Constipation and motility issues ■ Dyskinesia, dystonia ■ Decreased long term effectiveness with Levodopa	■ Coordinate PT 1 hour after taking Levodopa ■ Elderly schedule within an hour of their breakfast dose = < fatigue ■ If on drug holiday (3 days up to 3 weeks) treatment focus = maintain patient mobility Also = ↑ ↑ fall risk BP monitoring due to postural hypotension, dizziness, syncope, increased fall risk

(continued)

Table 6.88 Common Medications for Neurologic Conditions *(continued)*

*Classes of Drugs	Purpose of Medication	*Common Side Effects	PTA Implications
Skeletal Muscle Relaxants			
■ Baclofen (Lioresal)† ■ Dantrolene sodium (Dantrium)† ■ Diazepam (Valium)† ■ Gabapentin (Neurontin)† ■ Tizanidine (Zanaflex)† ■ Botulinum Toxin (Botox)†	■ †Indicated for CNS-related spasticity associated with SCI, MS ■ ††Used for skeletal muscle spasms related to PNS injury ■ †††Anticonvulsant medication used as an adjunct to other drugs for CNS dysfunctions related to SCI and MS	■ Long-term use of anti-spasmodic medications can result in sedation, physical dependence, or addiction ■ Anti-spasticity medications used to treat CNS dysfunctions may affect tone-reducing effects which may impede the reliance on muscle tone to assist in functional tasking (i.e., extensor tone in lower extremity would be reduced, thereby predisposing the patient to falls)	■ Sedation ■ Generalized muscle weakness ■ Liver toxicity - jaundice ■ Improved ability to participate in PT if well controlled with medications ■ PTA may need to schedule PT around dosing schedules to allow for optimal alertness during treatment
Medications to Manage Alzheimer's Dementia			
■ Donepezil (Aricept) ■ Memantine (Namenda)	■ Dementia management	■ Nausea/vomiting ■ Diarrhea ■ Insomnia ■ Dizziness ■ Weight loss ■ Muscle cramps ■ Drowsiness ■ Fatigue	■ ↑ fall risk ■ Hypertension

* Brand names associated with classes of medications and side effects found within this table are not representative of an all-inclusive list. It is incumbent on the clinician to research an appropriate drug information resource to obtain complete information about medications that patients may use while attending rehabilitation.
† The drugs have multi-purposes even though they are listed as skeletal muscle relaxants.

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