Part 3

Musculoskeletal Interventions

SECTION 3-1

Phases of Tissue Healing and Clinical Interventions

Tissue Healing and Interventions

Table 3-1 Tissue Healing and Interventions

Clinical Signs	Interventions
Inflammatory Phase	
• Begins immediately after injury • Lasts 2–4 days • Signs: pain (dolor), heat (calor), redness (rubor), swelling (tumor), and loss of function (functio laesa)	• Rest the area: immobilize and protect the affected area; exercise the unaffected areas; NWB or PWB; PROM if applicable; continuous passive motion (CPM) postoperatively • Ice: apply ice or cold • Compression: taping, bracing, or orthotics • Elevation: elevate the part • Decrease pain: use physical agents and modalities for pain management and swelling • Patient education: educate about avoidance of activities and how to protect the area
Fibroblastic Phase	
• Begins immediately after the inflammatory phase at approximately fifth day • Lasts up to 3 weeks • Signs: lessening of inflammation; may still have pain and weakness	• Protect the area: bracing or orthotics; progressive WB such as PWB or WBAT • Decrease pain: physical agents and modalities for pain management and swelling • Increase ROM and function: use scar mobilization techniques; PROM, AAROM, AROM; isometric exercises; stretching exercises (start with light stretching because tissue is delicate in the beginning); CKC if pain and swelling subsided; ADLs • Patient education: how to protect the affected area; avoid excessive motion for tissue irritation/destruction
Remodeling Phase	
• Lasts from 3 weeks to 3 months • Signs: inflammation is resolved • Caution: if scar tissue is irritated or stressed, the fibroblastic activity continues; patient may present with pain, swelling, stiffness, and muscle guarding	• Increase strength and function to normal: restore stability, mobility, joint arthrokinematics, gradual return to work/school/hobbies • Patient education: how to avoid future injury

SECTION 3-2

Bones

Human Skeleton

Bones make up the framework of the human body. The human skeleton has 206 bones, including 80 in the trunk (axial skeleton) and 126 in the limbs (appendicular skeleton) (Figure 3-1).

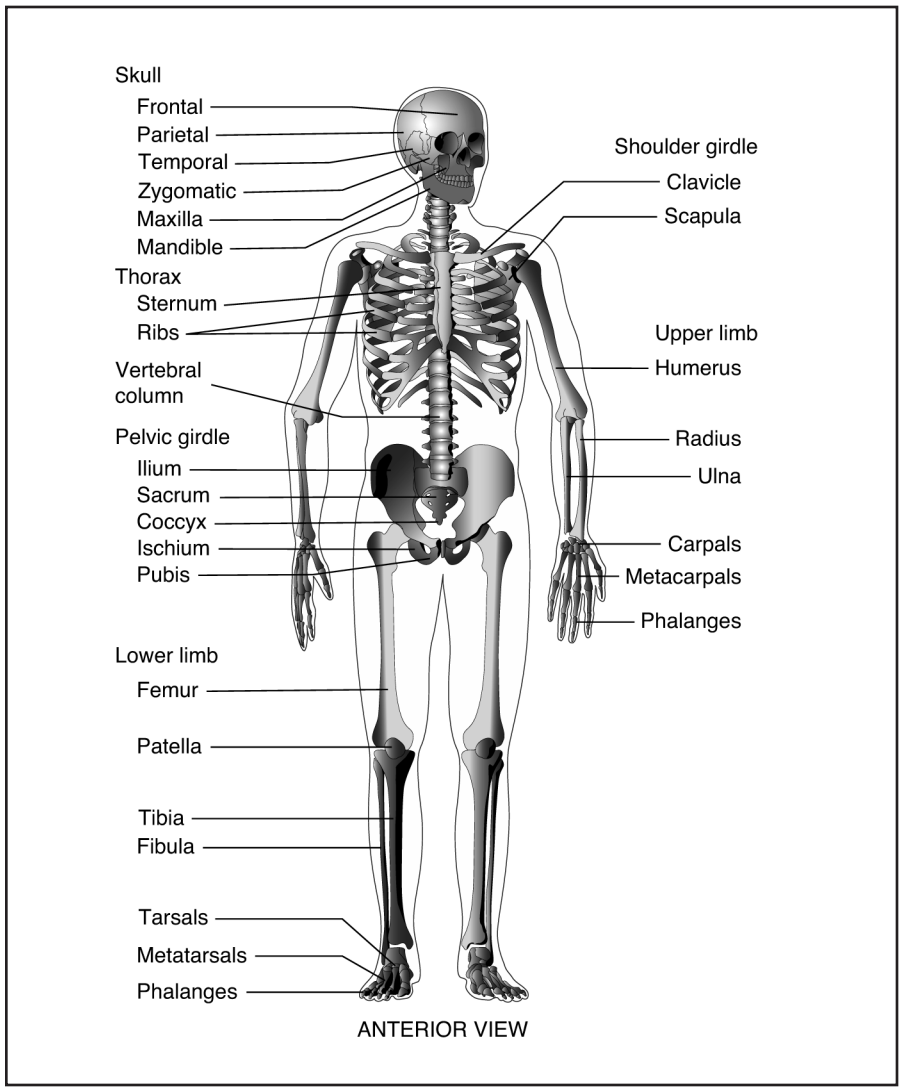


Figure 3-1 The human skeleton

Carpal Bones

Table 3-2 Carpal Bones

Proximal raw	Scaphoid (navicular); lunate; triquetrum; pisiform
Distal raw	Trapezium; trapezoid; capitate; hamate

Tarsal Bones

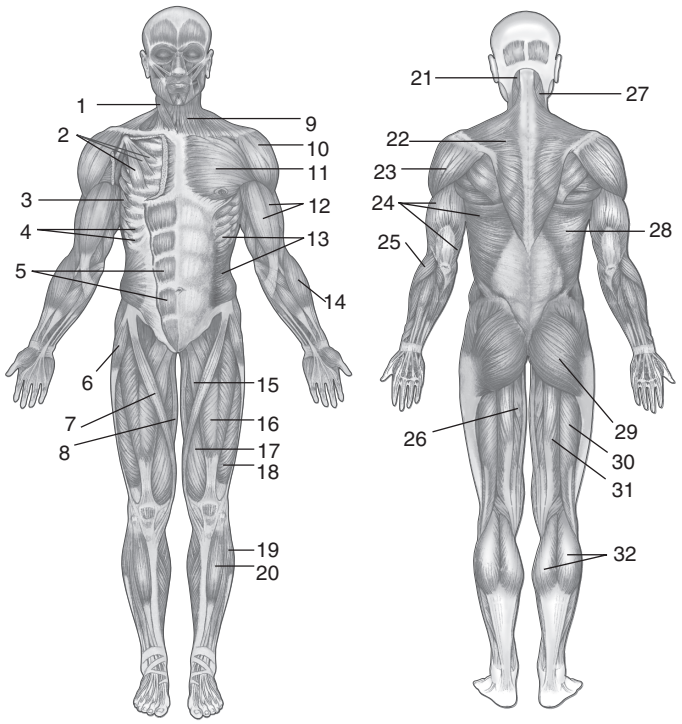
Table 3-3 Tarsal Bones

Calcaneus
Cuboid
First metatarsal
Talus
Navicular
First cuneiform (medial cuneiform)
Second cuneiform (intermediate cuneiform)
Third cuneiform (lateral cuneiform)

SECTION 3-3

Muscles: Function, Nerve, Origin, Insertion, and Palpation

See Figure 3-2.



1. Sternocleidomastoid
2. Pectoralis minor
3. Serratus anterior
4. External intercostals
5. Rectus abdominis
6. Tensor fasciae latae
7. Sartorius
8. Gracilis
9. Platysma
10. Deltoid
11. Pectoralis major
12. Biceps brachii
13. External abdominal oblique
14. Brachioradialis
15. Adductor longus
16. Rectus femoris
17. Vastus medialis
18. Vastus lateralis
19. Peroneus longus
20. Tibialis anterior
21. Levaor scapulae
22. Trapezius
23. Deltoid
24. Triceps brachii
25. Extensor carpi radialis longus
26. Adductor magnus
27. Splenius
28. Latissimus dorsi
29. Gluteus maximus
30. Biceps femoris
31. Semitendinosus
32. Gastrocnemius

Figure 3-2 Anterior and posterior superficial muscles

Pelvis and Hip Muscles

Table 3-4 Pelvis and Hip Muscles[1]

Muscle	Function	Nerve	Origin	Insertion	Palpation
Iliopsoas	Hip flexion, adduction, external rotation	Femoral nerve (L2–L3)	Iliac fossa, anterior, and lateral surfaces of T12–L5	Lesser trochanter of the femur	Psoas major can be palpated distal to the inguinal ligament on the medial side of the sartorius
Tensor fascia latae (helps knee to extend)	Combined hip flexion, abduction, internal rotation	Superior gluteal nerve (L4–L5)	ASIS	Through the iliotibial tract to the lateral condyle of the tibia	Iliotibial tract can be palpated at its insertion into the lateral tibial tubercle of the knee
Sartorius	Hip flexion, abduction, external rotation	Femoral nerve (two branches; L2–L3)	ASIS	Proximal part of the medial surface of the shaft of the tibia (pes anserinus)	Palpated at its origin, slightly inferior to the ASIS
Gluteus maximus (sciatic nerve lies underneath)	Hip extension, hyperextension, external rotation	Inferior gluteal nerve (L1–L5; S1–S2)	Posterior sacrum and ilium	Posterior femur distal to the greater trochanter and to the iliotibial band	Palpated in the prone position, when the buttocks are squeezed together, or when extending the hip and flexing the knee
Gluteus medius (with gluteus minimus and TFL abducts the thigh at the hip joint)	Hip abduction	Superior gluteal nerve (L4–S1)	Outer surface of ilium	Greater trochanter of the femur (lateral surface)	Origin can be palpated slightly below the iliac crest in a side-lying position, with the leg to be palpated raised in a few degrees of abduction

Gluteus minimus	Hip abduction, internal rotation	Superior gluteal nerve (L4–S1)	Lateral ilium	Greater trochanter of the femur (anterior border)	Cannot be palpated
Adductor magnus	Hip abduction	Superior gluteal nerve (L4–S1)	Outer surface of the ilium	Entire linea aspera and adductor tubercle	Cannot be palpated individually, only as a group
Adductor brevis	Hip abduction	Obturator nerve (L3–L4)	Outer surface of the inferior ramus of the pubis	Proximal part of the linea aspera and the pectineal line	Cannot be palpated individually, only as a group
Adductor longus	Hip abduction	Obturator nerve (L3–L4)	Outer surface of the inferior ramus of the pubis	Middle one-third of the linea aspera	Cannot be palpated individually, only as a group
Piriformis (muscle spasm can cause tenderness of sciatic nerve)	Hip external rotation	Nerves originating from S1 and S2 nerve root segments	Sacrum	Greater trochanter of the femur (superior border)	Cannot be palpated

Knee Muscles

Table 3-5 Knee Muscles[1]

Muscle	Function	Nerve	Origin	Insertion	Palpation
Rectus femoris (powerful knee joint stabilizer)	Hip flexion, knee extension	Femoral nerve (L2–L4)	AIIS	Quadriceps tendon into the tibial tubercle	Palpated as part of the quadriceps femoris group; for atrophy, measure the circumference of each thigh at 3 inches above the mid-patella
Vastus medialis	Knee extension	Femoral nerve (L2–L4)	Linea aspera	Quadriceps tendon into the tibial tubercle	Palpated as part of the quadriceps femoris group
Vastus lateralis	Knee extension	Femoral nerve (L2–L4)	Linea aspera	Quadriceps tendon into the tibial tubercle	Palpated as part of the quadriceps femoris group
Vastus intermedius	Knee extension	Femoral nerve (L2–L4)	Anterior femur	Quadriceps tendon into the tibial tubercle	Palpated as part of the quadriceps femoris group
Biceps femoris	Knee flexion, hip extension	Sciatic nerve for long head (S1–S3); common peroneal nerve for short head (L5–S2)	Long head: ischial tuberosity; short head: lateral lip of the linea aspera of the femur	Common tendon of the two heads inserts at the head of the fibula	Palpated near its insertion into the head of the fibula when flexing the knee
Semi-membranosus	Knee flexion, hip extension	Tibial portion of sciatic nerve (L5–S2)	Ischial tuberosity	Medial condyle of the tibia posterior surface	Hamstrings group palpated from the common origin on the ischium to insertion
Semi-tendinosus	Knee flexion, hip extension	Sciatic nerve (L5–S2)	Ischial tuberosity	Anteromedial surface of the shaft of the tibia (pes anserinus)	Hamstrings group palpated from the common origin on the ischium to insertion

Ankle and Foot Muscles

Table 3-6 Ankle and Foot Muscles[1]

Muscle	Function	Nerve	Origin	Insertion	Palpation
Gastrocnemius	Ankle plantarflexion, knee flexion	Tibial nerve (S1–S2)	Medial and lateral condyles of the femur	Through the Achilles tendon into the calcaneus	Gastrocnemius and soleus can be observed in action by asking the patient to walk on his or her toes
Soleus	Ankle plantarflexion	Tibial nerve (S1–S2)	Posterior fibula and tibia	Through the Achilles tendon into the calcaneus	Gastrocnemius and soleus can be observed in action by asking the patient to walk on his or her toes
Tibialis anterior	Ankle dorsiflexion, foot inversion	Deep peroneal nerve (L4–S1)	Lateral tibia and interosseous membrane	First cuneiform and metatarsal	Palpated medially at the dorsum of the foot at its insertion onto the first metatarsal and the first cuneiform bones
Tibialis posterior (supports the medial longitudinal arch of the foot)	Foot inversion, ankle plantarflexion	Tibial nerve (L5–S1)	Interosseous membrane, adjacent tibia, and fibula	Navicular and most tarsals and metatarsals	Tendon palpated behind and inferior to the medial malleolus
Peroneus longus (supports malleolus the lateral longitudinal arch of the foot)	Foot eversion, ankle plantarflexion	Superficial peroneal nerve (L4–S1)	Lateral proximal fibula and interosseous membrane	Plantar surface of the first cuneiform and metatarsal	Tendon palpated with the peroneus brevis tendon behind the lateral
Peroneus brevis	Foot eversion, ankle plantarflexion	Superficial peroneal nerve (L4–S1)	Lateral two-thirds of the lateral surface of the fibula	Plantar surface of the fifth metatarsal bone	Tendon palpated with the peroneus longus tendon behind the lateral malleolus
Extensor digitorum longus (EDL)	Extension of the four lesser toes, ankle, dorsiflexion foot eversion	Deep peroneal nerve (L4–S1)	Anterior surface of the shaft of the fibula	Distal phalanx of the four lesser toes	EDL tendon palpated lateral to the EHL when the toes are extended

(*continues*)

Table 3-6 Ankle and Foot Muscles[1] (continued)

Muscle	Function	Nerve	Origin	Insertion	Palpation
Extensor hallucis longus (EHL)	Extension of the great toe, ankle dorsiflexion, foot inversion	Deep peroneal nerve (L4–S1)	Fibula and interosseous membrane	Distal phalanx of the great toe	EHL tendon palpated lateral to the tibialis anterior when the big toe extends
Flexor digitorum longus (FDL)	Flexion of the four lesser toes, ankle plantarflexion, foot inversion	Tibial nerve (L5–S1)	Posterior tibia	Distal phalanx of the four lesser toes	FDL tendon palpated immediately behind the posterior tibialis, just above the medial malleolus, when the toes are flexed
Flexor hallucis longus (FHL; maintains the medial longitudinal arch of the foot)	Flexion of the great toe, ankle, plantarflexion toe, ankle, plantarflexion, foot inversion	Tibial nerve (L5–S1)	Posterior fibula and interosseous membrane	Distal phalanx of the great toe	Cannot be palpated

Shoulder Muscles

Table 3-7 Shoulder Muscles[1]

Muscle	Function	Nerve	Origin	Insertion	Palpation
Upper trapezius	Scapular elevation, upward rotation	Spinal accessory nerve CN XI (C3–C4)	Occipital protuberance, nuchal ligament	Outer half of the clavicle, acromion process	Palpated with the middle and lower trapezius from the origin through the clavicle, acromion, and spine of the scapula; for lower angle, continue to the spinous processes of the lower thoracic vertebrae (T12)
Middle trapezius (pulls scapula medially)	Retraction of shoulder girdle	Spinal accessory nerve CN XI (C3–C4)	Spinous processes of C7–T3	Superior lip of the spine of the scapula	Same as above
Lower trapezius (pulls scapula downward)	Scapular depression, upward rotation	Spinal accessory nerve CN XI (C3–C4)	Spinous processes of the middle and lower thoracic vertebrae	Base of the spine of the scapula	Same as above
Serratus anterior (prevents winging of the scapula)	Scapular protraction, upward rotation	Long thoracic nerve (C5–C7)	Lateral surface of the upper eight ribs	Anterior surface of the vertebral border of the scapula	Palpated at the medial wall of the axilla, over the ribs
Rhomboid major and minor (raises the medial border of the scapula)	Scapular retraction, downward rotation	Dorsal scapular nerve (C5)	Nuchal ligament and spinous processes of C7 and T5	Vertebral border of the scapula between the spine and the inferior angle	Palpated under the overlying trapezius; patient must have arm in the back in IR, pushing the hand posteriorly into the PTA's hand
Levator scapulae (raises the medial border of the scapula)	Scapular elevation, downward rotation	C3 and C4 nerves, and dorsal scapular nerve (C5)	Transverse processes of C1–C4	Vertebral border of the scapula between the superior angle and the base of the spine	Cannot be palpated

(*continues*)

Table 3-7 Shoulder Muscles[1] (continued)

Muscle	Function	Nerve	Origin	Insertion	Palpation
Deltoid (anterior, middle, and posterior)	Shoulder abduction, flexion, extension, hyperextension, internal rotation, external rotation, horizontal adduction	Axillary nerve (C5–C6)	Anterior at the lateral third of the clavicle; middle at the acromion process of the scapula; posterior at the inferior lip of the spine of the scapula	Anterior, middle, and posterior at the deltoid tuberosity of the humerus	Palpated from the acromion to the deltoid tuberosity of the humerus
Pectoralis major and minor (rotates the scapula forward and downward)	Major: shoulder flexion to about 90°, internal rotation, adduction, horizontal adduction	Major: lateral and medial pectoral nerves (C5–T1)	Major: clavicular head at the medial third of the clavicle; sternal head at the anterior surface of the sternum, and costal cartilage of the first six ribs	Major: both heads at the lateral lip of the bicipital groove of the humerus (crest of the greater tubercle)	Major: palpated bilaterally, mostly toward the medial portion; breast tissue overlies the pectoralis major
	Minor: scapular rotation	Minor: medial pectoral nerve (C8–T1)	Minor: third, fourth, and fifth ribs	Minor: medial border of the coracoid process	Minor: cannot be palpated
Latissimus dorsi (assists rotating scapula downward)	Shoulder extension, adduction, internal rotation, hyperextension	Thoracodorsal nerve (C6–C8)	Spinous process of T7–L5, sacrum and iliac crest, and lower three ribs	Bicipital groove of the humerus (floor and medial lip)	Palpated most easily along the posterior wall of the axilla when the patient abducts the arm
Teres major	Shoulder extension, adduction, internal rotation	Subscapular nerve (C5–C6)	Axillary border of the scapula near the inferior angle	Medial lip of the bicipital groove of the humerus (crest of the lesser tubercle)	Palpated on the lateral border of the scapula just below the axilla

Rotator Cuff Muscles

Table 3-8 Rotator Cuff Muscles[1]

Muscle	Function	Nerve	Origin	Insertion	Palpation
Supraspinatus (assists deltoid in abduction)	Shoulder abduction	Suprascapular nerve (C5–C6)	Supraspinous fossa of the scapula	Greater tuberosity of the humerus	Palpated as a group at the greater tuberosity of the humerus when the patient has the shoulder extended passively
Infraspinatus	Shoulder external rotation, horizontal abduction	Suprascapular nerve (C5–C6)	Infraspinous fossa of the scapula	Greater tuberosity of the humerus	Same as above
Teres minor	Shoulder external rotation, horizontal abduction	Axillary nerve (C5–C6)	Axillary border of the scapula	Greater tuberosity of the humerus	Same as above
Subscapularis	Shoulder internal rotation, abduction	Suprascapular nerve (C5–C6)	Subscapular fossa of the scapula	Greater tuberosity of the humerus	Cannot be palpated

Elbow and Forearm Muscles

Table 3-9 Elbow and Forearm Muscles[1]

Muscle	Function	Nerve	Origin	Insertion	Palpation
Biceps brachii (main supinator)	Elbow flexion, forearm supination	Musculocutaneous nerve (C5–C6)	Short head: coracoid process of the scapula Long head: supraglenoid tubercle of the scapula	Bicipital tuberosity of the radius	Palpated distally toward insertion when the patient flexes the elbow
Triceps brachii	Elbow extension	Radial nerve (C7–C8)	Long head: infraglenoid tubercle of the scapula Lateral head: lateral/posterior surfaces of the proximal humerus Medial head: medial/posterior surfaces of the distal humerus	Olecranon process of the ulna	Palpated from the infraglenoid tubercle to just before the olecranon process; the patient must be leaning on a table with the arm slightly abducted and the hand on the table (as if a crutch supported the arm)
Brachialis	Elbow flexion	Musculocutaneous nerve (C5–C6)	Distal part of the anterior surface of the humerus	Ulnar tuberosity and coronoid process of the ulna	Cannot be palpated
Brachioradialis (assists rotating the forearm to the mid-prone position)	Elbow flexion	Radial nerve (C5–C6)	Lateral supracondylar ridge of the humerus	Styloid process of the radius	Palpated on the anterolateral aspect of the arm, when the patient has the elbow flexed at 90° and is making a fist, pushing up under the edge of a table
Supinator	Forearm supination	Radial nerve (C6)	Lateral epicondyle of the humerus and the adjacent ulna	Anterior surface of the proximal radius	Cannot be palpated
Pronator teres	Forearm pronation, elbow flexion	Median nerve (C6–C7)	Medial epicondyle of the humerus, coronoid process of the ulna	Lateral surface of the radius at its midpoint	Palpated as the common tendon of the wrist flexor and pronator muscle group, at the medial epicondyle of the humerus

Table 3-10 Wrist, Hand, and Finger Muscles[1]

Muscle	Function	Nerve	Origin	Insertion	Palpation
Flexor carpi ulnaris (FCU)	Wrist flexion, ulnar deviation	Ulnar nerve (C8–T1)	Medial epicondyle of the humerus	Pisiform and base of the fifth metacarpal	FCU tendon palpated proximal to the pisiform on the ulnar side of the palmaris longus when the patient flexes the wrist against resistance
Flexor carpi radialis (FCR)	Wrist flexion, radial deviation	Median nerve (C6–C7)	Medial epicondyle of the humerus	Base of the second and third metacarpals (palmar surface)	FCR tendon palpated radially to the palmaris longus when the patient flexes the wrist and radially deviates the hand
Extensor carpi ulnaris (ECU)	Wrist extension, ulnar deviation	Radial nerve (C6–C8)	Lateral epicondyle of the humerus	Base of the fifth metacarpal	Palpated starting at the ulnar styloid process and going toward the ECU insertion
Extensor carpi radialis longus (ECRL)	Wrist radial deviation, extension	Radial nerve (C6–C7)	Supracondylar ridge of the humerus	Base of the second metacarpal	Palpated on the radial side of the dorsal radial tubercle when the patient clenches the fist
Extensor carpi radialis brevis (ECRB)	Wrist extension	Radial nerve (C6–C7)	Lateral epicondyle of the humerus	Base of the third metacarpal	Palpated on the radial side of the dorsal radial tubercle when the patient clenches the fist
Flexor digitorum superficialis (FDS)	Finger flexion of proximal interphalangeal (PIP) and meta-carpophalangeal (MCP) joints	Median nerve (C7, C8, T1)	Lateral epicondyle of the humerus, coronoid process, and radius	Sides of the middle phalanx of the four fingers	Can be isolated for a specific finger and tested by holding the nontested fingers in extension while asking the patient to flex the PIP joint of the tested finger
Flexor digitorum profundus (FDP)	Flexion of all three joints of the fingers	Median and ulnar nerves (C8–T1)	Upper three-fourths of the ulna	Distal phalanx of the four fingers	Can be isolated for a specific finger and tested by stabilizing the MCP

(*continues*)

Table 3-10 Wrist, Hand, and Finger Muscles[1] (continued)

Muscle	Function	Nerve	Origin	Insertion	Palpation
					and IP joints of the tested finger in extension while asking the patient to flex only the DIP of the tested finger
Extensor digitorum (extensor digitorum communis)	Extension of all three joints of fingers (MP, PIP, DIP)	Radial nerve (C6–C8)	Lateral epicondyle of humerus	Base of distal phalanx of fingers 2-5	Palpated between carpus and MCP joints when fingers are extended
Extensor digiti minimi (EDM)	Extension of all joints of the fifth finger (MP, PIP, DIP)	Radial nerve-deep branch (C6–C8)	Lateral epicondyle of humerus	Base of distal phalanx of the fourth finger	Palpated as a slight indentation lateral to the ulnar styloid process when patient's palm is resting on the table and patient raises little finger
Flexor pollicis longus (FPL)	Flexion of all joints of the thumb (IP, MP, CMC)	Median nerve (C8–T1)	Anterior surface of the radius	Distal phalanx of the thumb	Palpated on the palmar side of the thumb by asking the patient to flex and extend the thumb
Extensor pollicis longus (EPL)	Extension of all joints of the thumb (IP, MP)	Radial nerve (C6–C8)	Middle posterior ulna and interosseous membrane	Base of the distal phalanx of the thumb, dorsal surface	Palpated on the dorsal side of thumb by asking the patient to extend and flex the thumb
Abductor pollicis longus (APL)	Abduction of the thumb	Radial nerve (C6–C7)	Posterior radius, interosseous membrane, and middle ulna	Base of the first metacarpal	Palpated on the radial palmar side of the thumb
Dorsal interossei	Abduction of the fingers at the MCP joint	Ulnar nerve (C8–T1)	Adjacent metacarpals	Base of the proximal phalanx	Cannot be palpated, except for the first finger—is palpable at the base of the proximal phalanx of the first finger
Palmar interossei	Adduction of the fingers at the MCP joint	Ulnar nerve (C8–T1)	Respective metacarpals	Base of the proximal phalanx as originated	Cannot be palpated

Adductor pollicis	Adduction of the thumb	Ulnar nerve (C8–T1)	Capitate, base of the second metacarpal, palmar surface of the third metacarpal	Base of the proximal phalanx of the thumb	Palpated (with difficulty) on the palmar side of the web space of the thumb
Opponens pollicis	Opposition of the thumb	Median nerve (C6, C7)	Trapezium bone and flexor retinaculum	First metacarpal	Palpated along the radial shaft of the first metacarpal; it is lateral to the abductor pollicis brevis
Abductor pollicis brevis	Abduction of the saddle joint of the thumb	Median nerve (C6, C7)	Transverse carpal ligament, tuberosity of the scaphoid, and ridge of the trapezium	Radial side of the base of the proximal phalanx of the thumb	Palpated in the center of the thenar eminence, medial to the opponens pollicis
Flexor digiti minimi	Flexion of the CMC and MCP joints of the fifth finger	Ulnar nerve (C8–T1)	Hook of the hamate and flexor retinaculum	Base of the proximal phalanx of the fourth finger	Palpated on the palmar surface of the little finger when flexing the little finger
Opponens digiti minimi	Opposition of the fifth finger	Ulnar nerve (C8–T1)	Hamate bone and flexor retinaculum	Fifth metacarpal	Palpated on the hypothenar eminence on the radial side of the fifth metacarpal
Abductor digiti minimi	Abduction of the MCP joint of the fifth finger	Ulnar nerve (C8–T1)	Pisiform bone, tendon of the flexor carpi ulnaris	Proximal phalanx of the little finger	Palpated on the ulnar border of the hand

Thenar and Hypothenar Muscles

Table 3-11 Thenar and Hypothenar Muscles[1]

Thenar muscles	Abductor pollicis brevis; opponens pollicis; flexor pollicis brevis Thenar area innervation: median nerve
Hypothenar muscles	Abductor digiti minimi; opponens digiti; flexor digiti minimi Hypothenar area innervation: ulnar nerve

Neck, Trunk, and Back Muscles

Table 3-12 Neck, Trunk, and Back Muscles[1]

Muscle	Function	Nerve	Origin	Insertion	Palpation
Sternocleido-mastoid	Cervical flexion and rotation to the opposite side	Accessory nerve-CN XI (C2, C3)	Sternum and clavicle	Mastoid process	Palpated from the manubrium and clavicle to the mastoid
Scalene (anterior, medius, posterior) unilateral neck lateral	Bilaterally assisting in neck flexion and flexion	Lower cervical nerve	Sternum and clavicle	First and second ribs	Difficult to palpate First rib should be palpated from the posterior aspect by placing hands on upper traps and palpating just below the clavicle Second rib is best accessed posteriorly, directly below the upper trapezius but not on the spine of the scapula
Rectus abdominis	Trunk flexion and compression of the abdomen	Seventh through twelfth intercostal nerves (T7–T12)	Pubis	Cartilage of the fifth, sixth, and seventh ribs	Palpated at the midline of the thorax over the linea alba when the patient is performing a sit-up
External oblique	Bilateral trunk forward flexion, unilateral lateral flexion, and rotation to the opposite side	Eighth through twelfth intercostal nerves, iliohypogastric and ilioinguinal nerves	Lower eight ribs laterally	Iliac crest and linea alba	Palpated distally until reaching the anterior superior iliac spine; fibers run from out to in, as if both hands were inserted in the pockets
Internal oblique	Bilateral trunk forward flexion, unilateral lateral flexion, and rotation to the same side	Eighth through twelfth intercostal nerves, iliohypogastric and ilioinguinal nerves	Inguinal ligament, iliac crest, thoracolumbar fascia	Cartilages of the 10–12 ribs and the linea alba	Palpated on the lateral part of the anterior abdominal wall distal to the rib cage; fibers run from in to out, as if both hands were taken out of the pockets

Quadratus lumborum (fixes twelfth rib during inspiration, depresses twelfth rib during forced expiration)	Lateral bending of the trunk (to the same side)	Twelfth thoracic (T12) and first lumbar (L1) nerves	Iliac crest	Transverse processes of L2, L5, and twelfth rib	Cannot be palpated
Erector spinae: sacrospinalis, iliocostalis, longissimus dorsi, and spinalis dorsi	Head and vertebral column bilateral extension, unilateral lateral flexion	Spinal nerves	Spinous processes, transverse processes, and ribs from the occiput to the sacrum and ilium	Spinous processes, transverse processes, and ribs from the occiput to the sacrum and ilium	Palpated on both sides of the vertebral column by asking the patient to extend the spine while prone

SECTION 3-4

Musculoskeletal Data Collection

Goniometry—Joint Measurements: Body Position, Goniometer Alignment, and Normal Range of Motion Degrees (per AAOS)

Table 3-13 Goniometry—Joint Measurements: Body Position, Goniometer Alignment, and Normal ROM (per AAOS)[2]

Figure 3-3 The alignment of the goniometer at the end of the ROM of GH flexion

Figure 3-4 The alignment of the goniometer at the end of the ROM of GH extension

(*continues*)

Table 3-13 Goniometry—Joint Measurements: Body Position, Goniometer Alignment, and Normal ROM (per AAOS)[2] (continued)

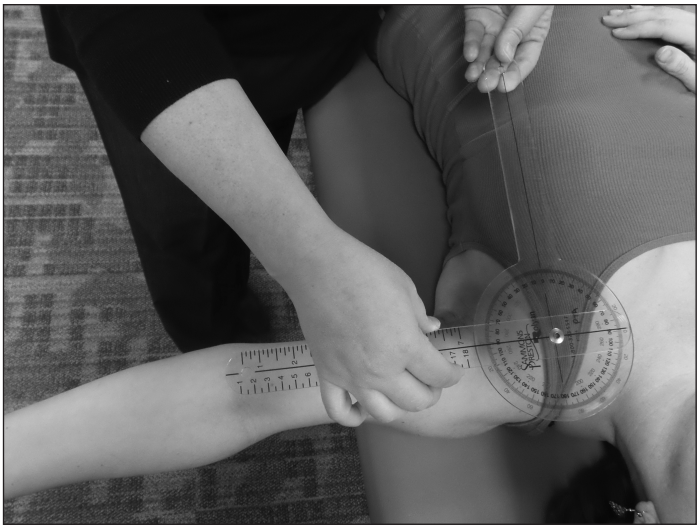


Figure 3-5 The alignment of the goniometer at the end of the ROM of GH abduction

Figure 3-6 The alignment of the goniometer at the end of IR ROM of the GH joint

Table 3-13 Goniometry—Joint Measurements: Body Position, Goniometer Alignment, and Normal ROM (per AAOS)[2] (continued)

Figure 3-7 The alignment of the goniometer at the end of ER ROM of the GH joint

Figure 3-8 The alignment of the goniometer at the end of elbow flexion ROM

(*continues*)

Table 3-13 Goniometry—Joint Measurements: Body Position, Goniometer Alignment, and Normal ROM (per AAOS)[2] (continued)

Figure 3-9 The alignment of the goniometer at the end of elbow extension ROM

Figure 3-10 The alignment of the goniometer at the end of pronation ROM

Table 3-13 Goniometry—Joint Measurements: Body Position, Goniometer Alignment, and Normal ROM (per AAOS)[2] (continued)

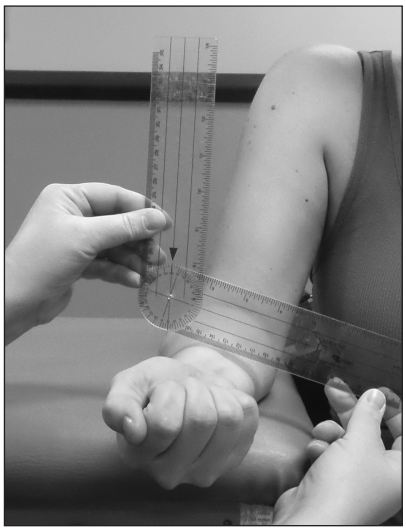


Figure 3-11 The alignment of the goniometer at the end of supination ROM

Figure 3-12 The alignment of the goniometer at the end of wrist flexion ROM

(*continues*)

Table 3-13 Goniometry—Joint Measurements: Body Position, Goniometer Alignment, and Normal ROM (per AAOS)[2] (continued)

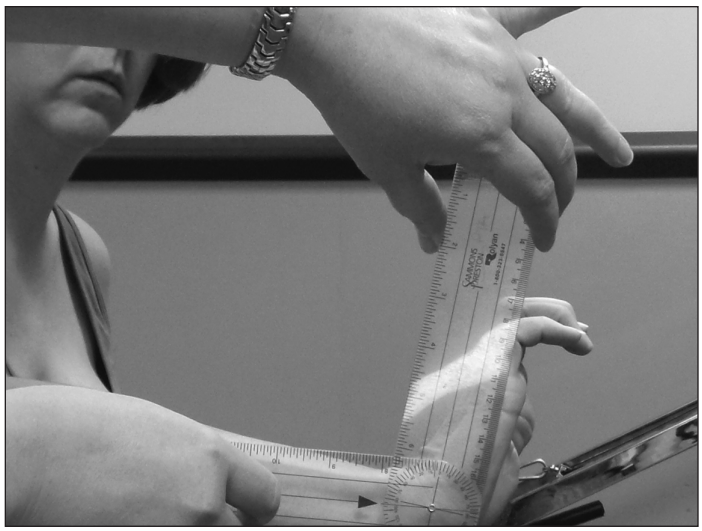


Figure 3-13 The alignment of the goniometer at the end of wrist extension ROM

Figure 3-14 The alignment of the goniometer at the end of radial deviation ROM

Table 3-13 Goniometry—Joint Measurements: Body Position, Goniometer Alignment, and Normal ROM (per AAOS)[2] (continued)

Figure 3-15 The alignment of the goniometer at the end of ulnar deviation ROM

Figure 3-16 The alignment of the goniometer at the end of hip flexion ROM

(*continues*)

Table 3-13 Goniometry—Joint Measurements: Body Position, Goniometer Alignment, and Normal ROM (per AAOS)[2] (continued)

Figure 3-17 The alignment of the goniometer at the end of hip extension ROM

Figure 3-18 The alignment of the goniometer at the end of hip abduction ROM

Table 3-13 Goniometry—Joint Measurements: Body Position, Goniometer Alignment, and Normal ROM (per AAOS)[2] (continued)

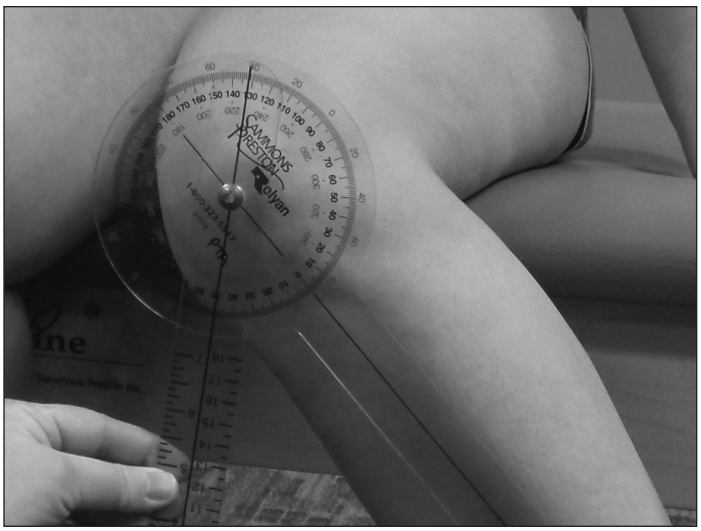


Figure 3-19 The alignment of the goniometer at the end of hip IR ROM

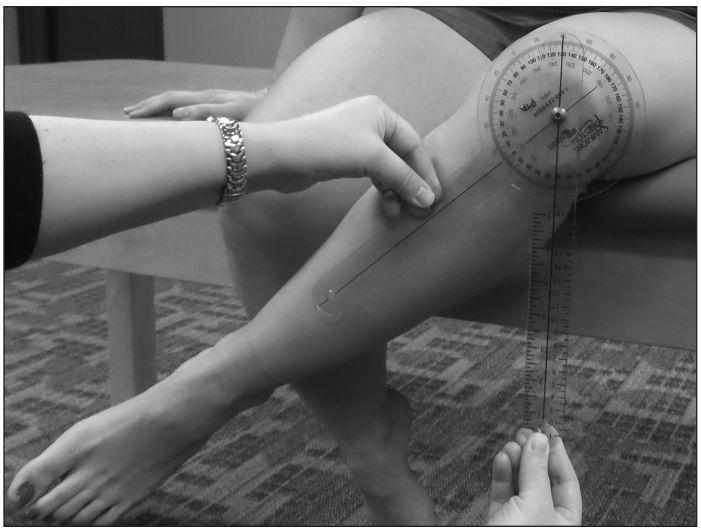


Figure 3-20 The alignment of the goniometer at the end of hip ER ROM

(*continues*)

Table 3-13 Goniometry—Joint Measurements: Body Position, Goniometer Alignment, and Normal ROM (per AAOS)[2] (continued)

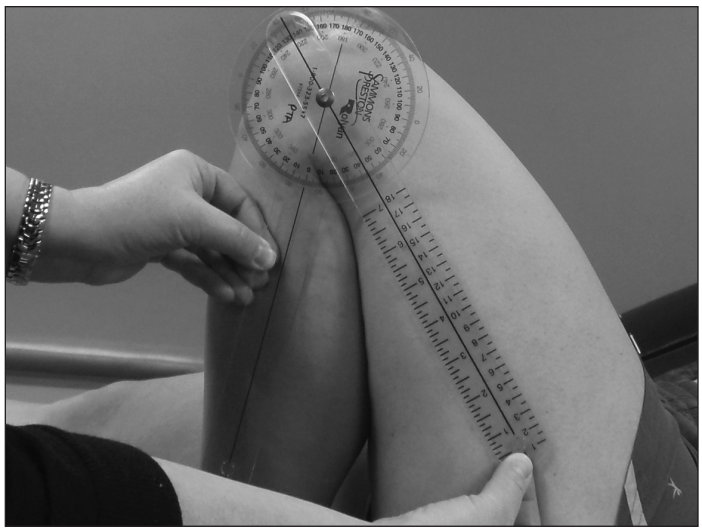


Figure 3-21 The alignment of the goniometer at the end of knee flexion ROM

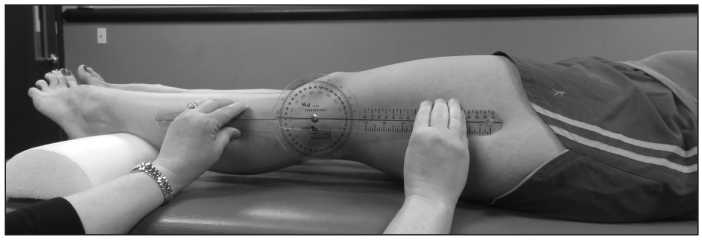


Figure 3-22 The alignment of the goniometer at the end of knee extension ROM

Table 3-13 Goniometry—Joint Measurements: Body Position, Goniometer Alignment, and Normal ROM (per AAOS)[2] (continued)

Figure 3-23 The alignment of the goniometer at the end of DF ROM

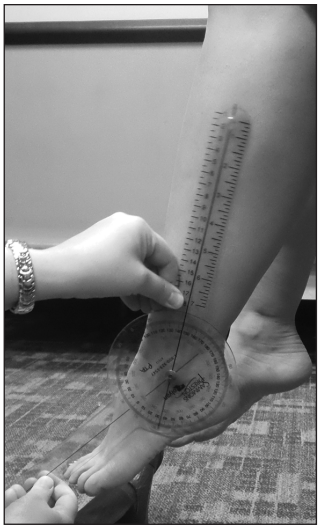


Figure 3-24 The alignment of the goniometer at the end of PF ROM

(*continues*)

Table 3-13 Goniometry—Joint Measurements: Body Position, Goniometer Alignment, and Normal ROM (per AAOS)[2] (continued)

Figure 3-25 The alignment of the goniometer at the end of inversion ROM

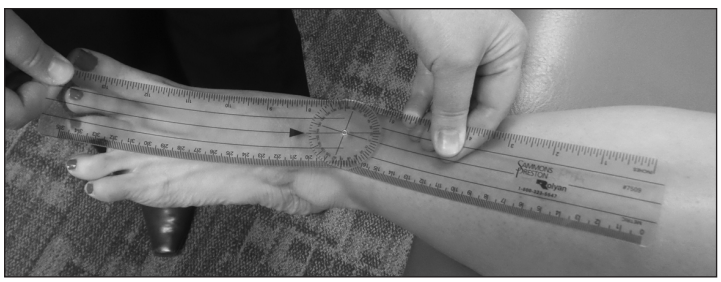


Figure 3-26 The alignment of the goniometer at the end of eversion ROM

Table 3-13 Goniometry—Joint Measurements: Body Position, Goniometer Alignment, and Normal ROM (per AAOS)[2] (continued)

Joint	Supine	Prone	Sitting	Goniometer Alignment (Ending Position)	ROM Degrees (AAOS)
Shoulder	Flexion Abduction Internal rotation (IR) External rotation (ER)	Extension		Shoulder flexion (Figure 3-3) Shoulder extension (Figure 3-4) Shoulder abduction (Figure 3-5) Shoulder IR (Figure 3-6) Shoulder ER (Figure 3-7)	Flexion = 180° Extension = 60° Abduction = 180° IR = 70° IR = 70° ER = 90° Horizontal adduction = 135°
	Elbow Extension		Flexion	Elbow flexion (Figure 3-8) Elbow extension (Figure 3-9)	Flexion = 150° Extension = 0°
	Knee Extension				Extension = 0°
Radioulnar (forearm)			Pronation Supination	Pronation (Figure 3-10) Supination (Figure 3-11)	Pronation = 80° Supination = 80°
Wrist			Flexion Extension Radial deviation Ulnar deviation	Wrist flexion (Figure 3-12) Wrist extension (Figure 3-13) Radial deviation (Figure 3-14) Ulnar deviation (Figure 3-15)	Flexion = 80° Extension = 70° Radial deviation = 20° Ulnar deviation = 30°
Hip	Flexion abduction	Extension	Internal rotation	Hip flexion (Figure 3-16) Hip extension (Figure 3-17)	Flexion = 120° Extension = 30°
	Adduction		External rotation	Hip abduction/adduction (Figure 3-18) Hip IR (Figure 3-19) Hip ER (Figure 3-20)	Abduction = 45° Adduction = 30° IR/ER = 45°
Knee	Flexion Extension			Knee flexion (Figure 3-21) Knee extension (Figure 3–22)	Flexion = 135° Extension = 0°
Talocrural (ankle)			Dorsiflexion Plantarflexion	Dorsiflexion (Figure 3-23) Plantarflexion (Figure 3-24)	DF = 20° PF = 50°
Subtalar (rear foot)			Inversion Eversion	Inversion (Figure 3-25) Eversion (Figure 3-26)	Inversion = 35° Eversion = 15°

Cervical and Thoracolumbar Range of Motion Normatives (per AAOS)

Table 3-14 Cervical and Thoracolumbar ROM Normatives (per AAOS)[2]

Cervical ROM
Flexion = 45°
Extension = 45°
Left lateral flexion = 45°
Right lateral flexion = 45°
Left rotation = 60°
Right rotation = 60°
Thoracolumbar ROM
Flexion = 80° (tape measure = 4 inches)
Extension = 20° to 30°
Left lateral flexion = 35°
Right lateral flexion = 35°
Left rotation = 45°
Right rotation = 45°

Manual Muscle Testing: Grading System of Hislop and Montgomery

Table 3-15 Grading System of Hislop and Montgomery[3]

Grade 5 (normal): completes full ROM against gravity. Maintains end-range position against maximal resistance.

Grade 4 (good): completes full ROM against gravity. Maintains end-range position against strong resistance. "Yields" (or "gives") at the end-range against maximal resistance.

Grade 3 + (fair +): completes full ROM against gravity. Maintains end-range position against mild resistance and has functional implications.

Grade 3 (fair): completes full ROM against gravity. Unable to maintain end-range position against any resistance.

Grade 2 (poor): completes full ROM in a gravity eliminated position (in a horizontal plane of motion).

Grade 2 (–) minus (poor minus): completes partial ROM in a gravity eliminated position (in a horizontal plane of motion).

Grade 1 (trace): examiner visually detects or palpates contractile activity in the muscle(s). There is no movement of the part as a result of contractile activity.

Grade 0 (zero): muscle is quiet, and no activity is detected.

Upper Extremity Manual Muscle Testing

Table 3-16 Manual Muscle Testing: Upper Extremity

Movement, Muscles, and Instructions to the Patient[3]	Patient/PTA Positions and Grades
Scapular Abduction and Upward Rotation	
Main muscles: Serratus anterior Others: Pectoralis minor Grades 4 and 5: "Raise your arm forward above your head; don't let me push your arm down." Grade 3: "Raise your arm forward above your head." Grade 2: "Hold your arm in this position (such as above 90°). Let it relax. Hold your arm up again. Let it relax." Grade 1: "Try to hold your arm in this position."	All grades: Patient sitting. Grades 4 and 5: PTA stands at test side and with one hand applies resistance to the patient's arm proximal to elbow. Patient's arm needs to be elevated more than 60° to use the serratus. PTA's other hand palpates edges of the scapula (Figure 3-27).
Scapular Elevation	
Main muscles: Upper trapezius Others: Levator scapulae and rhomboids Grades 4 and 5: "Raise your shoulders toward your ears. Hold it. Don't let me push them down." Grades 1, 2, and 3: "Raise your shoulders toward your ears."	Grades 1 and 2: Patient prone. Grades 3, 4, and 5: Patient, while sitting, elevates the shoulders. Grades 4 and 5: PTA stands behind the patient with both hands over the top of the patient's shoulders and gives resistance in downward direction (Figure 3-28).
Scapular Adduction (Scapular Retraction)	
Main muscles: Middle trapezius and rhomboid major Others: Levator scapulae, rhomboid minor and upper and lower trapezius Grades 4 and 5: "Lift your elbow toward the ceiling. Hold it. Don't let me push it down." Grade 3: "Lift your elbow toward the ceiling." Grades 1 and 2: "Try to lift your elbow toward the ceiling."	All grades: Patient prone. Grades 4 and 5: PTA stands at test side and with one hand stabilizes the contralateral scapula. PTA's other hand applies resistance downward toward the floor over the distal humerus (deltoid must be of grade 3 or better) (Figure 3-29).
Scapular Depression and Adduction	
Main muscles: Lower trapezius Others: Pectoralis and latissimus dorsi Grades 4 and 5: "Raise your arm from the table as high as possible. Hold it. Don't let me push it down." Grade 3: "Raise your arm from the table as high as possible." Grades 1 and 2: "Try to lift your arm from the table past your ear."	All grades: Patient prone. Grades 4 and 5: PTA stands at test side and applies resistance downward toward the floor over the distal humerus (Figure 3-30).

(*continues*)

Table 3-16 Manual Muscle Testing: Upper Extremity (continued)

Movement, Muscles, and Instructions to the Patient[3]	Patient/PTA Positions and Grades
Scapular Adduction and Downward Rotation	
Main muscles: Rhomboids (major and minor) Others: Levator scapulae Grades 4 and 5: "Lift your hand. Hold it. Don't let me push it down." Grade 3: "Lift your hand."	Grades 1 and 2: "Try to move your hand away from your back." Grades 1 and 2: Patient sitting with shoulder in internal rotation and arm extended and adducted behind back. Grades 3, 4, and 5: Patient prone with shoulder in internal rotation and arm adducted across the back. Grades 4 and 5: PTA stands at test side and applies resistance downward and outward over the humerus just above the elbow (Figure 3-31).
Main Muscles: Serratus anterior Grades 4 and 5: "Keeping your elbow straight, try to push your arm up toward the ceiling while I am pushing your arm down." Grade 3: Keeping your elbow straight, lift your arm up toward the ceiling." Grades 1 and 2: "Try to push your straight arm towards me."	Grades 1 and 2: Patient sitting facing PTA who is supporting the weight of the limb in a position of shoulder flexion to 90°, slight horizontal adduction (i.e., 15° medial to the sagittal plane), and the elbow extended. Grades 3, 4, and 5: Patient is supine with the shoulder flexed to 90°, slight horizontal adduction (i.e., 15° medial to the sagittal plane), with the elbow extended. Grades 4 and 5: PTA stands at the test side and applies resistance to the distal humerus just above the elbow in a downward / posterior direction (Figure 3-32).
Shoulder Flexion	
Main muscles: Anterior deltoid and coracobrachialis Others: Pectoralis major, middle deltoid, and serratus anterior Grades 4 and 5: "Raise your arm forward to shoulder height. Hold it. Don't let me push it down." Grade 3: "Raise your arm forward to shoulder height." Grades 1 and 2: "Try to raise your arm."	All grades: Patient sitting. Grades 4 and 5: PTA stands at test side and applies resistance downward over the distal humerus just above the elbow. PTA's other hand stabilizes the shoulder (Figure 3-33).
Shoulder Extension	
Main muscles: Latissimus dorsi, posterior deltoid, and teres major Other: Triceps brachii (long head) Grades 4 and 5: "Lift your arm as high as you can. Hold it. Don't let me push it down." Grades 2 and 3: "Lift your arm as high as you can." Grade 1: "Lift your arm."	All grades: Patient prone. Grades 4 and 5: PTA stands at test side and applies resistance downward over the posterior arm just above the elbow (Figure 3-34).

Table 3-16 Manual Muscle Testing: Upper Extremity (continued)

Movement, Muscles, and Instructions to the Patient[3]	Patient/PTA Positions and Grades
Shoulder Scaption	
Main muscles: Anterior and middle deltoid and supraspinatus Grades 4 and 5: "Raise your arm to shoulder height, halfway between straight and to the side. Hold it. Don't let me push it down." Grade 3: "Raise your arm to shoulder height, halfway between straight and to the side." Grades 1 and 2: "Try to raise your arm to shoulder height, halfway between straight and to the side."	All grades: Patient sitting. Grades 4 and 5: PTA stands in front and slightly to the side of the patient and applies resistance downward over the arm above the elbow. Patient elevates arm halfway between flexion and abduction (Figure 3-35).
Shoulder Abduction	
Main muscles: Middle deltoid and supraspinatus Grades 4 and 5: "Lift your arm out to the side to shoulder level. Hold it. Don't let me push it down." Grade 3: "Lift your arm out to the side to shoulder level." Grades 1 and 2: "Try to lift your arm out to the side."	All grades: Patient sitting. Grades 4 and 5: PTA stands behind the patient and applies resistance downward over the arm just above the elbow (Figure 3-36).
Shoulder External Rotation	
Main muscles: Infraspinatus and teres minor Others: Posterior deltoid Grades 4 and 5: "Raise your arm to the level of the table. Hold it. Don't let me push it down." Grade 3: "Raise your arm to the level of the table." Grades 1 and 2: "Turn your palm outward."	All grades: Patient prone. Grades 4 and 5: PTA stands at test side at the level of the patient's waist and applies resistance with two fingers downward at the wrist. PTA's other hand supports the patient's elbow, giving counterpressure at the end of the range (Figure 3-37).
Shoulder Internal Rotation	
Main muscles: Subscapularis, pectoralis major (clavicular and sternal parts), latissimus dorsi, and teres major Others: Anterior deltoid Grades 4 and 5: "Move your forearm up and back. Hold it. Don't let me push it down." Grade 3: "Move your forearm up and back." Grades 1 and 2: "Turn your arm so that the palm faces away from the table."	All grades: Patient prone. Grades 4 and 5: PTA stands at test side and applies downward and forward resistance on the anterior side of the forearm just above the wrist. PTA's other hand applies counterpressure backward and slightly upward (Figure 3-38).

(*continues*)

Table 3-16 Manual Muscle Testing: Upper Extremity (continued)

Movement, Muscles, and Instructions to the Patient[3]	Patient/PTA Positions and Grades
Elbow Flexion Main muscles: Biceps brachii (short and long head), brachialis, and brachioradialis Others: Pronator teres, extensor carpi radialis longus, flexor carpi radialis, and flexor carpi ulnaris Grades 4 and 5: "Bend your elbow. Hold it. Don't let me pull it down." Grade 3: "Bend your elbow." Grades 1 and 2: "Try to bend your elbow."	Grades 1 and 2: Patient supine (if cannot sit) with forearm supinated for the biceps, pronated for the brachialis, and in midposition for the brachioradialis, and elbow flexed to 45°. Grades 3, 4, and 5: Patient sitting with arm abducted and forearm supinated for the biceps, pronated for the brachialis, and in midposition for the brachioradialis. Grades 4 and 5: PTA stands in front of the patient and applies resistance over the flexor surface of the forearm proximal to the wrist. PTA's other hand applies counterforce, cupping the palm over the anterior superior surface of the shoulder (Figure 3-39).
Elbow Extension Main muscles: Triceps brachii (long, lateral, and medial heads) Other: Anconeus Grades 4 and 5: "Straighten your elbow. Hold it. Don't let me bend it." Grade 3: "Straighten your elbow." Grades 1 and 2: "Try to straighten your elbow."	Grades 1 and 2: Patient sitting with arm abducted to 90°, shoulder in neutral rotation, and elbow flexed to about 45°. Grades 3, 4, and 5: Patient prone with arm in 90° abduction and forearm flexed, hanging over the edge of the table. Grades 4 and 5: PTA supports the patient's arm above the elbow. PTA applies resistance downward over the dorsal surface of the forearm (Figure 3-40).
Forearm Supination Main muscles: Supinator Others: Biceps brachii (short and long head) Grades 4 and 5: "Turn your palm up. Hold it. Don't let me turn it down. Keep your wrist and fingers relaxed." Grade 3: "Turn your palm up." Grades 1 and 2: "Turn your palm toward your face."	All grades: Patient sitting. Grades 1 and 2: Patient's shoulder flexed between 45° and 90° and elbow flexed to 90°. Grades 3, 4, and 5: Patient's elbow flexed 90° and forearm in pronation. Patient supinates until the palm faces the ceiling. Grades 4 and 5: PTA stands at the patient's side, supports the elbow, grasps the forearm, and applies resistance to the anterior surface of the forearm at the wrist (Figure 3-41).

Table 3-16 Manual Muscle Testing: Upper Extremity (continued)

Movement, Muscles, and Instructions to the Patient[3]	Patient/PTA Positions and Grades
Forearm Pronation	
Main muscles: Pronator teres (humeral and ulnar heads) and pronator quadratus Others: Flexor carpi radialis Grades 4 and 5: "Turn your palm down. Hold it. Don't let me turn it up. Keep your wrist and fingers relaxed." Grade 3: "Turn your palm down." Grades 1 and 2: "Try to turn your palm down."	All grades: Patient sitting. Grades 3, 4, and 5: Patient's arm at side with elbow flexed to 90°and forearm in supination. Patient pronates until the palm faces the floor. Grades 1 and 2: Patient's shoulder flexed between 45° and 90° and elbow flexed to 90°. Forearm in neutral position. Grades 4 and 5: PTA stands at the patient's side and supports the elbow. PTA's other hand grasps the forearm, and applies resistance over the posterior surface of the forearm at the wrist (the same as in Figure 3-41 but the forearm is pronated).
Wrist Flexion	
Main muscles: Flexor carpi radialis and flexor carpi ulnaris Others: Palmaris longus, flexor digitorum superficialis, flexor digitorum profundus, abductor pollicis longus, and flexor pollicis longus Grades 4 and 5: "Bend your wrist. Hold it. Don't let me pull it down. Keep your fingers relaxed." Grade 3: "Bend your wrist (for all muscles). Bend your wrist leading with the little finger (for FCU). Bend your wrist leading with the thumb side (for FCR)." Grade 2: "Bend your wrist. Keep your fingers relaxed." Grade 1: "Try to bend your wrist. Relax. Bend it again."	All grades: Patient sitting. Grades 3, 4, and 5: Patient's forearm is supinated, posterior side of the forearm is supported on the table (or by the examiner's hand), and wrist is in neutral position. Grade 2: Patient's elbow is supported on the table, and forearm is in midposition with the hand resting on the ulnar side. Grade 1: Patient's fully supinated hand and forearm are resting on the table. Grade 1: PTA supports the patient's wrist in flexion with one hand, while the other hand palpates the appropriate tendon. Grade 2: PTA supports the patient's forearm proximal to the wrist. Grade 3: PTA supports the patient's forearm under the wrist. Grades 4 and 5: PTA stands in front of the patient and supports the patient's forearm under the wrist. PTA's other hand applies resistance to the palm (Figure 3-42).

(*continues*)

Table 3-16 Manual Muscle Testing: Upper Extremity (continued)

Movement, Muscles, and Instructions to the Patient[3]	Patient/PTA Positions and Grades
Wrist Extension	
Main muscles: Extensor carpi radialis longus, extensor carpi radialis brevis, and extensor carpi ulnaris Others: Extensor digitorum, extensor digiti minimi, and extensor indicis Grades 4 and 5: "Bring your wrist up. Hold it. Don't let me push it down." Grade 3: "Bring your wrist up." Grade 2: "Bend your wrist back. Grade 1: "Try to bring your wrist back."	All grades: Patient sitting. Grades 3, 4, and 5: Patient's flexed elbow and fully pronated forearm are supported on the table (or by the examiner's hand). Grade 2: Patient's forearm is in neutral position supported on the table. Grade 1: Patient's fully pronated hand and forearm are supported on the table. Grade 1: PTA supports the patient's wrist in extension with one hand, while the other hand palpates the appropriate muscle. Grade 2: PTA supports the patient's wrist in neutral position (elevates it from the table). Grades 3, 4, and 5: PTA stands in front of the patient and supports the patient's forearm under the anterior wrist. PTA's other hand applies resistance to the posterior surface of the metacarpals (Figure 3-43).

Figure 3-27 Scapular abduction and upward rotation MMT

Table 3-16 Manual Muscle Testing: Upper Extremity (continued)

Figure 3-28 Scapular elevation MMT

Figure 3-29 Scapular adduction MMT

(*continues*)

Table 3-16 Manual Muscle Testing: Upper Extremity (continued)

Figure 3-30 Scapular depression and adduction MMT

Figure 3-31 Scapular adduction and downward rotation MMT

Table 3-16 Manual Muscle Testing: Upper Extremity (continued)

Figure 3-32 Scapular abduction and lateral rotation MMT

Figure 3-33 Shoulder flexion MMT

(*continues*)

Table 3-16 Manual Muscle Testing: Upper Extremity (continued)

Figure 3-34 Shoulder extension MMT

Figure 3-35 Shoulder scaption MMT

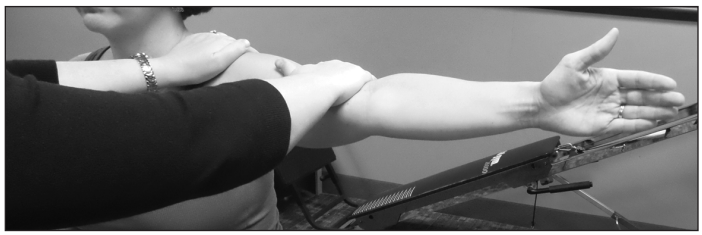


Figure 3-36 Shoulder abduction MMT

Table 3-16 Manual Muscle Testing: Upper Extremity (continued)

Figure 3-37 Shoulder ER MMT

Figure 3-38 Shoulder IR MMT

(*continues*)

Table 3-16 Manual Muscle Testing: Upper Extremity (continued)

Figure 3-39 Elbow flexion MMT

Figure 3-40 Elbow extension MMT

Table 3-16 Manual Muscle Testing: Upper Extremity (continued)

Figure 3-41 Forearm supination and pronation MMT
Resistance towards pronation = supination MMT
Resistance towards supination = pronation MMT

Figure 3-42 Wrist flexion MMT

(*continues*)

Table 3-16 Manual Muscle Testing: Upper Extremity (continued)

Figure 3-43 Wrist extension MMT

Finger and Thumb Manual Muscle Testing

Table 3-17 Finger and Thumb Manual Muscle Testing[3]

Finger MP Flexion
- Tests 1, 2, 3, 4 lumbricales, dorsal interossei, and palmar interossei.
- Grades 3, 4, and 5: Patient sitting with forearm in supination, wrist in neutral position, metacarpophalangeal (MP) joints fully extended, and interphalangeal (IP) joints fully flexed.
- Grades 4 and 5: Patient completes simultaneous MP flexion and finger extension and holds against maximal or moderate resistance. Resistance is given to fingers individually.

Finger PIP and DIP Flexion
- Tests flexor digitorum superficialis and flexor digitorum profundus.
- Grades 3, 4, and 5: Patient sitting with forearm in supination, wrist in neutral position, and finger to be tested in slight flexion at the MP joint.
- Grades 4 and 5: Patient completes ROM and holds against maximal or moderate finger resistance.

Finger MP Extension
- Tests extensor digitorum, extensor indicis, and extensor digiti minimi.
- Grades 3, 4, and 5: Patient sitting with forearm in pronation, wrist in neutral position, and MP and IP joints relaxed in flexed position.
- Grades 4 and 5: Patient completes active extension ROM with maximal and moderate finger resistance.

Finger Abduction
- Tests dorsal interossei and abductor digiti minimi.
- Grades 3, 4, and 5: Patient sitting with forearm in pronation, fingers in extension and adduction. MP joints are in neutral positions.
- Grades 4 and 5: Patient completes finger abduction with as much resistance as the uninvolved finger. PTA's resistance depends on the uninvolved patient's finger abduction manual muscle testing (MMT).

Thumb MP and IP Flexion
- Tests flexor pollicis brevis and flexor pollicis longus.
- Grades 3, 4, and 5: Patient sitting with forearm in supination, wrist in neutral position. Carpometacarpal (CPM) and IP joints of thumb are at 0°. Thumb is in adduction, lying relaxed by the second metacarpal.
- Grades 4 and 5: Patient completes ROM against maximal and moderate resistance.

Thumb MP and IP Extension
- Tests extensor pollicis brevis and extensor pollicis longus.
- Grades 3, 4, and 5: Patient sitting with forearm in midposition and wrist in neutral position. CPM and IP joints of thumb are relaxed in slight flexion. MP joint of thumb is in abduction and flexion.
- Grades 4 and 5: Patient completes ROM with resistance. PTA resistance depends on the uninvolved patient's thumb MP and IP extension MMT.

Thumb Abduction
- Tests mainly abductor pollicis longus and abductor pollicis brevis.
- Grades 3, 4, and 5: Patient sitting with forearm supinated, wrist in neutral, and thumb relaxed in adduction.
- Grades 4 and 5: Patient completes ROM against resistance. PTA resistance is dependent on the uninvolved patient's thumb abduction MMT.

Thumb Adduction
- Tests mainly adductor pollicis.
- Grades 3, 4, and 5: Patient sitting with forearm in pronation, wrist in neutral position, and thumb relaxed and in abduction.
- Grades 4 and 5: Patient completes ROM against maximal and moderate resistance.

Opposition (Thumb to Little Finger)
- Tests mainly opponens pollicis and opponens digiti minimi.
- Grades 3, 4, and 5: Patient sitting with forearm in supination, wrist in neutral position, and thumb in adduction with MP and IP flexed.
- Grades 4 and 5: Patient completes opposition with resistance at the head of the first metacarpal (in the direction of external rotation, extension, and adduction) for the opponens pollicis and at the palmar surface of the fifth metacarpal (in the direction of internal rotation, flattening the palm) for the opponens digiti minimi.

Lower Extremity Manual Muscle Testing

Table 3-18 MMT Lower Extremity

Movement, Muscles, and Instructions to the Patient[3]	Patient/PTA Positions and Grades
Hip flexion Main Ms: Psoas major and iliacus Others: Rectus femoris, sartorius, tensor fasciae latae, pectineus, adductors (brevis, longus, magnus), anterior gluteus medius Grades 4 and 5: "Lift your leg off the table and don't let me push it down." Grade 3: "Lift your leg straight up off the table." Grade 2: "Bring your knee up toward your chest. "Grade 1: "Try to bring your knee up to your nose."	Grade 1: Patient lying supine. Grade 2: Patient side lying with tested limb uppermost. Grades 3, 4 and 5: Patient sitting with thighs supported on the table. Grades 4 and 5: PTA standing next to limb to be tested, applies resistance over distal thigh proximal to the knee (Figure 3-44).
Hip extension Main Ms: Gluteus maximus, semitendinous, semimembranous, and long head of biceps femoris Others: Adductor magnus and gluteus medius Grades 3, 4, and 5: "Lift your leg off the table as high as you can. Do not bend your knee." Grade 2: "Bring your leg back toward me. Keep your knee straight." Grade 1: "Try to lift your leg from the table."	Grades 1, 3, 4, and 5: Patient prone. Grade 2: Patient side lying with tested limb uppermost and knee straight. Grades 4 and 5: PTA standing at side of limb to be tested, applies with one hand resistance on posterior leg above the ankle. The other hand stabilizes the pelvis (Figure 3-45).
Hip abduction Main Ms: Gluteus medius and gluteus minimus Others: Gluteus maximus, tensor fasciae latae, obturator internus, gemellus inferior and superior, and sartorius	Grades 1 and 2: Patient supine. Grades 3, 4, and 5: Patient side lying with tested limb uppermost and knee straight. Grades 4 and 5: PTA standing behind patient, palpates gluteus medius. PTA other hand applies resistance downward at the lateral surface of knee (Figure 3-46)

Figure 3-44 Hip flexion MMT

Table 3-18 MMT Lower Extremity (continued)

Figure 3-45 Hip extension MMT—examiner showed at opposite side not to obscure activity

Figure 3-46 Hip abduction MMT

(*continues*)

Table 3-18 MMT Lower Extremity (continued)

Movement, Muscles, and Instructions to the Patient[3]	Patient/PTA Positions and Grades
Grades 4 and 5: "Lift your leg up in the air. Hold it. Don't let me push it down." Grade 2: "Bring your leg out to the side." Grade 1: "Try to bring your leg out to the side."	
Hip adduction	
Main Ms: Adductor magnus, adductor brevis, adductor longus, pectineus, and gracilis Others: Gluteus maximus and obturator externus Grades 4 and 5: "Lift your bottom leg up to your top one. Hold it. Don't let me push it down. Grade 3: "Lift your bottom leg up to your top one. Don't let it drop." Grade 2: "Bring your leg in toward the other one." Grade 1: "Try to bring your leg in."	Grades 1 and 2: Patient supine. Grades 3, 4, and 5: Patient side lying with the tested limb lowermost resting on the table. The uppermost limb is in 25° abduction and is supported by PTA. Grades 4 and 5: PTA standing behind patient, cradles the uppermost limb with forearm supporting it on medial knee. PTA other hand applies to lowermost limb resistance on medial distal femur proximal to knee (Figure 3-47).
Hip external rotation	
Main Ms: Obturator externus, obturator internus, piriformis, gemelli superior and inferior, quadratus femoris, and gluteus maximus Others: Sartorius, long head biceps femoris, gluteus medius, psoas major, adductor magnus and longus, and popliteus Grades 4 and 5: "Don't let me turn your leg out." Grade 3: "Keep your leg in this position." Grades 2: "Roll your leg out." Grade 1: "Try to roll your leg out."	Grades 1 and 2: Patient supine with tested limb in internal rotation. Grades 3, 4, and 5: Patient sitting. Grades 4 and 5: PTA sitting besides limb to be tested, applies counterpressure to lateral distal thigh above the knee giving resistance in a medially directed force at the knee. PTA other hand applies resistance in a laterally directed force at the ankle grasping the ankle above the medial malleolus (Figure 3-48).

Figure 3-47 Hip adduction MMT

Table 3-18 MMT Lower Extremity (continued)

Movement, Muscles, and Instructions to the Patient[3]	Patient/PTA Positions and Grades
Hip internal rotation Main Ms: Gluteus minimus, tensor fasciae latae, and gluteus medius Others: Semitendinous, semimembranous, adductor magnus, and adductor longus Grades 4 and 5: "Don't let me turn your leg in." Grade 3: "Keep your leg in this position." Grade 2: "Roll your leg in toward the other." Grade 1: "Try to roll your leg in."	Grades 1 and 2: Patient supine with tested limb in partial external rotation. Grades 3, 4, and 5: Patient sitting. Grades 4 and 5: PTA kneeling in front of tested limb, applies counterpressure to medial distal thigh above the knee giving resistance in a laterally directed force at the knee. PTA other hand applies resistance in a medially directed force at the ankle above the lateral malleolus (Figure 3-49).
Knee flexion Main Ms: Long and short heads of biceps femoris, semitendinous, and semimembranous Other: Gracilis, tensor fasciae latae, sartorius, popliteus, gastrocnemius, and plantaris Grades 4 and 5: "Bend your knee. Hold it. Don't let me straighten it." Grade 2 and 3: "Bend your knee." Grade 1: "Try to bend your knee."	Grade 1, 3, 4, and 5: Patient prone. Grade 2: Patient side lying with tested limb uppermost. Grades 4 and 5: PTA standing next to limb to be tested (showed here at opposite side not to obscure activity), applies resistance around posterior surface of leg above the ankle. PTA's other hand is placed over the hamstrings on posterior thigh (Figure 3-50).
Knee extension Main Ms: Rectus femoris, vastus intermedius, vastus lateralis, vastus medialis longus, and vastus medialis oblique Other: Tensor fasciae latae Grades 4 and 5: "Straighten your knee. Hold it. Don't let me bend it." Grade 2 and 3: "Straighten your knee." Grade 1: "Push the back of your knee down into the table."	Grade 1: Patient supine. Grade 2: Patient side lying with tested limb uppermost. Grades 3, 4, and 5: Patient sitting. Grades 4 and 5: PTA standing at side of tested limb with one hand giving resistance downward over anterior distal leg above ankle. PTA's other hand is under distal thigh not allowing patient to hyperextend the knee (Figure 3-51).

Figure 3-48 Hip ER MMT

(*continues*)

Table 3-18 MMT Lower Extremity (continued)

Figure 3-49 Hip IR MMT

Figure 3-50 Knee flexion MMT

Table 3-18 MMT Lower Extremity (continued)

Figure 3-51 Knee extension MMT

Movement, Muscles, and Instructions to the Patient[3]	Patient/PTA Positions and Grades
Ankle plantarflexion Main Ms: Medial and lateral heads of gastrocnemius and the soleus Others: Posterior tibialis, plantaris, peroneus longus, peroneus brevis, flexor digitorum longus, and flexor hallucis longus Grades 4 and 5: "Stand on your right leg. Go up on your tiptoes. Now go down. Repeat this 20 times." Grade 3: "Stand on your right leg. Go up on your tiptoes. Now go down. Repeat this 9 times." Grade 2: "Stand on your right leg. Try to go up on your tiptoes." Grade 1: "Point your toes down."	Grade 1: Patient prone with feet at end of table. Grade 2: Patient standing on limb to be tested with knee extended, with two fingers on the table for balance assist. Grades 2, 3, 4, and 5: PTA standing with lateral view of patient's limb. Grades 3, 4, and 5: Patient standing on limb to be tested with knee extended with two fingers on a table for balance assist (Figure 3-52).
Ankle plantarflexion knee bent Main Muscle: Soleus (best recruited with 45° of knee flexion to place gastrocnemius on slack in attempt to isolate soleus better[7]) Other: Gastrocnemius Grades 3, 4, 5: "Stand on your right leg with your knee bent to 45°, try to raise your heel of the floor as you stand on your tip toes"	Grades 3, 4, 5: Patient standing with knee flexed to 45°, holding onto a table with 2 finger support (only if needed for balance if needed), and patient is instructed to perform a heel raise Grade 5: full heel off the floor > 6 repetitions; Grade 4: full heel off the floor x 3-5 repetitions, with subsequent repetitions gradually decreasing in heel distance from the floor; Grade 3: full heel off the floor x 1-2 repetitions only with subsequent repetitions decreasing in heel distance from the floor

(*continues*)

Table 3-18 MMT Lower Extremity (continued)

Movement, Muscles, and Instructions to the Patient[3]	Patient/PTA Positions and Grades
Grades 2, 1, 0: "Lie on your right side with your top (left) leg bent up towards your chest resting on a pillow to get it out of the way of your right leg", "place your right knee in a flexed position of 45°, now point your toes down"	Grade 2, 1, 0: PTA stabilizes at the distal ankle and makes ensures that the test leg is flexed 45°at the knee.
Grade 1: PTA visually detects or palpates a contraction of the muscle, but there is no actual movement observed	Grade 2: patient can go through full range of motion without the influence of gravity Grade 0: no active contraction is observed visually or palpably.
Foot dorsiflexion and inversion	
Main Ms: Tibialis anterior Others: Peroneus tertius, extensor digitorum longus, and extensor hallucis longus Grades 4 and 5: "Bring your foot up and in. Hold it. Don't let me push it down." Grades 1, 2, and 3: "Bring your foot up and in."	All grades: Patient sitting with heel resting on PTA's thigh. Grades 4 and 5: PTA sitting on stool in front of patient with patient's heel resting on his or her thigh. One hand is supporting around posterior leg above malleoli. PTA's other hand gives resistance over dorsal and medial aspect of the foot (Figure 3-54).
Foot inversion	
Main Ms: Tibialis posterior Other: Tibialis anterior, flexor digitorum longus, flexor hallucis longus, soleus, and extensor hallucis longus Grades 4 and 5: "Turn your foot down and in. Hold it." Grades 2 and 3: "Turn your foot down and in." Grade 1: "Try to turn your foot down and in."	All grades: Patient sitting. Grades 2, 3, 4, and 5: Patient with ankle in slight plantarflexion. Grade 1: PTA palpates tibialis posterior tendon. Grades 4 and 5: PTA sitting on low stool in front of patient. One hand is stabilizing the ankle above malleoli. PTA's other hand gives resistance toward eversion and slight dorsiflexion at the dorsal and medial side of the foot at the metatarsal heads (Figure 3-55).

Figure 3-52 Gastrocnemius MMT

Table 3-18 MMT Lower Extremity (continued)

Figure 3-53 Soleus MMT

Figure 3-54 Foot DF and inversion MMT

(*continues*)

Table 3-18 MMT Lower Extremity (continued)

Movement, Muscles, and Instructions to the Patient[3]	Patient/PTA Positions and Grades

Figure 3-55 Foot inversion MMT

Foot eversion with plantarflexion

Main Ms: Peroneus longus and brevis

Others: Extensor digitorum longus, peroneus tertius, and gastrocnemius

Grades 4 and 5: "Turn your foot down and out. Hold it. Don't let me move it in."

Grades 2 and 3: "Turn your foot down and out."

All grades: Patient sitting. Grades 2, 3, 4, and 5: Patient with ankle in neutral. Grade 1: PTA palpates main muscle's tendon. Grades 4 and 5: PTA sitting on low stool in front of patient. One hand is stabilizing the ankle above malleoli. PTA's other hand gives resistance toward inversion and slight dorsiflexion at the dorsal and lateral side of the forefoot (Figure 3-56).

Figure 3-56 Foot eversion and plantarflexion

Big Toe and Other Toes Manual Muscle Testing

Table 3-19 Big Toe and Other Toes: Manual Muscle Testing[3]

Hallux and Toe MP Flexion

- Tests lumbricales and flexor hallucis brevis (two heads).
- All grades: Patient sitting with legs hanging over the edge of the table and the ankle in neutral position.
- Grades 4 and 5: Patient completes metatarsophalangeal (MP) flexion (for big toe or each lateral toe) and holds against strong or moderate resistance. Resistance is given with the index finger placed beneath the proximal phalanx of the great toe or under the MP joints of the four lateral toes.

Hallux and Toe DIP and PIP Flexion

- Tests flexor digitorum longus, flexor digitorum brevis, and flexor hallucis longus.
- All grades: Patient sitting with foot on the PTA's lap.
- Grades 4 and 5: Patient completes ROM of toes and the big toe with minimal resistance. Resistance is given under the middle phalanges (for PIP) and under the distal phalanges (for DIP).

Hallux and Toe MP and IP Extension

- Tests extensor digitorum longus, extensor digitorum brevis, and extensor hallucis longus.
- All grades: Patient sitting with foot on the PTA's lap.
- Grades 4 and 5: Patient extends the big toe or the toes against minimal resistance. Resistance is given by PTA's thumb over the MP joint or over the IP joint.

Myotomes Testing

Table 3-20 Myotomes Testing[4]

- Shoulder shrug: tests upper trapezius muscle. For CN XI (spinal accessory nerve) and spinal roots C2, C3 (posterior surface of neck), and C4 (AC joint).
- Shoulder abduction: tests deltoid muscle. For axillary nerve and spinal roots C5 (lateral aspect of arm) and C6 (lateral aspect of forearm; hand and thumb; index finger).
- Elbow flexion of supinated arm: tests biceps brachii muscle. For musculocutaneous nerve and spinal roots C5 and C6.
- Elbow flexion of neutral arm: tests brachioradialis muscle. For radial nerve and spinal roots C5 and C6.
- Elbow extension: tests triceps brachii muscle. For radial nerve and spinal roots C6, C7 (middle finger), and C8 (little and ring finger; medial aspect of hand and wrist).
- Radial wrist extension: tests ECU muscle. For radial nerve and spinal roots C6, C7, and C8.
- Wrist flexion: tests FCU muscle. For ulnar nerve and spinal roots C8 and T1 (medial forearm).
- Thumb extension: tests EPL muscle. For radial nerve and spinal roots C6, C7, and C8.
- Fifth digit abduction: tests abductor digiti minimi muscle. For ulnar nerve and spinal roots C8 and T1.
- Hip flexion: tests iliopsoas muscles. For lumbar plexus and spinal roots L1 (proximal medial thigh), L2 (proximal anterior thigh), and L3 (distal anterior and medial thigh and knee).
- Knee extension: tests quadriceps femoris muscles. For femoral nerve and spinal roots L2, L3, and L4 (anterior and medial lower extremity).
- Ankle dorsiflexion: tests anterior tibialis muscle. For deep peroneal nerve and spinal roots L4 and L5 (anterior and lateral lower extremity; medial dorsal foot; plantar aspect of big toe).
- Big toe extension: tests EHL muscle. For deep peroneal nerve and spinal roots L5 and S1 (lateral dorsal foot; most of plantar foot).
- Knee flexion: tests hamstring muscles. For sciatic nerve and spinal roots L5, S1, and S2 (posterior thigh; proximal lower extremity).
- Ankle plantarflexion: tests gastrocnemius muscle. For tibial nerve and spinal roots S1 and S2.

Pain Rating

Table 3-21 Pain Scales: Questions

Questions Regarding Pain Location

- "Where is your pain?"
- "Can you point the location?"
- "Has the pain changed its location?"
- "Did the pain go to other areas?"

Can also use a body chart for the patient to mark the location of the pain.

Questions Regarding the Severity of Pain

- "How severe is your pain on a scale of 0 to 10, with 0 meaning no pain and 10 meaning the most severe pain?"
- "Is the pain sharp, dull or throbbing?"

Can also use a visual analog pain scale with a line of 3.9 inches length on which the patient marks the severity of pain.

Questions Regarding the Type of Pain and Other Signs Involving the Nervous System

- "Do you feel any numbness, tingling, pins and needles, burning sensation, stabbing sensation or shooting pain?"

Can also use the McGill-Mellzack pain questionnaire, on which the patient marks the type of pain and other signs regarding pain.

Deep Tendon Reflexes and Grades

Table 3-22 Deep Tendon Reflexes and Grades

DTR Most Tested	DTR Grading
Biceps and brachioradialis: test C5–C6	Absent DTR: grade is 0
Triceps: tests C7–C8	DTR for hyporeflexia: grade is 1+
Quadriceps: tests L2–L4	Normal DTR: grade is 2+
Hamstrings: tests L5–S3	DTR for hyperreflexia: grade is 3+
Achilles tendon: tests S1–S2	DTR for high hyperreflexia (clonus): grade is 4+ or 5+

Orthopedic Special Tests: Shoulder, Elbow, Wrist, and Hand

Table 3-23 Orthopedic Special Tests: Shoulder, Elbow, Wrist, and Hand

Area, Test, and Purpose	Interpretation	Procedure
Shoulder: Yergason's for bicipital tendonitis[4]	Tests: integrity of the transverse humeral ligament (THL) that holds the biceps tendon in the bicipital groove of the humerus. Positive for tendonitis: tenderness (or pain) in the bicipital groove. Positive for THL tear: tendon felt to "pop out" of the groove.	Patient remains seated with elbow flexed to 90° and stabilized against the thorax, forearm pronated. One of the therapist's hands palpates the biceps tendon in the bicipital groove; the other hand resists supination when the patient laterally rotates the arm against resistance.
Shoulder: Adson's maneuver for thoracic outlet syndrome (TOS)[5]	Tests: presence of TOS. Positive for TOS: disappearance of the radial pulse when the patient holds a deep breath.	Patient remains seated with head rotated toward the tested shoulder; extends the head while taking a deep breath and holding it. One of the therapist's hands palpates the patient's radial pulse; the other hand rotates and extends the patient's shoulder.
Shoulder: Neer impingement test for injury of the supraspinatus muscle or biceps tendon tear[4]	Tests: overuse injury of the supraspinatus muscle. Positive: patient's face shows pain.	Patient remains seated while his or her arm is forcibly flexed and internally rotated by the therapist. The passive stress causes compression of the greater tuberosity of the humerus against the acromion.
Shoulder: drop arm (Codman's) test for rotator cuff tear[4]	Tests: tear of rotator cuff muscles. Positive: patient drops his or her arm to the side.	Patient remains standing while the therapist abducts the patient's shoulder to 90° and asks the patient to slowly lower his or her arm to the side.
Shoulder: apprehension test for anterior shoulder[4] dislocation	Tests: traumatic instability of the anterior shoulder. Positive: patient complains of pain or apprehensively resists the therapist's hand when moving the patient's arm in external rotation.	Patient remains supine while the therapist abducts the patient's arm to 90° and laterally rotates the patient's shoulder slowly.
Elbow: lateral epicondylitis test (Cozen's test)[4]	Tests: inflammation of the lateral epicondyle (tennis elbow). Positive: sudden severe pain in the area.	Patient remains seated with elbow extended, forearm pronated, making a fist. One of the therapist's hands stabilizes the patient's elbow, palpating the lateral epicondyle. The other hand resists the patient's wrist extension and forearm supination.
Elbow: medial epicondylitis test[4]	Tests: inflammation of the medial epicondyle (golfer's elbow). Positive: sudden severe pain in the area.	Patient remains seated with elbow extended, forearm supinated. One of the therapist's hands stabilizes the patient's elbow, palpating the medial epicondyle. The other hand passively extends and supinates the patient's wrist and forearm.

(*continues*)

Table 3-23 Orthopedic Special Tests: Shoulder, Elbow, Wrist, and Hand (continued)

Area, Test, and Purpose	Interpretation	Procedure
Wrist: Phalen's test for carpal tunnel syndrome[4]	Tests: pressure on median nerve secondary to carpal tunnel syndrome. Positive: tingling sensation in the thumb, index finger, and middle and lateral half of the ring finger.	Patient remains standing. The therapist flexes the patient's wrist, pushing the wrists together and holding them for 1 minute.
Wrist: Tinel's sign for carpal tunnel syndrome[4]	Tests: pressure on median nerve and the rate of regeneration of sensory fibers of the nerve. Positive: tingling and paresthesia into the thumb, index finger, middle and lateral half of ring finger, and distal to the point of pressure. The most distal point felt is the limit of nerve regeneration.	Patient remains seated, with forearm supinated and hand relaxed. The therapist taps over the carpal tunnel.
Thumb: Finkelstein's test for DeQuervain's tenosynovitis[4]	Tests: tendon inflammation of the abductor pollicis longus and extensor pollicis brevis. Positive: pain in the area of these two tendons.	Patient remains seated with elbow extended, making a fist with the thumb inside the fingers. One of the therapist's hands stabilizes the patient's forearm. The other hand moves the patient's wrist toward the ulnar side.

Orthopedic Special Tests: Hip, Knee, and Ankle

Table 3-24 Orthopedic Special Tests: Hip, Knee, Ankle

Area, Test, and Purpose	Interpretation	Procedure
Hip: Ober test for TFL (iliotibial band) contracture[5]	Tests: contracture or tightness (shortness) of the iliotibial band. Positive: tested leg remains abducted while the patient's muscles are relaxed.	Patient remains side lying, with the lower leg flexed at the hip and knee. Patient's tested limb is uppermost, with knee extended. The therapist passively abducts and extends the upper leg, and slowly lowers the limb.
Hip: Thomas test for hip flexion tightness[4,5]	Tests: contracture or tightness (shortness) of hip flexors. Positive: patient's thigh lifts up from the table, bending at the knee.	Patient remains supine. The therapist flexes the unaffected hip, asking the patient to hold his or her knee to his or her chest (flattening the lumbar spine and stabilizing the pelvis). Patient holds the flexed hip against his or her chest.
Hip: Patrick's test (FABER[4,5] test)	Tests: arthritis of the hip or sacroiliac joint dysfunction. Positive: pain in the hip and the tested leg's knee remaining above the opposite knee.	Patient remains supine. The therapist flexes, abducts, and externally rotates the patient's hip until the lateral malleolus rests on the opposite knee above the patella. In this position, the therapist gently pushes the knee downward.
Hip: Supine Straight Leg Raise Test[7]	Test: Hamstring tightness (shortness) Positive: hip flexion range of motion measurement < 80° suggests hamstring tightness.	Patient remains supine with bilateral lower extremities in extension. The non-test leg should be stabilized. The clinician passively raises the test leg into the straight leg raise position while keeping the knee straight. Hip flexion range of motion measurement is taken to determine if tightness is present.
Knee: Valgus test (abduction test) for medial instability[4]	Tests: instability of the medial collateral ligament (MCL). Positive: pain or excessive gapping of the joint (the tibia moves away from the femur because of gaps on the medial side).	Patient remains supine, with the tested knee first in full extension, then in slight flexion (20–30°). The therapist stabilizes the ankle by sitting on it. One of the therapist's hands palpates the knee joint line at the medial side; the other hand at the lateral joint line pushes the knee medially by applying a valgus stress.
Knee: Varus test (adduction test) for lateral instability[4]	Tests: instability of the lateral collateral ligament (LCL). Positive: pain or excessive gapping of the joint (the tibia moves away from the femur because of gaps on the lateral side).	Patient remains supine, with the tested knee first in full extension, then in slight flexion (20–30°). The therapist stabilizes the ankle by sitting on it. One of the therapist's hands palpates the knee joint line at the lateral side; the other hand at the medial joint line pushes the knee laterally by applying a varus stress.

(*continues*)

Table 3-24 Orthopedic Special Tests: Hip, Knee, Ankle (continued)

Area, Test, and Purpose	Interpretation	Procedure
Knee: Lachman test for ACL instability[4,5]	Tests: instability of the anterior cruciate ligament (ACL). Positive: "mushy" or soft end feel when the tibia is moved forward on the femur. Caution: A false-negative is possible if the femur is not properly stabilized or a meniscal tear is present.	Patient remains supine, with the tested knee in 30° of flexion. One of the therapist's hands stabilizes distal femur; the other hand translate the proximal tibia forward on the femur.
Knee: McMurray test for loose meniscal fragments[4,5]	Tests: integrity of the lateral and medial meniscus. Positive: snap or click (or feeling a crepitation) accompanied by pain as the knee suggests anterior meniscus; with knee flexed suggests posterior horn of meniscus.	Patient remains supine, with the tested knee completely flexed. One of the therapist's hands holds the patient's calcaneus (for internal or external rotation); the other hand holds the knee joint for knee extension.
Knee: Thessaly Test for dynamic loading of the knee joint to determine meniscal pathology.[5,6]	Tests the integrity of the medial and lateral meniscus. Positive: medial or lateral joint line discomfort or patient may perceive locking, snapping or catching in the knee joint.	Patient stands on the affected leg while the clinician holds the outstretched hands of the patient for support, patient is instructed to bend the knee slightly (5° knee flexion) and twist on the knee by rotating the body/trunk on the fixed lower extremity for a total of three times. The procedure is repeated with the knee flexed to 20°.
Knee: Thomas Test for rectus femoris tightness[7]	Tests: tightness of rectus femoris. Positive: knee flexion < 80° may suggest rectus femoris tightness.	Patient lies supine. The PTA flexes the unaffected hip, asking the patient to hold thatknee to their chest (to flatten the lumbar spine and stabilize the pelvis). The PTA passively flexes the affected knee to the limit of motion to assess if the rectus femoris is shortened.
Ankle: Thompson's test for rupture of Achilles tendon[4]	Tests: rupture of Achilles tendon. Positive: absence of plantar flexion when the calf muscles are squeezed.	Patient remains prone, relaxed, with the feet over the edge of the table. The therapist squeezes the calf muscles.
Ankle: Homan's sign for deep vein thrombosis (DVT)[4]	Tests: DVT. Positive: calf pain. Patient may also have pallor, loss of dorsalis pedal pulse or swelling.	Patient remains supine, with the knee extended. One of the therapist's hands holds and lifts the lower leg off the table; the other hand passively dorsiflexes the foot.

Common Injuries of the Brachial Plexus

Table 3-25 Common Injuries of the Brachial Plexus

Nerve and Its Origin	Motor Innervation	Musculoskeletal Injuries
Median nerve cords: medial and lateral. Divisions: anterior. Trunks: upper, middle, and lower. Origin: nerve roots C6, C7, C8, and T1.	Motor innervation muscles: pronator teres; pronator quadratus; palmaris longus; FCR; FDS; FPL; lateral half of FDP; lumbricales 1 and 2; thenar muscles (abductor pollicis brevis; lateral half of FPB; and opponens pollicis).	Median nerve compression injuries: • Thoracic outlet syndrome: presence of a cervical rib or narrowing of the thoracic outlet • Pronator teres syndrome: caused by trauma, humeral fracture, hypertrophy of muscle, or repetitive injury (such as using a screwdriver) • Anterior interosseus syndrome: caused by fibrous sheaths, thrombosis of vessels, or forearm fractures • Carpal tunnel syndrome: caused by hormonal factors in pregnancy, hypothyroidism, congenital bone deformities, RA, or overuse syndrome Median nerve trauma injuries: • Humeral fractures • Wrist lacerations • Carpal bones trauma Median nerve lesion deformities: • Ape hand: paralysis and atrophy of thenar muscles; opposition is lost, thumb is permanently extended • Benediction sign: inability to flex the thumb and second and third digits; they remain in extension because the FDP and FPL are weak; ring and little fingers are flexed while others are extended; cannot make a fist[8]
Ulnar nerve cord: medial. Division: anterior. Trunk: lower. Origin: nerve roots C8 and T1.	Muscles: FCU; medial half of FDP; palmaris brevis; hand interossei; third and fourth lumbricales; adductor pollicis; medial half of FPB; hypothenar muscles (opponens digiti minimi, abductor digiti minimi, and flexor digiti minimi).	Ulnar nerve compression injuries: • Thoracic outlet syndrome: presence of a cervical rib or narrowing of the thoracic outlet • Crutches injury: pressure on the axillary region • Cubital tunnel syndrome: entrapment at the elbow secondary to trauma, repetitive motion, or inflammatory conditions • Guyon's canal (or ulnar tunnel): secondary to RA or trauma (karate) Ulnar nerve lesion deformity: claw hand (hyperextension of the proximal phalanges of the digits and extreme flexion of the middle and distal phalanges; loss of opposition and inability to abduct the little finger)[8]

(*continues*)

Table 3-25 Common Injuries of the Brachial Plexus (continued)

Nerve and Its Origin	Motor Innervation	Musculoskeletal Injuries
Radial nerve cord: posterior. Division: posterior. Trunks: upper, middle, lower. Origin: nerve roots C5, C6, C7, C8, and T1	Muscles: brachioradialis, ECRL, triceps, anconeus, ECRB, supinator, ED, EDM, ECU, abductor pollicis longus, EPL, EPB, extensorindicis.	Radial nerve compression injuries: • Spiral groove syndrome (called also Saturday night palsy): caused by falling asleep (inebriated) with the spiral groove of the arm against a hard object or caused by direct trauma • Crutches injury: pressure on the axillary region Radial nerve trauma injuries: • Radial neck fractures • Humeral fractures • Shoulder dislocations

Common Muscle Substitutions

Table 3-26 Examples of Common Muscle Substitutions

- Scapular stabilizers initiate shoulder motion for weak shoulder abductors
- Lateral trunk muscles or TFL takes over for weak hip abductors
- Long head of the biceps, coracobrachialis, and anterior deltoid take over for a weak pectoralis major
- Use of passive finger flexion by contracting wrist extensors for weak finger flexors
- Lower back extensors, adductor magnus, and quadratus lumborum for weak hip extensors
- Lower abdominals, lower obliques, hip adductors, and latissimus dorsi for weak hip flexors

SECTION 3-5

Basic Clinical Impairments and Activity Limitations Related to Common Musculoskeletal Conditions

Clinical Impairments and Activity Limitations of Arthritic Disorders

Table 3-27 Clinical Impairments and Activity Limitations of Arthritic Disorders*

Osteoarthritis: Impairments and Activity Limitations	Rheumatoid Arthritis: Impairments and Activity Limitations
Sensory deficits: decreased proprioception and/or kinesthesia (such as during ambulation and/or ADLs); pain with weight bearing depending on the stages of the disease (or if it involves discal nerve root compromise); aching during sleep; hip pain can be prevalent depending on the stages of the disease; pain upon rising that eases through the morning with movement.	Sensory deficits: sharp pain with certain movements; paresthesia; decreased proprioception and/or kinesthesia.
Motor deficits: decreased muscular strength; decreased muscular endurance; decreased ROM; decreased flexibility (morning stiffness); sometimes a leg-length discrepancy; decreased balance; deformities such as valgus or varus in the knee joint; joint crepitus; joint swelling (moderate); increased muscular spasms; joint deformity (usually in abduction, flexion, and external rotation); postural deficits (such as increased kyphosis or lordosis); abnormal reflexes.	Motor deficits: decreased flexibility; decreased muscular strength; decreased muscular endurance; decreased flexibility (morning stiffness); decreased ROM; fatigue (lack of energy); joint swelling; increased joint laxity; crepitus; increased, joint hypermobility or hypomobility; increased skin and soft-tissue temperature; edema; decreased balance and coordination; joint deformity especially in the second and third MP and PIP; may have Boutonniere deformity (PIP joint flexion and DIP joint extension); Swan neck deformity (PIP joint extension and MP and DIP joints flexion); valgus deformity at the knees and ankles; clawed toes deformity.
Functional deficits: antalgic gait pattern; may need assistive device in transfers and ambulation; decreased independence with ADLs (such as dressing) and home management activities; decreased independence with IADLs; inability to ambulate stairs (steps); inability to participate in work/play/school or perform leisure activities.	Functional deficits: decreased independence with ADLs and home management activities; decreased independence with IADLs; inability to ambulate stairs (steps); inability to participate in work/play/school or perform leisure activities; may need assistive devices in transfers and ambulation. Pulmonary deficits: may have pleural effusion or pleuritis; shallow breathing; chest pain during inspiration.

* These are basic guidelines. The PTA should also consider the findings from the PT's initial examination, evaluation and any environmental factors that may be associated with these diagnoses.

Table 3-28 Impairments Activity Limitations and Participation Restrictions Related to Tendonitis, Bursitis, Sprains, Strains, Dislocations, and Fractures

- Sensory deficits: pain at rest and with weight bearing; decreased sensation; decreased proprioception and/or kinesthesia.
- When cervical spine is involved (such as with an acceleration injury or cervical sprain of the CS), the patient can have neck pain; headaches, vertigo, dysesthesias (numbness, burning, prickling, or tingling) of the face and upper extremities; and changes in vision and hearing.
- In rib fractures, the patient may have pain with deep inspiration. In brachial plexus lesions, the patient may have sharp and burning pain in the upper extremity and numbness and pins and needles in the upper extremity.
- In cervical disk pathology, the patient can have sensory changes in the respective dermatomes. In cervical faucet syndrome, the patient can have paresthesia and pain with hyperextension and rotation of the CS.
- Motor deficits: increased muscular spasms; decreased muscular strength; decreased muscular endurance; decreased ROM; decreased flexibility; localized swelling; joint crepitus with active motion; decreased balance (if the deficit is in the lower extremity); postural deficits; muscular substitutions (stronger muscles compensate for the loss of motion); postural changes (such as forward head kyphosis with cervical sprain).
- Colle's or Smith's fractures can have edema and ecchymosis, structural deformity (Colles' distal fragment is dorsal and Smith's is palmar), and limited ROM.
- Functional deficits: decreased independence with ADLs (such as dressing) and home management activities, decreased independence with IADLs, inability to ambulate stairs or steps (if it is in the lower extremity), and inability to participate in work/play/school or perform leisure activities.

SECTION 3-6

Types of Musculoskeletal Interventions

Therapeutic Exercises: Indications and Contraindications

Table 3-29 Therapeutic Exercises: Indications and Contraindications

Exercises	Indications	Contraindications, Limitations, and Precautions[9]
PROM exercises (including the CPM device)	To demonstrate a movement, to prepare a patient for stretching, to maintain joint connective tissue mobility, to maintain elasticity of muscle, to increase synovial fluid for joint nutrition, to assist circulation, to prevent joint contracture, to decrease pain, to help in the healing process.	Contraindication: Disruption of the healing process. Limitations: Will not increase muscle strength or endurance, will not prevent or counteract muscle atrophy, will not assist in the blood circulation to the same extent as the active movement.
AROM exercises	For weak muscles, to promote bone and soft-tissue integrity, to promote coordination and motor skills, to prevent DVT, to increase blood circulation, for aerobic conditioning, for preparation for functional activities.	Contraindications: Disruption of the healing process, harm to recent surgical procedure(s). Limitations: Will not increase strength in muscles that are already strong.
AAROM exercises using manual or mechanical assistance (wand, cane, finger ladder, or overhead pulleys)	To increase circulation and prevent DVT; to promote integrity of bone, muscles, ligaments and tendons; to promote coordination and motor abilities; to assist with learning a new movement pattern.	Contraindications: Disruption of the healing process, harm to recent surgical procedure(s). Limitations: will not increase strength in muscles already strong; less effective than AROM exercises.
Muscle setting isometric exercises (quadriceps sets; gluteal muscle sets; HS sets)	For very weak muscles, for acute stage of soft-tissue healing, to increase circulation, to promote relaxation, to decrease pain.	Precautions: Cardiovascular disease, CVA, Valsalva maneuver (to avoid performing a Valsalva maneuver, the patient can count out loud or sing).
Resisted isometrics exercises (higher intensity than muscle setting): manual or mechanical (door frame or wall)	To increase strength throughout permitted ROM, and when manual or mechanical resistance is painful or harmful.	Precautions: Cardiovascular disease, CVA, Valsalva maneuver (to avoid performing a Valsalva maneuver, the patient can count out loud or sing).
Stabilization exercises (isometrics and rhythmic stabilization; co-contraction)	To develop muscle strength and stability, and to assist with postural control (muscles of trunk).	Precautions: Cardiovascular disease, CVA, Valsalva maneuver (to avoid performing a Valsalva maneuver, the patient can count out loud or sing).

(*continues*)

Table 3-29 Therapeutic Exercises: Indications and Contraindications (continued)

Exercises	Indications	Contraindications, Limitations, and Precautions[9]
Manual and mechanical resistance exercises: PNF D1 flexion; PNF D1 extension; PNF D2 flexion; PNF D2 extension. For concentric contractions, the resistance must be applied in the opposite direction to the desired motion. For eccentric contractions, the resistance must be applied in the same direction as the desired motion.	Manual resistance: For very weak muscles, for the transition from manual to mechanical resistance, where adjustment of resistance is indicated, when the patient's muscles must work maximally at all points in ROM, when protection of healing tissues is indicated, and when prevention of substitute motion is indicated. Mechanical resistance: To increase strength and endurance, for independent training, and in the intermediate and advanced stages of rehabilitation.	Contraindications: Acute inflammation, acute diseases/disorders, pain, polio or post-polio syndrome, and Guillain-Barré syndrome. Mechanical resistance is not appropriate for very weak muscles and in the early stages of healing. Precautions: Cardiovascular conditions, to monitor vital signs, Valsalva maneuver, DOMS.
DeLorme PREs: (1) Determine the patient's 10 RM; (2) the patient performs one set of 10 reps at 50% of the 10 RM; (3) the patient performs a second set of 10 reps at 75% of the 10 RM; (4) the patient performs a final set of 10 reps at the full 10 RM.	To increase strength and endurance.	Contraindications: Acute inflammation, acute diseases/disorders, pain, polio or post-polio syndrome, Guillain-Barré syndrome. Precautions: Cardiovascular conditions, to monitor vital signs, Valsalva maneuver, DOMS.
Oxford PREs: (1) Determine the patient's 10 RM; (2) the patient performs one set of 10 reps at the full 100% RM; (3) the patient performs a second set of 10 reps at 75% of the 10 RM; (4) the patient performs a final set of 10 reps at 50% of the 10 RM.	To increase strength and endurance.	Contraindications: Acute inflammation, acute diseases/disorders, pain, polio or post-polio syndrome, Guillain-Barré syndrome. Precautions: Cardiovascular conditions, to monitor vital signs, Valsalva maneuver, DOMS.

Table 3-29 Therapeutic Exercises: Indications and Contraindications (continued)

Exercises	Indications	Contraindications, Limitations, and Precautions[9]
DAPRE PREs: (1) Determine the patient's 6 RM; (2) in set 1, the patient performs 10 reps at 50% of the 6 RM; (3) in set 2, the patient performs 6 reps at 75% of the 6 RM; (4) in set 3, the patient performs as many as possible reps at 100% of the 6 RM; (5) in set 4, the patient performs as many as possible reps at 100% of the "working weight" performed during set 3. The number of reps done in set 4 is used to determine the "working weight" for the next day.	To increase strength and endurance.	Contraindications: Acute inflammation, acute diseases/disorders, pain, polio or post-polio syndrome, Guillain-Barré syndrome. Precautions: Cardiovascular conditions, to monitor vital signs, Valsalva maneuver, DOMS.
Circuit weight training: Using mechanical resistance for various muscle groups. Circuit training exercises: Using mechanical resistance for various muscle groups, flexibility exercises, and total-body conditioning.	To increase muscular strength, to increase muscular endurance, to increase cardiovascular endurance.	Contraindications: Acute inflammation, acute diseases/disorders, pain, polio or post-polio syndrome, Guillain-Barré syndrome. Precautions: Cardiovascular conditions, to monitor vital signs, Valsalva maneuver, DOMS.
Isokinetic exercises (use accommodating resistance).	To increase muscular strength and endurance, for later stages of rehabilitation, when the patient has full or partial ROM in a pain-free mode.	Contraindications: Acute inflammation, acute diseases/disorders, pain, polio or post-polio syndrome, Guillain-Barré syndrome. Precautions: Recent musculotendinous surgeries, cardiovascular diseases or disorders. Limitations: Resistance depends entirely on the patient's efforts; exercises do not accommodate all muscle groups; the patient cannot perform exercises independently in his or her environment; exercises are nonfunctional; exercises use specialized and expensive equipment. Precautions: Can increase BP.

(*continues*)

Table 3-29 Therapeutic Exercises: Indications and Contraindications (continued)

Exercises	Indications	Contraindications, Limitations, and Precautions[9]
Open kinetic chain (OKC) and closed kinetic chain (CKC) exercises.	OKC: For strengthening of individual muscle groups, and for NWB postures. CKC: For functionality, for WB postures, and to stimulate joint and mechanoreceptors.	Precautions: When using resistive OKC while terminal knee extension (TKE); when using CKC between 60° and 90° in nonoperative and operative ACL injuries; when using CKC in postoperative meniscal tears.
Stretching exercises: Manual passive stretching, self-stretching, prolonged mechanical or positional passive stretching, ballistic stretching (for athletes), cyclic mechanical stretching.	To elongate structures, to improve ROM, for hypomobile joints.	Contraindications: When a bony block limits joint motion; acute infectious and inflammatory processes; acute sharp pain; recent fracture; hematoma and joint hypermobility; when contractures provide stability and functionality. Ballistic stretching contraindications: sedentary individuals, older patients, patients with musculoskeletal pathology or chronic contracture. Precautions: Do not stretch passively beyond normal ROM. Use care in cases involving newly united fractures, osteoporosis, prolonged immobilization, bone malignancy, or total joint replacements.
Aerobic conditioning exercises (cardiopulmonary endurance exercises or total-body endurance exercises): (1) Karvonen formula: total heart rate reserve (THRR) = maximal HR – resting HR (40% to 85%) + resting HR; (2) age-adjusted maximal heart rate formula: THRR = (220 – age) × (65–85%); (3) MET method; (4) Borg's rate of perceived exertion (PRE) scale method.	To increase coronary arteries' blood flow, to increase the heart wall thickness and muscle mass of the left ventricle, to increase blood cortisol level, to improve thermal regulation capability, to reduce the risk of coronary artery disease, to increase aerobic enzymatic activity, to increase the maximum ventilatory ability.	Contraindications: Unstable angina; resting systolic BP more than 200 mm Hg; resting diastolic BP more than 110 mm Hg; orthostatic hypotension; acute systemic illness or fever; tachycardia; thrombophlebitis; recent embolism; severe orthopedic problems; metabolic problems (such as thyroiditis). Precautions: Swimming and cross-country skiing, dancing, basketball, racquetball, and competitive activities should not be used with patients who may have cardiorespiratory symptoms or are very deconditioned.

Table 3-29 Therapeutic Exercises: Indications and Contraindications (continued)

Exercises	Indications	Contraindications, Limitations, and Precautions[9]
Aquatic exercises	Poor standing balance, for stretching, for relaxation, for strengthening, for aerobic conditioning, for PWB gait training.	Contraindications: Bowel and bladder incontinence, UTI, unstable BP, skin infections and water and airborne infections, unprotected open wounds, severe epilepsy, severe kidney disease, severe cardiac and respiratory dysfunction. Precautions: Patients who experience fear of water (need prior orientation).
Relaxation exercises: (1) Progressive relaxation (teaches voluntary contraction and relaxation of the muscles from distal to proximal); (2) one breathing technique (awareness of diaphragmatic breathing while silently repeating the word "one" with each exhalation).	Chronic pain (tension headache, vascular headache, or chronic neck and back pain) with biofeedback; cardiopulmonary stress or chronic pulmonary problems such as asthma or emphysema.	Precautions: Patients with cardiopulmonary disorders performing progressive relaxation (when isometrically contracting the muscles).

Relaxation Exercises

Table 3-30 Relaxation Exercises

- Relaxation exercises are performed with active participation from the patient to generate a relaxation response.
- The systemic effects of relaxation include decreased sympathetic nervous system (SNS) activity, respiratory rate, oxygen consumption, blood pressure, skeletal muscle blood flow, and muscle tension.
- Relaxation techniques can be performed singly or incorporated into other exercise sessions such as part of the warm-up or cool-down of the aerobic conditioning exercises.
- The relaxation training is effective if it is acceptable to the patient, is easy to apply in different settings, helps to restore the patient's sense of control, and offers immediate reduction of pain.
- Types of relaxation exercises include autogenic training, progressive relaxation, and Feldenkrais awareness through movement.
  - Autogenic training involves conscious relaxation through autosuggestion and a progression of exercises as well as meditation.
  - Progressive relaxation is one of the most widely used techniques that teaches voluntary contraction and relaxation of the muscles, going from distal to proximal.
  - Feldenkrais awareness through movement combines self-massage, movements of the limbs and trunk, deep breathing, sensory awareness, and conscious relaxation procedures to adjust postural and muscular imbalances and decrease pain and tension.[10]
- Other types of relaxation exercises include "one breathing" technique, eye-movement breathing technique, cognitive relaxation techniques such as listening to audiotapes or watching videotapes with instructions or music for relaxation, guided imagery, hypnosis, and nontraditional psychophysical techniques such as Trager psychophysical integration, Tai Chi Chuan, and Hatha yoga.
  - The "one breathing" technique is a form of meditation that involves passive focusing of awareness on the diaphragmatic breathing cycle while silently repeating the word "one" with each exhalation.[10]
  - The patient or the client is instructed to maintain a passive attitude and allow but not force relaxation to occur at its own pace.
  - The eye-movement breathing technique involves looking up toward the eyebrows (without head movement) during the inspiratory phase of diaphragmatic breathing, then holding the breath for 2 seconds, followed by looking down toward the chin (without head movement) while breathing out very slowly and completely. To promote relaxation, the expiratory phase of diaphragmatic breathing can be extended.
- When applying progressive relaxation exercises, the following procedures are used:
  1. Relaxation training can be performed in a quiet environment with low lighting and soothing music.
  2. The therapist's voice has to be soft and soothing.
  3. The patient should be in a comfortable position and free of restrictive clothing.
  4. The procedure must be explained to the patient.
  5. The patient needs to breathe in deeply and in a relaxed manner.
  6. The patient is asked to contract voluntarily for a few seconds the distal muscle of the hands or feet.
  7. The patient is asked to voluntarily relax for a few seconds the distal muscle of the hands or feet.
  8. The patient is asked to try to feel a sense of heaviness in the hands or feet.
  9. The patient is asked to try to feel a sense of warmth in the muscles just relaxed.
  10. The exercises can progress to a more proximal area of the body by asking the patient to voluntarily contract and relax the more proximal musculature for a few seconds.
  11. The patient is asked to voluntarily contract isometrically and relax the entire upper extremity or lower extremity.
  12. At the end of the procedures, the patient is asked to try to feel a sense of relaxation and warmth throughout the entire extremity and eventually throughout the entire body.
- Relaxation exercises can be coupled with heating modalities such as hot packs, paraffin, ultrasound, or massage techniques such as light or deep stroking (effleurage).

Closed Kinetic Chain Exercises to Increase Weight-Bearing Control and Stability

Table 3-31 CKC Exercises

CKC Isometric Exercises

- Muscle setting exercises (to facilitate co-contraction of the quadriceps and hamstrings): Patient sits on a chair with the knee extended or slightly flexed and the heel on the floor. Have the patient press the heel against the floor and the thigh against the seat of the chair, and concentrate on contracting the quadriceps and hamstrings simultaneously to facilitate co-contraction around the knee joint. Hold the muscle contraction, relax, and repeat rhythmic stabilization.
- Muscle setting exercises (to facilitate contraction of muscles in the ankles, knees, hips and trunk): Patient stands with bilateral weight bearing. Apply manual resistance to the pelvis in several directions as the patient holds the position. This will facilitate isometric contraction of muscles in the ankles, knees, hips, and trunk. Progress to rhythmic stabilization activity by having the patient bear weight only on the involved lower extremity while resistance is applied.

CKC Dynamic Exercises

- Mini-squats (short-arc training): Patient stands and bends both knees up to 30–45°, and then extends the knees. Progress by using elastic resistance placed under both feet or by holding weights in the hands. Having the knees move anterior to the toes as the hips descend increases the shear forces on the tibia and strains the ACL. Squatting, as if sitting on a chair, in which the tibia remains relatively vertical requires greater trunk flexion to maintain balance and stronger quadriceps contraction to support the load of the pelvis posterior to the knee axis at an angle where patellar compressive loads are great (helping to reduce the stress on the ACL).
- Forward, backward, and lateral step-ups and step-downs: Begin with a low step, 2–3 inches in height, and increase the height as the patient is able. Make sure that the patient keeps the trunk upright. Emphasize control of body weight during concentric (step-up) and eccentric (step-down) quadriceps activity. Instruct the patient that the heel is to be the last to leave the floor and the first to return ("Keep the toes up").
- Standing wall slides: The patient flexes the hips and knees and slides the back down and then up the wall, lifting and lowering the body weight. As control improves, the patient moves into greater knee flexion, up to a maximum of 60°. Knee flexion beyond 60° is not recommended to avoid excessive shear forces on ligamentous structures of the knee and compressive forces on the patellofemoral joint. Wall slides that are performed with a gym ball behind the back decrease stability and require more control.
- Partial and full lunges: Patient assumes a step-forward stance position with weight acceptance on the forward foot. Have the patient rock the body weight forward, allowing the knee to flex slightly, and then rock backward and control knee extension.

Patient Education Topics Related to the Lumbar Spine

Table 3-32 Patient Education for the Lumbar Spine

- When supine, hook lying flexes the spine, while legs extended extends the spine. A pillow under the head flexes the neck; a small roll under the neck stabilizes a mild lordosis with the head in neutral position.
- When prone, the patient should use a pillow under the abdomen (because it flexes the spine; without a pillow, this position extends the spine).
- Sitting usually causes spinal flexion, especially if the hips and knees are flexed. To emphasize flexion, the patient should prop the feet up on a small footstool (to increase hip flexion). To emphasize extension, the patient should use a lumbar pillow (or support) in the low back region.
- Standing usually causes spinal extension. To emphasize flexion, the patient should stand with a small stool under one of the feet.
- If tolerated, the patient is taught to perform simple movements while protecting the spine in the functional position.

(*continues*)

Table 3-32 Patient Education for the Lumbar Spine (continued)

- Gentle pelvic tilting or chin tucks should be taught in every position tolerated by the patient, including supine, prone, side lying, sitting, and standing.
- Postlaminectomy or postdiskectomy (in the hospital), the patient is taught:
  1. To use the "log roll" technique to turn from supine to side lying to prone and return
  2. To practice maintaining spinal alignment by keeping the shoulders aligned with the pelvis while rolling the trunk over as a unit (a log) and not twisting the spine
  3. To sit from the supine-lying position by log rolling on to the side, pushing the body up with the hands while bringing the legs forward over the side of the bed
  4. To keep the back in lordosis if there is an extension bias (or in flexion if there is a flexion bias)
  5. To go from standing to sitting and the reverse with spinal control
  6. To move the trunk as a whole
  7. Not to bend over
  8. Not to lift heavy or moderately heavy objects
  9. Not to twist the back
  10. Not to sit for prolonged periods of time
  11. Not to climb long flights of stairs
  12. To maintain proper body mechanics (to lessen strain and pressure on the spine), including proper body alignment and good posture
  13. To sleep on a firm mattress
  14. To start an exercise program (after 6 weeks postoperatively) of gradual abdominal muscle strengthening

Abdominal Strengthening Exercises

Table 3-33 Abdominal Muscles Strengthening Exercises

Curl-ups

- Position of patient: hook lying, with the lumbar spine flat (posterior pelvic tilt).
- First, have the patient lift the head off the mat (causing a stabilizing contraction of the abdominal muscles).
- Patient progresses by lifting the shoulders until the scapulae and thorax clear the mat, keeping the arms horizontal. The patient does not come to a full sit-up because after the thorax clears the mat, the rest of the motion is performed by the hip flexor muscles.
- Further progress the difficulty of the curl-up by changing the arm position from horizontal to folded across the chest and then to behind the head.[6]

Diagonal Curl-ups

- To emphasize the external oblique muscles, the patient performs a diagonal curl-up by reaching one hand toward the outside of the opposite knee while curling up, then alternating.
- The patient reverses the muscle action by bringing one knee up toward the opposite shoulder and then repeating with the other knee.

Double Knee to Chest

- To emphasize the lower rectus abdominis and oblique muscles, have the patient set a posterior pelvic tilt, then bring both knees to the chest and return.
- Progress the difficulty by decreasing the angle of the hip and knee flexion.

Pelvic Lifts

- The patient begins with the hips at 90° and knees extended.
- The patient performs a posterior pelvic tilt and lifts the buttocks upward off the mat (small motion; the feet move also upward toward the ceiling).
- The patient should not push against the mat with the hands.

Table 3-33 Abdominal Muscles Strengthening Exercises (continued)

Bilateral Straight-Leg Raising (SLR)

- This is a progression in difficulty of the double knee-to-chest exercise (it should be undertaken only if the muscles are strong enough to maintain a posterior pelvic tilt).
- The patient begins with legs extended (the patient first performs a posterior pelvic tilt, then flexes both hips, keeping the knees extended; if the hips are abducted before initiating this exercise, greater stress is placed on the oblique abdominal muscles)

Exercise Topics for the Obstetric Patient

Table 3-34 Guidelines Related to Interventions for the Obstetric Patient

Pregnancy-Induced Pathology: Diastasis Recti

- Diastasi recti: separation of the rectus abdominis muscles in the midline at the linea alba. Any separation larger than 2 cm or two fingerwidths is considered significant.
- Diastasis recti is not exclusive to childbearing women but is seen frequently in this population. The incidence increases as the pregnancy progresses, reaching a peak in the third trimester.
- Diastasis recti does not always spontaneously resolve after childbirth and may continue past the 6-week postpartum period.
- Diastasis recti can occur above, below, or at the level of the umbilicus but appears to be less common below the umbilicus.[9]

Diastasis Recti Test

The diastasis is measured by the number of fingers that can be placed between the rectus abdominis muscle bellies. A diastasis can also present as a longitudinal bulge along the linea alba.

Diastasis Recti Intervention

Perform corrective exercises for diastasis recti exclusive of other abdominal exercise until the separation is decreased to 2 cm or less.

Corrective Exercises for Diastasis Recti[9]: Head Lift Corrective Exercise

- Position of the patient is supine hook-lying with her hands crossed over midline at the diastasis to support the area.
- As the patient exhales, the patient lifts only her head off the floor or until the point just before a bulge appears.
- The patient's hands should gently pull the rectus muscles toward midline.
- The patient lowers the head slowly and relaxes.

Corrective Exercises for Diastasis Recti[9]: Head Lift with Pelvic Tilt Corrective Exercise

- Patient is positioned supine hook-lying.
- If diastasis recti is present, the arms are crossed over the diastasis and pulled toward midline.
- The patient slowly lifts her head off the floor while performing a posterior pelvic tilt. She then slowly lowers her head and relaxes.
- All abdominal contractions should be performed with an exhalation so the intra-abdominal pressure is minimized.

Guidelines for Obstetric Exercise Instruction

- Supine positioning should not exceed 5 minutes at any one time after the fourth month of pregnancy to avoid vena cava compression by the uterus.
- When the patient is supine, a small wedge or rolled towel should be placed under the right hip (to lessen the effects of uterine compression on abdominal vessels and to improve cardiac output by turning the patient slightly toward the left). Left side lying is the best position for pregnancy.

Table 3-34 Guidelines Related to Interventions for the obstetric Patient (continued)

Recommendations for Obstetric Aerobic Exercise[9]

- It is preferable that the patient exercises regularly at least three times per week rather than intermittently.
- Non-weight-bearing aerobic exercises such as stationary cycling or swimming should be used to minimize the risk of injury but, if able, the patient may continue activities such as running and aerobic dancing.
- Resumption of prepregnancy exercise routines during the postpartum period should occur gradually.
- Physiologic and morphologic changes of pregnancy continue for 4–6 weeks postpartum.

Absolute Contraindications to Obstetric Aerobic Exercises

- Incompetent cervix
- Early dilation of the cervix before the pregnancy is full term
- Vaginal bleeding of any amount
- Placenta previa
- Rupture of membranes (loss of amniotic fluid prior to the onset of labor)
- Premature labor
- Maternal heart disease
- Maternal diabetes or hypertension
- Intrauterine growth retardation

Precautions for Obstetric Aerobic Exercises

- Multiple gestation
- Anemia
- Systemic infection
- Extreme fatigue
- Musculoskeletal complaints or pain
- Overheating
- Phlebitis
- Diastasis recti
- Uterine contractions

Suggested Sequence for Obstetric Aerobic Exercise Class

- Warm-up activities
- Gentle selective stretching exercises
- Aerobic activity for cardiovascular conditioning (15 minutes or less)
- Upper and lower extremity strengthening
- Cool-down activities

Biophysical Agents and Modalities: Indications and Applications

Table 3-35 Biophysical Agents and Modalities: Indications and Applications[11]

Physical Agent/Modality	Indications	Applications
Therapeutic heat (hot moist pack [HMP])	Joint stiffness; musculoskeletal pain and muscle spasm; preparation for electrical stimulation and massage; subacute, chronic, and traumatic conditions	The HMP is placed in a terry cloth cover and wrapped in six to eight layers of dry towels; it is then placed on the patient's treated area. Another towel is placed over the hot pack to minimize heat loss. The HMP must be secured well to the patient using towels, pillows, or straps if necessary. If the patient is lying on the HMP, additional towels (more than eight layers) are necessary. The PTA monitors the patient's treated area after 5–10 minutes of HMP application. The patient receives a call bell to alert the PTA of any sensory changes.[11]
Whirlpool	Wound care; wound debridement; postsurgical orthopedic conditions such as for hip, knee, and ankle; subacute and chronic musculoskeletal conditions; rheumatoid arthritis (RA)	The PTA assists the patient in immersing his or her body or body part into the whirlpool tank. The PTA uses towels to pad any pressure points and minimize compression on the tank edges. The PTA adjusts the agitator for position, force, direction, depth, and aeration. The PTA monitors the patient's response and tolerance to treatment. Patients who have most of the body immersed in the whirlpool (such as in a Hubbard tank) need close monitoring. The patient may also need a cold compress (and a cool drink). Insert a tank liner for patients with hepatitis and open wounds, burns, and HIV. Hubbard tank: Closely monitor the patient's physiological responses. Temperatures: limbs = 103–110°F; open wound = 92–96°F; multiple sclerosis (MS) = 88°F; peripheral vascular disease = 95–100°F.[11]

(*continues*)

Table 3-35 Biophysical Agents and Modalities: Indications and Applications (continued)

Physical Agent/Modality	Indications	Applications
Paraffin bath	Subacute and chronic inflammatory conditions such as RA, OA, joint stiffness, hand contracture, or scleroderma	Glove method: The PTA washes the patient's hands (or feet) prior to treatment. The PTA inspects the patient's hands (or feet) for infection, wounds, or cuts. The patient's sensation and heat tolerance are assessed. The patient is instructed not to touch the sides or bottom of the paraffin container and to avoid movements that could crack the paraffin. The patient is instructed first to dip the treated part into paraffin, creating a higher first layer of paraffin. Then other layers lower than the first one will follow. The patient is instructed to dip the treated part in paraffin until 6–12 layers have formed. The PTA wraps the treated part in plastic and towels.
Aquatic therapy	Relaxation and improvement of circulation; muscle strengthening; gait training with decreased stress on weight-bearing joints; mobility training for RA, OA, joint replacements, MS, and paraplegia	The patient needs to shower before immersion in the water. The type of water activity and duration of treatment depend on the patient's tolerance. General pool temperature = 92–98°F; MS = 84°F; spasticity (20–45 minutes) = 86–94°F; RA/OA (10–20 minutes) = 96.8–98.6°F.
Ultraviolet (UV) radiation	Acne; subacute and chronic psoriasis; decubitus ulcers; infected wounds	Dependent on the MED test and types of UV lamps. MED = smallest UV exposure time to produce faint erythema 8 hours postexposure. MED subsides within 24 hours. First-degree erythema is 2.5 the MED (appears 6 hours after exposure). It presents with definite redness with desquamation, and lasts for 1–3 days. Second-degree erythema is 5.0 times the MED (appears 2 hours after exposure). It presents with intense erythema with edema and peeling, with an appearance similar to that seen with severe sunburn. Third-degree erythema is 10.0 times the MED. It appears after the exposure test as erythema with severe blistering, peeling, and exudation. Treatment time = proportion of the MED.

Table 3-35 Biophysical Agents and Modalities: Indications and Applications (continued)

Physical Agent/Modality	Indications	Applications
Ultrasound (US): thermal US (TUS); pulsed US (PUS); phonophoresis	Thermal US: joint contractures; muscle spasm; musculoskeletal pain; subacute and chronic traumatic and inflammatory conditions; prior to stretching shortened soft tissue; reduction of pain. Pulsed US: tissue healing of dermal ulcers, surgical skin incisions, tendon injuries, bone fractures; acute conditions (where thermal US is contraindicated).	Can be applied via either direct contact or indirect contact using water (or a balloon). Deeper tissues (2.5–5 cm) need 1 MHz frequency. Less deep tissues (1–2.5 cm) need 3 MHz frequency. The PTA places the transducer parallel to the patient's skin, moving it in a slow circular pattern. The transducer is always in firm contact (but not heavy) with the patient's skin. The transducer must not be held in the air (without skin contact) when the US unit is on. For TUS periosteal pain: Decrease intensity; increase treatment surface area. For TUS "hot spot:" Apply more coupling agent; decrease intensity; keep the transducer moving. Use a plastic container for US in the water (the transducer must be 0.5–1 inch from the patient's skin). TUS intensity = 0.2–3.0 W/cm^2. PUS intensity = 0.2–1.0 W/cm^2. Treatment time TUS/PUS = 5–10 minutes per treated area. PUS duty cycles: 10%, 20%, and 50%. Phonophoresis: Applied direct-contact continuous-mode TUS or direct-contact pulsed-mode PUS. Apply US gel and the medication. Do not whip medication into an US gel (air can be trapped in the mixture, decreasing transmission of US). Phonophoresis intensities: direct-contact continuous mode = 1.0–2.0 W/cm^2; direct-contact pulsed mode = 0.5–0.75 W/cm^2 (20% duty cycle).[12]
Fluidotherapy	Subacute and chronic musculoskeletal conditions such as RA, OA, muscular pain, reflex sympathetic dystrophy; any other disorder where it promotes desensitization of hypersensitive tissues	Cover with a plastic barrier: open wounds; lesions. Safe to use with patients having splints, bandages, tape, metal implants, artificial tendons, or plastic joint replacements. Procedure: The PTA places the UE in a sleeve (of the machine) or the LE over the treatment slot. The PTA sets the desired temperature and turns the unit on. The PTA adjusts agitation of the cellulose (or silicone) particles to the desired effect and the patient's tolerance. The PTA instructs the patient in stretching or strengthening exercises during treatment. For desensitization, the PTA monitors the patient's response to treatment. Treatment time = 15–20 minutes.

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Table 3-35 Biophysical Agents and Modalities: Indications and Applications (continued)

Physical Agent/Modality	Indications	Applications
Diathermy: short wave (SW); microwave (MW)	Same as thermal US for thermal effects of SW/MW diathermy. Nonthermal or pulsed SW diathermy: wound care to decrease pain and edema, to increase oxygen to the tissue, and to increase muscle, bone, and nerve tissue repair by stimulation of protein synthesis at the tissue cell level	Check patient often during treatment—the treated area is not visible. SW diathermy delivers a thermal or pulsed electromagnetic field. Typical SW frequency = 27.12 MHz. • SW diathermy-treated area as part of the electrical circuit method: The patient's body part is placed between two conducting electrodes for 15–30 minutes. • SW inductive field method: The patient's body part is placed in a magnetic field of electrodes and current is induced within the patient's body tissues (that are not part of circuit). Tissue resistance to the current produces an increased temperature in the deep body tissues. • MW diathermy applied using electromagnetic radiation directed through a coaxial cable to an antenna mounted in the treatment applicator. Caution when using MW diathermy: When energy is reflected at fat/muscle and muscle/bone interfaces, it can increase superficial tissues' temperatures (skin or fat). Treatment time MW diathermy = 15–30 minutes.
Therapeutic cold: cold pack (CP); ice pack (IP); ice massage with ice cube (IC)	CP/IP: acute and chronic traumatic and inflammatory conditions; edema; muscle spasm; musculoskeletal pain; thermal burns. Ice massage with IC: small areas of muscle guarding; muscle spasm; acute injuries to decrease pain, edema, and hemorrhage.	First treatment: Monitor adverse effects (such as urticaria; facial flush; anaphylaxis; call EMS for anaphylaxis). Patient's normal response to ice: cold, burning, aching, and numbness (CBAN). • A CP wrapped in a warm moist towel is placed on the patient's treated area; place two to three dry towels over the CP. Secure the CP to the patient with elastic bandages or towels. The PTA monitors the patient's treated area visually after 5 minutes. The patient receives a call bell. The patient should not lie on the CP. Treatment time = 10–20 minutes. • IP treatment is the same as CP treatment except the IP should be placed in dry towels. • The IC for ice massage must be round without sharp edges. It is applied in overlapping circles or overlapping longitudinal strokes, with each stroke

Table 3-35 Biophysical Agents and Modalities: Indications and Applications (continued)

Physical Agent/Modality	Indications	Applications
		covering half of the previous stroke. Treated area = 4 inches by 6 inches. The PTA should not do ice massage over bony area or superficial nerves (such as the peroneal nerve in the lower leg). The PTA uses a towel to wipe the excess water as it melts on the skin. Treatment time = 5–10 minutes.
Contrast bath	Peripheral vascular disease; impaired peripheral blood circulation in the limbs; sprains and strains; edema; acute trauma	Check water temperature: Hot (warm) = 100–110°F; cold = 55–65°F. Select water based on the patient's condition: PVD = 105°F hot and 65°F cold; open wounds = add disinfectant. Prepare two pails of water. The PTA first immerses the patient's treated limb in hot water for 6–10 minutes. The PTA then transfers the patient's treated limb to cold water for 1 minute. The PTA transfers the patient's treated limb to hot water again for 4 minutes. The PTA continues this sequence of immersion for 20–30 minutes. The PTA ends the treatment in hot water (the patient's condition determines whether the treatment ends in hot or cold water). For edema or acute sprains/strains, it is more beneficial to end in cold water.
Therapeutic massage[12]	Subacute and chronic pain; muscle spasm; superficial scar formation and adhesions from trauma or burns; edema; postural drainage. Deep transverse friction can help to effect collagen fiber orientation in wound healing.	Effleurage: The PTA's hand is molded over the patient's body part, and movement is distal to proximal. Pétrissage is grasping, lifting, squeezing, or pressing of tissues (compression for sports massage). Friction is performed by rubbing one surface repeatedly over another surface. Deep friction is used to stretch scar tissues and loosen adhesions (cross-fiber friction consists of deep strokes across the direction of the muscle fibers; deep transverse friction is a specific cross-fiber friction applied to the site of a granulated wound for scar formation). Tapotement is a series of brisk percussive movements following one another in a rapid, alternating manner (hacking, cupping, slapping, tapping, and pincement). Cupping is applied to the chest to mobilize bronchial secretions in pulmonary physical therapy. Vibration is an oscillating, trembling motion performed rapidly and repeatedly for postural drainage to loosen adherent secretions.

(*continues*)

Table 3-35 Biophysical Agents and Modalities: Indications and Applications (continued)

Physical Agent/Modality	Indications	Applications
Intermittent compression	Chronic edema; lymphedema (after mastectomies); venous stasis ulcer; traumatic edema; venous insufficiency; amputation	The PTA takes the patient's BP. The patient is positioned comfortably with the UE or LE abducted between 20° and 70°, and elevated at approximately 40°. Before application of compression sleeve, a stockinette is put on, with the PTA removing all the wrinkles in the fabric. The compression sleeve is applied and the rubber tubing is attached to the sleeve and the pump. Set three parameters: inflation pressure (to be set below the patient's diastolic BP), inflation and deflation time (to be set at a ratio of 3:1, inflating for 80–100 seconds. and deflating for 25–35 seconds), and total treatment time (2–3 hours). For amputation, inflate the sleeve for 40–60 seconds and deflate it for 10–15 seconds. Lymphedema requires a treatment time of 2- to 3-hour daily sessions; venous stasis ulcer requires treatment lasting for 2.5 hours, three times per week.
Electrical stimulation (ES): HVPC; NMES; FES; IFC[12]	Decrease muscle spasm using (1) tetanic contractions to fatigue the muscle, (2) a muscle pump effect to obtain rhythmic contraction and relaxation of the muscle, and (3) a muscle pump effect using ultrasound with electrical stimulation to increase muscle tissue temperature and obtain a pumping effect; increase or maintain joint ROM by decreasing joint pain and edema; increase muscle strength through muscle reeducation exercises; repair of the soft tissue in wound healing; decrease edema; decrease spasticity; denervated muscle. Interferential current (IFC): pain relief; muscle relaxation; edema control; increased circulation; tissue and bone healing.	High-voltage pulsed current (HVPC): • Acute-stage edema control: frequency of 120 pps, continuous mode, with pulse between 20–100 msec for 30 minutes, four times per day. It has a long-lasting effect. • Postacute edema control: frequency of less than 20 pps, with a duty cycle of 2–10 seconds on and 2–10 seconds off, for 15–60 minutes, 2–3 times per week. It has a muscle pumping effect. • Wound healing: negative polarity for bactericidal effect; positive polarity for wound closure. A gauze pad with sterile saline solution is applied first over the wound; a small active electrode is attached to gauze (dressing); a large dispersive electrode is placed ipsilateral, proximal to wound. Neuromuscular electrical stimulation (NMES) • Muscular strengthening and reeducation (Russian stimulation) achieved using isometric muscular contractions: frequency between 50 to 80 pps; duty cycle = 1:5; treatment time = 10–30 minutes.

Table 3-35 Biophysical Agents and Modalities: Indications and Applications (continued)

Physical Agent/Modality	Indications	Applications
		• Muscular endurance: frequency of 30–50 pps; duty cycle is 6–15 seconds on and 6–15 seconds off; treatment time = 5–20 minutes and up to several hours per day. • Spasticity: ES applied to the antagonist of the spastic muscle; frequency = 30–50 pps; duty cycle of 2–10 seconds on and 2–10 seconds off; treatment time = 10–30 minutes, two times per day. • For peripheral circulation: frequency of 50–200 pps; treatment time = 20–60 minutes. • Stimulation of denervated muscle: controversial. Functional electrical stimulation (FES): • Most common use is to control for foot drop. • Ankle dorsiflexors and evertor muscles during the swing phase of gait: frequency of 30–50 pps, with a duty cycle of 6–15 seconds on and 6–15 seconds off. AC carrier must have frequency of 2,500 Hz. Interferential current (IFC) • Pain relief: four electrodes placed diagonally to one another over large areas of treatment; frequency = 80–100 pps. • Circulation and edema control: two-electrode placement over or around small areas of treatment; frequency = 20–40 pps. • For circulation through muscle contraction: frequency of 35–50 pps and pulse duration of 125–200 msec. Application of ES • PTA checks that all controls are at zero before turning on device. • The PTA can shave the patient's hair on top of the treated skin or can rub alcohol on the skin to reduce the amount of skin oil.

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Table 3-35 Biophysical Agents and Modalities: Indications and Applications (continued)

Physical Agent/Modality	Indications	Applications
		• The PTA selects two or four electrodes for size. The PTA prepares and places the electrodes on the patient's area that needs to be treated. The space between two electrodes must be at least the diameter of one electrode. The PTA secures the electrodes to the patient's treated area. • The PTA sets the appropriate frequency, waveform, and modulation rate. The PTA adjusts intensity to achieve optimal treatment effects. • After 3–4 minutes of treatment, the PTA needs to slightly increase the intensity due to the patient's accommodation. • At the end of the treatment, the PTA slowly decreases the intensity to zero before lifting the electrodes from the treated area. • The PTA turns all controls to zero.
Iontophoresis	Neuritis; bursitis; musculoskeletal inflammatory condition; calcific tendonitis; muscular relaxation; softening of scar tissue and adhesions; reducing calcium deposits; decreasing edema; skin conditions such as ischemic ulcers, hyperhydrosis, and fungal infections	Check for intact skin; no scratches or abrasions. Use negative medication for the (–) electrode and positive medication for the (+) electrode; use low levels of current intensity for the (–) electrode; the (–) electrode must be twice as large as the (+) electrode. Alkaline chemical reactions caused by negative polarity are stronger than acidic reactions. Carrier frequency = 2,500 Hz or 4,000 Hz. The electrical wave form is DC (monophasic, continuous current). Recommended dosage for the positive electrode is 1.0 mA/cm^2 and for the negative electrode is 0.5 mA/cm^2. The current must be started, terminated, or interrupted slowly, never abruptly. The current intensity must be lower than 4.0 mA. The treatment time varies from 10 to 40 minutes depending on the medication dose. For example, if the current intensity of 4.0 mA is comfortable for the patient and a dosage of 80.0 mA/min of dexamethasone is applied, this dexamethasone dosage can be delivered in 20 min ($4 \times 20 = 80$). The PTA observes the treated area every 3–5 minutes, staying alert to any adverse reactions. Negative medications: dexamethasone, acetate, salicylate (DAS). Positive medication most typically used: lidocaine.

Table 3-35 Biophysical Agents and Modalities: Indications and Applications (continued)

Physical Agent/Modality	Indications	Applications
Transcutaneous electrical nerve stimulation (TENS): conventional TENS; acupuncture-like or strong low-rate TENS; point stimulation TENS	Pain management and pain modulation through activation of the gate control theory and the endogenous opiate theory	Patient education for use of TENS units: Not to be used in shower or when sleeping; electrode placement; skin inspection-skin irritation; checking adherence of electrodes to the skin; accommodation to ES (the patient should contact the PT/PTA-modulation TENS). • Conventional TENS: frequency of 50–200 pps; pulse duration of 50–100 msec; uses gate theory mechanism; has fast pain relief; is short-lasting (approximately 1 hour). • Acupuncture-like or strong low-rate TENS: frequency of 1–20 pps. • Burst-mode TENS: frequency of 50–100 pps sent in bursts or packets of 1–5 pps. • Point stimulation TENS or neuroprobe for trigger points or acupuncture points: frequency of 1–5 pps. All nonconventional TENS technologies use the endogenous opiate theory, and all offer long-lasting pain relief TENS.
Traction: cervical; lumbar	Spinal nerve root impingement caused by herniated nucleus pulposus (HNP) or spinal stenosis; muscle spasm; spinal hypomobility; muscle inflammation; subacute and chronic joint pain; spinal pain	Cervical traction: Observe the patient for discomfort in the TMJ; adjust the head halter and ensure force is applied to the occipital region. When the treated segment is lower than C2, the cervical spine must be positioned in 20–30° of spinal flexion. For nerve root impingement, the cervical spine must be positioned in 15° of spinal flexion. The force of the traction should not exceed the weight of the patient's head. Start at 8–10 pounds (or 7% of the patient's head weight). Increase the force gradually up to 25–30 pounds. Research showed that the optimal force is 10 pounds. Maximum elongation occurs at 24° of spinal flexion. Treatment time = 5–10 minutes for HNP and 10–30 minutes for other technologies. Initially static force is given, and then intermittent force at 15 seconds on and 15 seconds off. Disc problems: use 60 seconds on and 20 seconds off; muscular spasm: use 5 seconds on and 5 seconds off.

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Table 3-35 Biophysical Agents and Modalities: Indications and Applications (continued)

Physical Agent/Modality	Indications	Applications
		Lumbar traction: Prone positions for posterior HNP. To increase L5–S1 space, use a small bench under the patient's lower legs (45–60° of hip flexion). Start with low-force traction-use a split table and 25% of the patient's body weight. Increase the force gradually to half of the patient's body weight (to effect intervertebral separation). Use of a split table decreases leg/pelvis friction. Treatment time for HNP = 5 minutes at first and then increase to 10 minutes; use 10–30 minutes for others. Initially, begin with static force, and then give intermittent force (joint distraction) of 15 seconds on and 15 seconds off. Muscle spasm: use 5 seconds on and 5 seconds off; disc problems: use 60 seconds on and 20 seconds off.
Electromyographic biofeedback (EMG biofeedback)	Muscle recruitment and strengthening in patients with peripheral nerve injury, muscle weakness caused by immobilization, joint surgery, pain, deconditioning, muscle spasticity, and reeducation of weak or flaccid muscle. Relaxation for chronic pain such as tension headaches, and chronic neck and back pain.	Patients receiving EMG biofeedback must have good vision, good hearing, excellent communication abilities, good comprehension of simple commands, good concentration, and motor planning skills. Bipolar technique: Two active electrodes are applied parallel to the muscle fibers at approximately 15 cm, over or near the motor points of treated muscles; a reference electrode is applied between active electrodes or closer to active electrodes. • To increase muscular strength of two or more weak muscles, the PTA places two active electrodes widely spaced. • To increase muscular strength of one weak muscle, the PTA places two active electrodes close together. Instrument sensitivity must be high for one or two or more weak muscles. The PTA instructs the patient to contract the muscle isometrically, holding the contraction for as long as possible (up to 10 seconds) to produce a tall and loud audiovisual signal. As the patient's motor recruitment improves, active electrodes must be placed closer together and instrument sensitivity decreased.

Table 3-35 Biophysical Agents and Modalities: Indications and Applications (continued)

Physical Agent/Modality	Indications	Applications
		• For relaxation, the PTA places two active electrodes closely spaced. Instrument sensitivity must be low. The PTA instructs the patient to relax and to lower the audiovisual signal; the PTA applies breathing or imagery exercises. As the patient is able to relax, instrument sensitivity must be increased and the patient should perform functional activities. Treatment time = first 5 minutes and then 10–30 minutes.

Therapeutic Massage Application

Table 3-36 Application of Therapeutic Massage[12]

1. When applying therapeutic massage to a specific anatomical region of the patient's body, the patient should be comfortable in a relaxed position.
2. The treatment part should be in a gravity-eliminated position or in a position in which the gravity assists the venous flow.
3. The patient's body part must be draped and well supported.
4. The PTA should start with light effleurage and then advance to deep effleurage and other types of stroking necessary in that specific intervention.
5. When using all forms of massage, deep effleurage is followed by pétrissage, then friction, and then tapotement, concluding with vibration and light effleurage.
6. Massage should begin in the proximal segments of the lower or upper extremity, move distally, and then return to the proximal region.
7. On the lower or upper extremity, all effleurage movements must be directed in a distal to proximal direction, especially for edema treatment.
8. Therapeutic massage treatment depends on the patient's tolerance and specific intervention.
9. Similar to other physical agents or modalities, therapeutic massage is a passive modality that should be used for a short period of time as an adjunct to—not a substitute for—active interventions such as therapeutic exercises and activities and patient education.

Orthotics

Table 3-37 Orthotics I: Orthopedic Shoes[13]

- For the patient (client) with orthopedic impairments and functional limitations, orthopedic shoes reduce pressure on sensitive deformed structures and are a foundation for ankle-foot orthoses (AFOs) and more extensive bracing.
- The most common orthopedic shoes:
  1. The Blucher lace stay: has a separation between anterior margin of the lace stay and the vamp; offers adjustability for edema.
  2. The Balmoral lace stay: the lace stay is continuous with the vamp.
  3. The low quarter-height shoe: below the malleoli; does not restrict foot or ankle motion.

(*continues*)

Table 3-37 Orthotics I: Orthopedic Shoes[13] (continued)

4. The high quarter-height shoe: covers the malleoli; indicated for rigid pes equinus or to increase stability without an AFO.
5. Shoes with reinforcements.
6. Shoes with special soles.
7. Shoes with high heels or low heels.

- Foot orthoses: appliances that apply forces to the foot.
  1. Can be soft inserts; made of viscoelastic plastics, rubber, rigid plastics, or metal.
  2. Longitudinal arch support (LAS): corrects for flat foot—pes planus.
     - Scaphoid pad: made of rubber; used under navicular bone
     - UCBL insert: applies medial force to calcaneus and lateral and upward force to medial midfoot
     - Thomas heel: corrects for pronated foot—flexible pes valgus
     - Metatarsal bar: takes pressure off metatarsal heads
     - Rocker bar: improves weight shift on metatarsals; helps in late stance
     - Shoe lifts: for leg-length discrepancy
     - Heel wedges: absorb forces at heel contact; alter alignment of calcaneus

Table 3-38 Orthotics II: Ankle-Foot Orthoses[13]

- Appliances made of a foundation, ankle control, foot control, and a superstructure:
  1. The foundation is made of a shoe and a plastic or metal component.
  2. The traditional foundation has a steel stirrup that can be solid stirrup (for maximum stability) or split stirrup (eases donning the orthosis).
- Types of AFOs:
  1. Solid ankle AFO: limits all foot and ankle motion; used for severe pain and instability; increases stride length and cadence in hemiplegia
  2. Hinged solid ankle AFO: similar to solid ankle AFO; provides slight sagittal motion for foot flat position in early stance; used for spastic diplegia in children
  3. Bichannel adjustable ankle locks (BiCAALs): an alternative to solid ankle AFO; resists PF and DF
  4. Ypsilon AFO: carbon composite AFO; provides assistance to DF; used for mild to moderate isolated foot drop
  5. Anterior stop AFO: limits ankle DF; prevents excessive knee flexion or "buckling"; helps in late stance of gait
  6. Posterior stop AFO: limits ankle PF; prevents knee hyperextension/recurvatum
  7. Posterior leaf spring AFO: provides DF assistance; used for foot drop
  8. Steel DF spring assist AFO-Klenzak joint: has DF spring assist in each stirrup; provides DF assistance; used for foot drop; bulkier than posterior leaf
  9. Toe off AFO: provides DF assistance; used for mild to severe food drop and instability
  10. Spiral AFO: controls but does not eliminate motion in all planes; fits snugly for maximal control; contraindicated for fluctuating edema
  11. Silicone ankle foot orthosis (SAFO): a contemporary AFO made of silicone for foot drop; provides a flexible dynamic function giving comfort and cosmesis for the foot and ankle; good for heel strike with a smooth transition to toe-off

Table 3-39 Orthotics III: Other Types of Orthoses[13]

- Floor reaction force orthosis: type of solid ankle AFO; resists knee flexion; provides a knee extension moment to control knee flexion in stance
- Tone-reducing orthosis: plastic AFO designed for spastic CP and spastic hemiplegia (applies constant pressure to plantarflexors and invertors); used for equinovarus and moderate spasticity with varus instability; patients achieve better foot and knee control; contraindicated in fixed deformity
- Supramalleolar orthosis: used for the ankle to maintain the foot in neutral alignment; allows ankle DF/PF; does not offer knee control; used for spastic diplegia
- Stabilizing boots AFO: custom-made AFO for paraplegia (used by adults); conforms to the patient's legs and feet; feet angled at 15° PF; legs angled posterior to keep knees extended; patient keeps stability by leaning backward; used with crutches or walker

Table 3-40 Orthotics IV: Knee–Ankle–Foot Orthoses[13]

- Knee–ankle–foot orthosis (KAFO): appliance made of a shoe, foundation, ankle control, and superstructure.
- The KAFO may include also foot control.
- The KAFO controls for knee flexion/extension and genu valgum and genu varum. It is used for paralysis or limb deformity.
- The most common knee flexion or extension control of a KAFO is the drop ring lock (may have spring-loaded retention buttons to unlock each upright; the pawl lock with bail release is used for simultaneous locking of uprights). The drop ring lock and pawl lock are contraindicated with knee flexion contracture.
- Sagittal stability of KAFO:
  - Leather kneecap
  - Rigid anterior band: made of plastic; can be suprapatellar or pretibial bands, which do not interfere with sitting; easier to don
  - Electronic stance control mechanism: newer; prevents knee flexion in stance without interfering with knee extension; permits knee flexion in swing
- Frontal plane knee control (for genu varum or genu valgum):
  - Plastic calf shells: semirigid shell for valgum applies lateral force at the knee; semirigid shell for varum applies medial force at the knee
  - Valgum correction strap: knee cap with a fifth strap buckled around lateral upright; less effective than semirigid shells
- Specialized KAFO: KAFO with computer controlled knee joint.
- Craig Scott KAFO: custom-made KAFO for paraplegia (used by adults). It includes a shoe reinforced with transverse and longitudinal plates.
- BiCAAL AFO set in slight DF; pawl lock with bail release; single thigh band: allows the patient to stand with a backward lean to prevent untoward hip or trunk flexion.
- Walkabout orthosis: custom-made pair of KAFOs permitting hip flexion and extension and restricting hip abduction, adduction, and rotation.

Table 3-41 Orthotics V: Hip-Knee-Ankle-Foot Orthoses, Trunk–Hip–Knee–Ankle–Foot Orthoses, Reciprocating Gait Orthoses, and Standing Frames[13]

- Hip–knee–ankle–foot orthosis (HKAFO): KAFO with added pelvic band and hip joints. The HKAFO controls for hip abduction, adduction, rotation, and flexion. To reduce internal or external rotation, you can use a strap. To reduce flexion, a drop ring lock can be added.
- Trunk–hip–knee–ankle–foot orthosis (THKAFO): HKAFO with a metal band to anchor the trunk. The THKAFO is not widely used because it is difficult to don, the metal band is uncomfortable, and it restricts ambulation in swing to or swing through (when the hip joints are locked).
- Reciprocating gait orthosis (RGO): custom-made THKAFO. The hips are joined by one or two metal cables or rods, the knees are stabilized with knee locks (offset knee joints or pretibial bands), and the feet are stabilized with solid AFOs. The RGO is used for bilateral lower extremities and trunk paralysis. The patient can walk with crutches (using a four- or two-point gait) by shifting his or her weight to the right, tucking the pelvis (by extending the upper thorax), pressing on the crutches, and allowing the left leg to swing through. The reverse procedure follows for the right leg to swing.
- Standing frames: for standing without crutches. It is used by children and adults.
- Swivel walker: for standing and twirling without crutches. It is used by children and adults. Swivel walkers are similar to standing frames except for the slightly rocking base to enable a swiveling gait.
- Parapodium: for standing and performing activities without crutches; allows sitting. It is used by children and adults. Children can also move from place to place by rotating the upper torso to shift their weight, causing the frame to rock and rotate.

Table 3-42 Orthotics VI: Corsets, Lumbosacral Orthoses, and Thoracolumbosacral Orthoses[13]

- Corset: used for low back musculoskeletal disorders, sacroiliac support, and SCI (assists with respiration). The corset increases intra-abdominal pressure but reduces frontal movement. The increase in the intra-abdominal pressure reduces stress on the posterior spinal musculature, diminishing the load on the lumbar intervertebral discs.
- Lumbosacral orthoses (LSOs): control or limit flexion, extension, and lateral control. The LS flexion extension lateral control orthosis (LS FEL; e.g., Knight spinal orthosis) controls flexion, extension, and lateral flexion. An alternative version of LS FEL is used for spondylolisthesis (controls extension). Use of an LS FEL for low back pain is controversial. A plastic LS FEL jacket restricts motion in all directions.
- Thoracolumbosacral orthoses (TLSOs): limit flexion and extension (and gross spinal movement). The amount of movement permitted by a TLSO varies from one person to another. Examples include TLSO flexion/extension devices (e.g., Taylor brace), which may be used for SCI.

Table 3-43 Orthotics VII: Cervical Orthoses, Scoliotic Curves Orthoses, and Externally Powered Orthoses[13]

Cervical Orthoses

- Soft foam-rubber collar: may be used for whiplash; gives minimal support
- Four-poster orthosis: may be used for cervical fracture and SCI; gives moderate support
- Halo orthosis or Minerva orthosis: may be used for cervical fracture and SCI; gives maximal support

Scoliotic Curves Orthoses

- Cervical thoracic lumbosacral orthosis (CTLSO) such as the Milwaukee (the oldest orthosis for scoliosis): may be used for all kyphotic and scoliotic curves of 40° or less.
- Boston TLSO: used for midthoracic or lower scoliosis of 40° or less curves; also used for spondylolisthesis and conditions with severe trunk weakness such as muscular dystrophy.
- Wilmington TLSO: has tight contact and fit; is custom made.
- Charleston bending brace and Providence brace: to wear only at night when the effects of gravity are at a minimum; provide overcorrection of the spinal curve.

Table 3-43 Orthotics VII: Cervical Orthoses, Scoliotic Curves Orthoses, and Externally Powered Orthoses (continued)

Externally Powered Orthoses

- Pneumatic foot control and functional electrical stimulation (FES): enable patients to ambulate in their residences or in the community (in rare cases).
- FES uses electrical stimulation (ES) to the quadriceps and gluteus maximus. The peroneal nerves may also use ES (to initiate DF and reflex hip flexion) if the ankles are not supported by bilateral AFOs.
- To use the FES, the patient (client) needs full passive mobility in all joints and to be able to control the timing and the amount of electrical current to transfer from a chair to the standing position and to walk in different directions.

Orthotic Interventions

Table 3-44 Orthotic Interventions

Patient education for skin inspection, orthosis care, and donning/doffing the orthosis

- AROM, PROM, and static and dynamic balance and gait training using the orthosis
- Assessments or reassessments:
  - Assessment of the discrepancy of limb length
  - Assessment of sensation
- Functional activities using the orthosis:
  - Traditional MMT for muscle function if permitted
  - In cases of spasticity, functional tests of motor performance
- Assessment and reassessment of gait deviations using the orthosis-examples of common gait deviations and possible causes:
  - Lateral trunk bend in early stance: caused by a too-high medial upright of the KAFO; excessive abduction of the hip joint by the HKAFO; patient requires a cane; insufficient shoe lift; weak gluteus medius; abduction contracture; hip pain; poor balance; short leg
  - Circumduction during swing: caused by knee lock; excessive PF; inadequate PF stop; inadequate DF assist; weak hip flexors; extensor synergy; weak dorsiflexors; pes equinus; knee or ankle ankylosis
  - Hyperextended knee in early stance: caused by inadequate PF stop or knee lock; pes equinus; weak quads; extensor synergy; short contralateral LE; contralateral knee or hip flexion contracture
  - Knee instability in early stance: caused by too much knee flexion; inadequate knee lock; inadequate DF stop; weak quads; knee pain; knee or hip flexion contracture; flexor synergy; short contralateral LE
  - Foot slap in early stance: caused by weak DF; inadequate dorsiflexor assist; inadequate plantarflexion stop
  - Flat foot contact during early stance: caused by inadequate DF stop; inadequate traction from the sole; patient requires a cane; poor balance; pes calcaneus
  - Anterior trunk bending in early stance-leans forward as weight is transferred to LE: caused by inadequate knee lock; weak quads; hip and knee flexion contracture
  - Posterior trunk bending in early stance-leans backward as weight is transferred to LE: caused by inadequate hip lock; knee lock; weak gluteus maximus; knee ankylosis
  - Hip hiking in swing: caused by knee lock; inadequate DF stop; inadequate PF stop; short contralateral LE; weak hip flexors; extensor synergy; weak dorsiflexors; pes equinus; knee and ankle ankylosis
  - Vaulting (exaggerated PF of contralateral LE) in swing: caused by knee lock; inadequate DF and PF assist; weak hip flexors; pes equinus; extensor spasticity; short contralateral LE; weak dorsiflexors; knee or ankle ankylosis

Transtibial (Below Knee) Prostheses

Table 3-45 Below-Knee Amputation Prostheses[13]

- Foot and ankle assembly: nonarticulated feet that are light in weight, durable, attractive, and most popular. Types of nonarticulated feet:
  - Solid ankle cushion heel (SACH) foot: simple design; least cost; lowest function; permits PF in early stance; absorbs shock; hyperextends in late stance
  - Stationary attachment flexible endoskeleton (SAFE) foot: good on uneven terrain; permits medial-lateral motion in the rear foot; heavier and more expensive than SACH
- Foot and ankle assembly: articulated feet that have a metal bolt or cable; are shock absorbent; control plantarflexion; have dorsiflexion stop; can loosen over time. Types of articulated feet:
  - Single-axis feet: most common; permit PF, DF, and toe break; do not allow medial-lateral or transverse motion. Single-axis feet may use rotators-components placed above the prosthetic foot to absorb shock in the transverse plane; rotators are used with active individuals who had transfemoral amputations.
  - Multiple-axis feet: move slightly in all planes for maximum contact with an irregular walking surface; reduce shearing forces on residual limb; heavier and less durable than single-axis or nonarticulated feet
- Other types of foot and ankle prosthetic componentry:
  - Energy storing, dynamic elastic response
  - Energy storing with multiaxial features
  - Energy storing with vertical shock pylon
- Energy-storing and dynamic-response feet have internal structures that absorb energy during the stance and release energy at toe-off. They provide a smoother and more energy-efficient gait, and are extremely lightweight and durable. Examples of energy-storing dynamic response feet: Flex Foot, Springlite Foot (weighs less than 11 ounces; has shock absorption and smooth transition to midstance and toe-off), Seattle Foot, and Carbon Copy II foot (energy-storing and energy-releasing or dynamic feet; can be used to play basketball or to run).
- Exoskeletal and endoskeletal shanks-substitutes for human leg:
  - Exoskeletal shank: made of wood or rigid plastic.
  - Endoskeletal shank: made of aluminum or rigid plastic pylon covered with foam rubber and a sturdy stocking or similar finish. The pylon permits slight adjustment.
- Transtibial socket-plastic receptacle for the amputated foot:
  - Below-knee amputation (BKA) requires a patellar tendon-bearing (PTB) socket (has a prominent indentation over patellar tendon). Newer BKA sockets are hypobaric (with total surface bearing; no indentation).
  - Sockets are custom made through computer-aided design (CAD) or computer-aided manufacture (CAM). An electronic sensor transmits a detailed map of the limb to a computerized program consisting of socket-shaped variations. The prosthetist selects the appropriate shape and transmits it to an electronic carver, which creates the model; the plastic is then shaped over the computer-generated model.
  - Sockets have "reliefs," which are concavities over sensitive areas such as bony prominences. Sockets can be unlined, made of thin thermoplastic with removable liners (polyethylene foam liners). "Buildups" are convexities in the socket over pressure-tolerant areas. Transtibial socket usually has a removable polyethylene foam liner. Other sockets made of thin thermoplastic in a rigid frame can be unlined. These types of sockets adhere to the skin better than rigid plastic sockets, improving prosthetic suspension. Plastic sockets or socket liners should be washed to keep them clean, especially in warm climates.
- Suspension—to hold the prosthesis in place:
  - Supracondylar cuff suspension increases medial lateral stability of the prosthesis. Modern transtibial prostheses use a supracondylar cuff suspension made of leather, which allows the patient (client) to adjust the tightness of the suspension. A suspension cuff with a fork strap or a waist belt is indicated for patients (clients) who climb ladders or perform long-duration activities when the prosthesis is not supported on the ground.

Table 3-45 Below-Knee Amputation Prostheses[13] (continued)

- Supracondylar/suprapatellar (SC/SP) suspension has a high anterior wall that terminates above the patella, accommodating a short amputated limb. The anterior wall interferes with kneeling and is not cosmetically appealing in sitting.
- Patients with sensitive skin may need thigh corset suspension. Prolonged use of a thigh corset suspension may produce pressure atrophy of the thigh, and the device is difficult to don.
- Vacuum-assisted socket suspension promotes fluid exchange, increases proprioception, reduces moisture, and regulates edema fluctuations.

Transfemoral (Above Knee) Prostheses

Table 3-46 Above-Knee Amputation Prostheses[13]

- Foot and ankle assembly: the same as transtibial prostheses. A SACH foot or single-axis foot is used the most.
- Knee unit: allows the user to bend the knee. It is made of an axis (single-axis hinge or polycentric linkage that has better stability), a friction mechanism (can have constant or variable friction), an extension aid (assists with knee extension in the late swing phase of gait; can be external in front of the knee axis and internal within the knee unit), and mechanical stabilizers (manual lock; friction brake).
  - The knee unit uses a constant-friction (remains the same) or variable-friction (friction changes with high friction in the early swing phase of gait, less friction in the midswing phase of gait, and increased friction again in the late swing phase of gait) mechanism. The friction can be applied through sliding of the clamp (least expensive), hydraulically (using oil), or pneumatically (using air).
  - Hydraulic and pneumatic friction units are the best because they allow symmetrical movements. A newer type of friction knee unit uses computer-programmed electronic sensors that provide almost-instantaneous friction adjustments in gait patterns, accommodating navigation of various terrains and bicycle riding.
  - Knee extension mechanisms: external aids (made of elastic webbing; most simple; may pull knee in extension while sitting) and internal extension aids (elastic strap or coiled spring; keeps knee flexed when sitting; included in pneumatic/hydraulic units).
  - Stabilizing mechanisms: manual lock (when the pin lock is engaged, it prevents knee flexion; most simple; need to disengage pin lock in sitting) and friction brake (one version in clamp sliding allows knee flexion to 25°; another version in hydraulic units stabilizes better).
  - Types of computer-programmed electronic sensors for the knee unit: Rheo Knee (uses a knee's microprocessor to adjust resistance during the stance; maintains knee stability on uneven terrain; uses a lithium battery) and C-Leg (uses computerized sensors and hydraulic pistons; useful for stepping down out of a vehicle and descending curbs, ramps, or stairs).
- Transfemoral socket: quadrilateral socket (with a horizontal posterior shelf for ischial tuberosity and gluteal muscles) and ischial containment socket.
  - Transfemoral sockets are made of flexible plastic (provides sensory input from external objects) enclosed in a rigid frame that transmits weight to the ground. Concave "reliefs" are made for pressure-sensitive areas and to allow contraction of the gluteus maximus and rectus femoris.
  - An ischial containment socket (also known as a contoured adducted trochanter-controlled alignment method [CAT-CAM] socket) increases the entire transfemoral socket stability. Slight socket flexion allows hip extensors' contraction to reduce lumbar lordosis for equal step length. An example of CAT-CAM is the Comfort Flex Socket System (also called the Hanger Comfort Flex Socket) combined with the Otto Bock C-Leg. This AKA prosthesis uses a microprocessor-controlled hydraulic knee with swing and stance control. It accommodates navigation of uneven surfaces, stairs, slopes, biking, running, dancing, and golfing.
- Suspension:
  - Total suction: provides maximum control of the prosthesis
  - Partial suction: requires one or more socks or a silicone liner
  - No suction: has a distal hole; no pressure between inside and outside the socket; requires a pelvic band

Prosthetics: Levels of Amputation

Table 3-47 Levels of Amputation

- Toe disarticulation: amputation at the metatarsal phalangeal joint
- Transmetatarsal: amputation through the midsection of all metatarsals
- Symes ankle disarticulation with attachment of heel pad to distal end of tibia: may include removal of tibial and fibular flares and both malleoli
- Transtibial amputation: below-the-knee amputation (BKA)
  - Short BKA: less than 20% of tibial length
  - Long BKA: more than 50% of tibial length
  - Standard BKA: between 20% and 50% of tibial length
- Knee disarticulation: amputation through the knee joint (femur is intact)
- Transfemoral amputation: above-the-knee amputation (AKA)
  - Short AKA: less than 35% of femoral length
  - Long AKA: more than 60% of femoral length
  - Standard AKA: between 35% and 60% of femoral length
- Hip disarticulation: amputation through the hip joint (pelvis is intact)
- Hemipelvectomy: resection of lower half of pelvis
- Hemicorporectomy: amputation of both lower extremities and pelvis (below L4–L5 level)

Prosthetics: Pressure-Tolerant and Pressure-Sensitive Areas

Table 3-48 Prosthetics: Pressure-Tolerant and Pressure-Sensitive Areas

Pressure-Tolerant (Buildup) Areas	Pressure-Sensitive (Relief) Areas
BKA	**BKA**
Patellar tendon	Fibular head and neck
Proximal and medial tibia (at pes anserinus)	Anterior tibial crest
Tibial and fibular shafts	Tibial condyles
Belly of gastrocnemius	Anterior distal tibia
Medial and lateral hamstring tendons	
AKA	**AKA**
Ischial tuberosity	Distolateral end of femur
Gluteals	Pubic symphysis
Lateral sides of residual limb	Perineal area
Distal end (rarely may be sensitive)	Adductor longus tendon

Prosthetic Wearing Schedule Patient Education[14]

Table 3-49 Prosthetics: Wearing Schedule Recommendations

Days 1-2	1/2 hour in morning, monitor fit, check for excessive areas of pressure
	Allow some ambulation with prosthesis on
	Repeat 1/2 hour in the evening, monitoring fit and areas of pressure
Days 3-4	Increase morning and evening wearing time to 1 hour each session
	Allow some ambulation
	Monitor fit and areas of pressure

Table 3-49 Prosthetics: Wearing Schedule Recommendations (continued)	
Days 5-10	Increase morning and evening wearing time to 2 hours each session
	Allow some ambulation
	Monitor fit and areas of pressure
Days 11-14	Don prosthesis on first thing in the morning
	Check skin for pressure areas before lunch, if no adverse response
	Continue to wear prosthesis and perform skin check before dinner
	If no skin concerns, resume wearing the prosthesis until bed time, making sure to check skin for areas of pressure upon removal of prosthesis for the night
Days 14 +	If no adverse issues have been experienced the prosthesis may now be worn on a full time basis.
	Continued monitoring for prosthetic fit and areas of pressure should be done at least once per day by the wearer or a family member to ensure no adverse responses are resulting from prosthetic use

Prosthetic Interventions

Table 3-50 Prosthetic Interventions

Functional Interventions
- Bed mobility
- Transfers
- ADLs
- Gait training with prosthesis and assistive device (such as crutches and walker for balance deficits)
- Wheelchair training
- Mobility without prosthesis (for use at night)

Residual Limb Care
- Use of removable rigid dressing and temporary prosthesis: both help with early ambulation
- Residual limb wrapping: using elastic bandages and figure-of-eight technique
- Use of shrinker: easier to apply than elastic bandages
- Prevention of contracture: positioning the patient prone as much as possible during the day and attaching a posterior board to the wheelchair in sitting; to avoid knee flexion, and hip flexion, abduction, and ER

Patient Education
- Care of residual limb: including desensitizing activities, hygiene, and bandaging of residual limb
- Care of the uninvolved extremity
- Proper positioning
- Exercises
- Education about edema, pain, and changes in skin color
- Phantom limb: normal
- Phantom pain: abnormal and disabling
- HEP

Therapeutic Exercises
- Individualized
- AROM
- Stretching: for hip and knee extensors
- Strengthening: AKA needs strength in residual hip extensors and abductors mostly; BKA needs strength in residual knee extensors and flexors mostly
- Balance and coordination training

(*continues*)

Table 3-50 Prosthetic Interventions (continued)

Balance and Coordination Training

- Can start at parallel bars, especially for patients with AKA prostheses (because it is difficult to control the mechanical knee)
  - Some clinicians prefer not to use parallel bars because patients pull on them. When using parallel bars, encourage the patient to rest the hand on bars and not to grip on it hard.
  - For patients who grip on parallel bars, use a sturdy mat platform table to start balance training with standing posture (equal weight bearing and without excessive lordosis). The PTA should stand near the patient's prosthesis to encourage the patient to shift his or her weight symmetrically and in stepping movements (may use a mirror for visual feedback).
- Static balance training is performed on the amputated side
- The prosthetic tolerance must increase gradually to minimize skin abrasion
- Patient to exercise while standing and performing hip flexion (causes the knee to bend)
- Patient to perform hip extension (stabilizes the knee in stance)
- Patient stepping on a low stool with involved and uninvolved LE (causes to shift weight symmetrically)

Transfer Training

- Patient to start with wheelchair (with armrest) to transfer to another wheelchair (patient to transfer weight to uninvolved LE first, then to push on armrests to stand)
- Later practice transfers from wheelchair to mat and back, wheelchair to sofa (deep upholstered) and back, wheelchair to low chair and back, wheelchair to toilet and back, and wheelchair to automobile and back (patient to sit sideways with both feet out of the car door, then to pivot on the seat and swing the prosthesis into the car)

Gait Training

- Gait: progression from dynamic balance training
- PNF exercises
- Rhythmic counting and walking with music to improve gait symmetry and speed
- For patient who fatigues rapidly: use an assistive device such as a cane (or two canes) or forearm crutches (use caution because the patient may lean on axillary crutches)
- For the patient who is able to ambulate indoors without cane: use the cane when ambulating outdoors (to negotiate curbs and on uneven surfaces)
- For the patient with generalized weakness: may need an aluminum walker for maximum stability
  - The patient should not lean too far forward on the walker.
  - In case of a BKA prosthesis, the patient may use a two-wheeled walker (as opposed to a four-leg walker) to increase speed.

Stairs (with Rails), Ramps, and Curbs Climbing

- Patients with BKA prosthesis having Syme's: ascend and descend stairs and inclines with equal step length
- Patients with unilateral AKA prosthesis: ascend by leading with the uninvolved LE and descend by placing the involved LE on the lower step
  - The techniques are the same for curbs when no rails are available.
  - When stairs, ramps, or curbs are too steep, the patient (client) may ascend diagonally or sidestep with the prosthesis on the downhill side.

Prosthetic Gait Deviation Assessment for BKA

- Excessive knee flexion in early stance: caused by socket too far anterior; high shoe heel; insufficient PF; socket excessively flexed; stiff heel cushion; weak quads; or knee flexion contracture
- Inadequate knee flexion in early stance: caused by socket too far posterior; socket not flexed enough; soft heel cushion; low heel shoe; excessive PF; weak quads; or spastic quads
- Medial thrust at midstance: caused by excessive foot outset
- Lateral thrust at midstance: caused by excessive foot inset
- Premature knee flexion in late stance ("drop-off"): caused by socket too far forward; high shoe heel; insufficient PF; socket flexed too much; DF stop too soft; or knee flexion contracture
- Delayed knee flexion in late stance: caused by socket too far back; socket not flexed enough; DF stop too stiff; excessive PF; low shoe heel; or extensor spasticity

Table 3-50 Prosthetic Interventions (continued)

Prosthetic Gait Deviation Assessment for AKA[12]

- Circumduction in swing: caused by prosthesis too long; locked knee unit; socket too small; loose socket; loose friction; inadequate suspension; foot in PF; or abduction contracture
- Abducted gait in stance: caused by long prosthesis; inadequate lateral wall adduction; high or sharp medial wall; abduction contracture; or weak abductors
- Lateral trunk bending in stance: caused by short prosthesis; low lateral wall; high or sharp medial wall; weak abductors; hip pain; or abduction contracture
- Medial or lateral whip at heel-off: caused by faulty socket contour; knee bolt rotated externally or internally; or foot mal rotated
- Vaulting in swing: caused by too-long prosthesis; too-small socket; inadequate suspension; or too little knee flexion
- Forward flexion in stance: caused by unstable knee unit or instability
- High heel rise in swing: caused by inadequate friction or too little tension in the extension aid
- Foot slap at heel contact: caused by stiff heel cushion
- Uneven step length: caused by insufficient socket flexion; uncomfortable socket; hip flexion contracture; or instability

Phases of Gait Cycles

Table 3-51 Phases of Gait Cycles: Traditional Versus RLA[12]

Traditional	RLA
Heel strike	Initial contact
Heel strike to foot flat	Loading response
Foot flat to midstance	Midstance
Midstance to heel-off	Terminal stance
Toe-off	Preswing
Toe-off to acceleration	Initial swing
Acceleration to midswing	Midswing
Midswing to deceleration	Terminal swing

Muscle Activation Patterns

Table 3-52 Muscle Activation Patterns[12]

Heel Strike

- Person's heel contacts the ground
- Muscles: quadriceps muscles and ankle dorsiflexors muscles (anterior tibialis, extensor hallucis longus, and extensor digitorum longus)

Foot Flat

- Person's sole of the foot makes contact with the ground (immediately after the heel strike)
- Muscles: gastrocnemius and soleus

Midstance

- Person's full body weight is taken by the reference extremity
- Muscles: hip and ankle extensor muscles control the forward motion of the trunk; hip abductors stabilize the pelvis

(*continues*)

Table 3-52 Muscle Activation Patterns[12] (continued)

Heel-Off
- After the midstance when the person's heel leaves the ground
- Muscles: ankle plantarflexors have peak activity immediately after the heel-off to propel the body forward

Toe-Off
- Person's toe is still in contact with the ground
- Muscles: hamstrings and quadriceps contribute to forward propulsion

Acceleration
- Starts at the toe-off of the reference extremity until the midswing of the same reference extremity
- Muscles: hip flexor muscles (iliopsoas) help to accelerate the extremity and propel it forward

Midswing
- Reference extremity moves directly beneath the person's body
- Muscles: hip and knee flexor muscles and ankle dorsiflexors muscles contract to achieve foot clearance of the reference extremity

Deceleration
- Reference extremity is slowing down with the knee extended in preparation for heel strike
- Muscles: hamstrings work hard to decelerate the reference extremity in preparation for the heel strike

Common Gait Deviations: Stance Phase

Table 3-53 Gait Deviations: Stance Phase

- Lateral bending of trunk: weak gluteus medius (Trendelenburg gait)
- Backward leaning of trunk: weak gluteus maximus (difficulty walking stairs/ramps)
- Forward leaning of trunk: weak quadriceps or hip/knee flexion contracture
- Excessive hip flexion: weak hip extensors or tight hip/knee flexors
- Decreased hip flexion: weak hip flexors or tight hip extensors
- Decreased hip extension: tight hip flexors
- Excessive knee flexion: weak quadriceps or knee flexion contracture (difficulty walking stairs/ramps)
- Hyperextension of knee: weak (or tight) quadriceps or contracture of plantarflexors
- Toes contact at heel strike: weak dorsiflexors, tight plantarflexors, shorter leg, or painful heel
- Foot slap (steppage gait): weak dorsiflexors or excessive hip/knee flexion
- Foot flat: weak dorsiflexors (normal for children younger than 2 years of age)
- Excessive dorsiflexion (calcaneus gait): weak plantarflexors
- Excessive plantarflexion (equinus gait): tightness or contracture of plantarflexors
- Varus foot throughout stance: weak peroneal or tight anterior tibialis
- Limited push off: weak plantarflexors or pain in forefoot
- Short stance on involved extremity and uneven gait pattern: pain in ambulation (antalgic gait)

Common Gait Deviations: Swing Phase

Table 3-54 Gait Deviations: Swing Phase

- Limited pelvic retraction (forward rotation of pelvis): weak hip flexors and abdominals
- Limited hip and knee flexion: weak hip and knee flexors
- Circumduction: weak hip and knee flexors
- Hip hiking of quadratus lumborum: weak hip and knee flexors
- Excessive hip and knee flexion (steppage gait): shorter leg, tight plantarflexors, or weak dorsiflexors
- Limited knee flexion: tight quadriceps, weak hamstrings, or knee pain
- Excessive knee flexion: tight hamstrings
- Foot drop (equinus gait): weak dorsiflexors or tight plantarflexors
- Varus or inverted foot: weak peroneals or tight anterior tibialis
- Equinovarus: tight posterior tibialis and gastrocnemius and soleus

Gait Training Points

Table 3-55 Gait Training Points

- Key points of control while guarding the patient: patient's shoulder, the opposite pelvis, and the safety belt.
- Patient loses balance forward: With one hand, pull the patient back by the safety belt; with the other hand, hold the patient's anterior shoulder and assist the patient to regain balance. If balance cannot be regained and the patient is falling forward, the patient must be instructed to remove the assistive devices and reach for the floor while the therapist retards the patient's forward fall by holding the patient by the safety belt. During the fall, the patient can be instructed to cushion the fall by bending the elbows and turning the head to one side.
- Patient loses balance backward: With one hand, hold the patient by the safety belt; with the other hand on the patient's posterior shoulder, assist the patient to regain balance. The therapist's lower extremity is on the patient's involved pelvis to help the patient regain balance. If balance cannot be regained and the patient is falling backward, the patient must be instructed to remove the assistive devices while the therapist lowers the patient toward the floor by holding onto the safety belt.

Canes

- Widen BOS, improve balance (unload forces on involved LE by as much as 30%), and reduce forces acting at the stance hip.
- Canes are not intended for patients with weight-bearing restrictions (such as NWB or PWB).
- Canes are used in the hand opposite to the affected (involved) lower extremity:
  - Widens BOS with decreased lateral shifting of COM compared to when used ipsilaterally
  - Approximates a normal reciprocal gait pattern
  - Reduces forces created by the abductor muscles acting at the involved hip in the stance phase; creates gravitational moment at the stance hip
- Cane measurement: must be 6 inches from the lateral border of the toes; top of the cane must be at greater trochanter and elbow flexed at about 20–30°.

Crutches

- Improve lateral stability and balance, and decrease weight bearing on involved LE. (Patient education: Do not to lean on axillary crutches because of the potential damage of radial nerve and axillary artery.)
- Crutches are awkward in small and crowded areas.
- Axillary crutches measurement: in standing position from 2 inches (width of two fingers) below the axilla at 2 inches lateral and 6 inches anterior to the foot (can also subtract 16 inches from the patient's height). Elbow must be flexed at about 20–30° when using crutches.

(*continues*)

Table 3-55 Gait Training Points (continued)

- Forearm crutches measurement: in standing position, distal end at 2 inches lateral and 6 inches anterior to the foot; elbow must be flexed at about 20–30°; forearm cuff must be at 1.0–1.5 inches below the elbow.
- Gait patterns for crutches: three-point gait, modified three-point gait; four-point gait; two-point gait; swing to; swing through.

Walkers

- Widen BOS, decrease weight bearing fully or partially on the involved LE, improve balance, and provide lateral and anterior stability. Walkers offer the greatest stability.
- Walker measurement: the walker handgrip (handle) must be at the greater trochanter, and elbow must be flexed at about 20–30°.
- Nonrolling walkers can use FWB, PWB, or NWB patterns.

Wheelchair Management

Table 3-56 Wheelchair Measurements[12]

Taken on a firm surface (sitting or supine); hips, knees, and ankles should be positioned at 90°.

Seat Width Measurement

- Measure the widest part of hips and add 2 inches to the measurement.
- Typical seat-width dimensions:
  - Standard adult wheelchair = 18 inches
  - Narrow adult or junior wheelchair = 16 inches
  - Extra-wide adult wheelchair = 22 inches
- Potential problems: extra-wide seat width can cause difficulty reaching; narrow seat width can cause lateral pelvis and thighs discomfort.

Seat Depth Measurement

- Measure from the posterior buttocks on the lateral side of the thigh to the popliteal fossa and subtract 2 inches from the measurement.
- Typical seat-width dimensions for standard adult, narrow adult, junior, and extra-wide adult wheelchairs = 16 inches.
- Potential problems: too-long seat depth can cause circulatory problems to posterior knees, posterior tilt sitting, and kyphotic posture; too-short seat depth can cause inadequate thigh support.

Seat Height Measurement

- Measured relative to the entire wheelchair: 2 inches measurement from the floor to the lowest point on the bottom of the foot plate of the footrest (or first measuring leg length and adding 2 inches to the measurement).
- Leg length measurement: Measure from the bottom of the patient's shoe to the posterior popliteal fossa and subtract 2 inches.
- Typical seat height dimensions:
  - Standard adult, narrow adult, and extra-wide adult wheelchairs = 20 inches
  - Junior wheelchair = 18.5 inches
- Potential problems: too-short leg length can cause excessive weight on ischial seat and decubitus ulcers; too-long leg length can cause sacral sitting and sliding forward in the wheelchair.

Back Height Measurement

- Measure from the seat platform to the lower angle of the patient's scapula, midscapula, or top of the shoulder, depending on the patient's needs.
- If a cushion is used, it must be added to the measurement.

Table 3-57 Wheelchair's Postural Support System[13]

Solid Insert (Seat Support)

- Types of solid inserts:
  - Padded insert board
  - Reinforcement board inside cushion cover
  - Contoured or flat insert board between cushion and wheelchair
- Benefits of the solid insert:
  - Increases stability
  - Decreases possibility of LE's adduction and IR
  - Decreases possibility of posterior pelvic tilt and slipping forward in the seat
  - Improves pelvic position
  - Encourages neutral pelvic tilt and symmetrical spinal alignment
  - Can promote trunk extension and upper body stability
  - Increases head and UE function
  - Has low cost
- Limitations of the solid insert:
  - Increases seat height
  - Can shift on seat to cause asymmetrical seating

Solid Hook-On Seat (Seat Support)

- Can be installed using hardware to hook to the seat rails. Has adjustable angle and height to be able to change positions of the seat surface on the wheelchair's frame.
- Benefits of the solid hook-on seat:
  - Creates stable base of support
  - Improves pelvic position
  - Decreases possibility of LE's adduction and IR, posterior pelvic tilt, and slipping forward in wheelchair (by raising the anterior portion of the solid hook-on seat)
  - Encourages neutral pelvic tilt and symmetrical alignment of the spine
  - If posterior portion of the solid hook-on seat is raised, can facilitate trunk co-contraction
- Limitations of the solid hook-on seat:
  - Difficult to remove
  - Adds weight to the wheelchair's frame

Pressure-Relieving Foam (Custom or Premade Contoured Seat Cushion)

- Can increase surface contact and improve pressure distribution and relief. Has different degrees of firmness, and the generic types work well for symmetrical individuals.
- Benefits of the pressure-relieving foam:
  - Increases surface contact
  - Improves distribution of weight
  - Accommodates moderate and severe postural asymmetry
  - Is low maintenance
  - Allows easier positioning and repositioning of the patient (client) for the caregiver
- Limitations of the pressure-relieving foam:
  - Is expensive
  - Can interfere with sliding transfers
  - Can cause a feeling of being locked in because the movement on the cushion surface is restricted

Comfort Cushion (Planar or Contoured Seat Cushion)

- Made of layered foam, and used for postural control and for limited ROM.
- Benefits of the comfort cushion:
  - Promotes neutral pelvic position
  - Increases patient's comfort
  - Creates a stable base of support

(*continues*)

Table 3-57 Wheelchair's Postural Support System[13] (continued)

- Does not interfere with sliding transfers
- Is inexpensive
- Is lightweight
- Patient can sit anywhere on the cushion without any discomfort

- Limitations of the comfort cushion:
  - Does not offer pressure relief
  - Gives minimal support and postural control

Pressure-Relieving Air Cushion (Seat Cushion)

- Responds to patient's weight and increases surface contact to improve distribution of weight and relief (bony prominences feel like floating).
- Benefits of the pressure-relieving air cushion:
  - Is very lightweight
  - Offers pressure relief (moderate to significant)
  - Improves moderate to significant postural asymmetry
  - Increases sitting time
  - Prevents decubitus ulcers (especially over bony prominences)
  - Improves postural control for specific body segments (using segmented air cushions)
- Limitations of the pressure-relieving air cushion:
  - Is expensive
  - May be unstable for some patients (clients)
  - Decreases UE reach distance (because users keep arms closed to the body for stability)
  - May make transfers difficult because of the unstable base
  - Air pressure needs to be monitored carefully
  - Needs continuous maintenance

Pressure-Relieving Fluid or Fluid/Foam Combination Cushion (Seat Cushion)

- Has generic contour or planar surface contour with fluid-filled sac. The bony prominences feel immersed in the fluid (increases surface contact); accommodates limited ROM (by cutting foam base as needed); generic contoured shapes work well with symmetrical individuals.
- Benefits of the pressure-relieving fluid or fluid/foam combination cushion:
  - Provides a stable base of support for proper seating alignment
  - Controls postural alignment (using add-on pieces)
  - Increases comfort and sitting tolerance (especially for oblique pelvis)
  - Improves head and shoulders alignment
  - Can be used for moderate to significant seating needs
  - Increases sitting time; decreases possibility of decubitus ulcers (especially over bony prominences)
  - Increases pelvic stability (especially with gel medium fluid)
  - Is easier to position and reposition (for caregivers)
- Limitations of the pressure-relieving fluid or fluid/foam combination cushion:
  - Is expensive
  - Some maintenance required
  - Heavier than foam or air
  - Can cause a feeling of being locked in because the movement on the cushion surface is restricted

Solid Insert (Back Support)

- Maintains pelvic alignment and can accommodate back contour and provide postural control (with special foaming).
- Benefits of the solid insert:
  - Maintains pelvic alignment (when interfaced with seat surface)
  - Improves upright seating, trunk, and head alignment
  - Provides some lateral support (with shaped foam)
  - Increases trunk control and distal extremities function
  - Can be easily removed
  - Adds minimal weight to the wheelchair

Table 3-57 Wheelchair's Postural Support System[13] (continued)

- Limitations of the solid insert:
  - May not be stable in the chair
  - Can be easily lost or left behind when folding the wheelchair

Pita Back (Back Support)

- A solid board (padded or unpadded) that slips into a pocket in the back upholstery of the wheelchair. It provides mild to moderate support and is used for patients (clients) who need a slight reminder to sit upright.
- Benefits of the pita back:
  - Encourages trunk extension
  - Is lightweight
  - Is easy to put on and to remove
- Limitations of the pita back:
  - Provides only a slight degree of support
  - Can be lost or left behind when the wheelchair is folded

Solid Hook-on (Back Support)

- A very stable back support that can be aligned and angled as necessary. It can hold planar, contoured, molded back, or air flotation cushion; can be custom made or manufactured; and mounts using permanent (can strengthen the wheelchair frame) or removable hardware.
- Benefits of the solid hook-on support:
  - Improves upright sitting
  - Accommodates patients with limited ROM
  - Accommodates patients with any degree of deformity
  - Increases UE and head control
  - Improves comfort and pressure relief
  - Maintains trunk and pelvis alignment
  - Resists extensor thrusting
  - Allows additional attachments (such as headrests)
- Limitations of the solid hook-on support:
  - Increases wheelchair weight
  - Requires manipulation and removal of hardware to fold the wheelchair

Head and Neck Supports (Specialized Supports)

- Used for patients with fair, poor, or absent head control. The hardware can be fixed or removable.
- Benefits of head and neck supports:
  - Improve anterior, posterior, or lateral head and neck control
  - Promote neutral cervical spine and head position
  - Eliminate uncontrolled lateral flexion and rotation (which disturb trunk and pelvis alignment)
  - Assist with respiration, feeding, swallowing, and visual interaction
  - Improve safety during the patient's (client's) transportation
- Limitations of head and neck supports:
  - May interfere with head movement
  - May trigger extensor thrust
  - May cause skin problems in areas of high pressure

Lateral Trunk Support (Specialized Support)

- Used for weak or spastic trunk muscles. Can be straight or contoured; hardware can be fixed or swing away (for transfers).
- Benefits of the lateral trunk support:
  - Improves trunk stability and control
  - Increases pelvic alignment
  - Controls lateral trunk flexion
  - Facilitates UE movement
  - Improves respiration, feeding, and swallowing
  - Increases safety during the patient's movement

(*continues*)

Table 3-57 Wheelchair's Postural Support System[13] (continued)

- Limitations of the lateral trunk support:
  - May interfere with trunk movement
  - Increases the weight of the wheelchair (chair)
  - May interfere with the patient's self-propelling ability when using the UE

Anterior Chest Support (Specialized Support)

- Used for upright trunk posture and shoulder control. Can be maximally or minimally supportive (having additional features such as straps and padded straps).
- Benefits of the anterior chest support:
  - Eliminates forward lean
  - Discourages shoulder protraction (as in CVA)
  - Improves trunk control (and, in turn, respiration), eating, swallowing and visual interaction
  - Improves UE, shoulder (promotes better head posture), and head control
  - Improves trunk upright position
  - Stabilizes the trunk to free up the arms and head for movement
- Limitations of the anterior chest support:
  - Restricts trunk movement
  - Long usage may limit trunk control improvements

Lateral Hip Guides (Specialized Supports)

- Used for pelvic alignment. Assist with maintenance of the pelvic position on a contoured seat.
- Benefits of lateral hip guides:
  - Improve weight distribution (symmetrical weight bearing) on the pelvis
  - Increase sitting time
  - Increase upper and lower body segments alignment
  - Reduce asymmetries in trunk and LEs
- Limitations of lateral hip guides:
  - May interfere with transfers (if not removable)
  - Can cause a feeling of being locked in on the seat
  - Increase the weight of the wheelchair (i.e., the chair)

Lateral Knee Guides (Specialized Supports)

- May be built into the cushion contours or fabricated separately (from padded wood or plastic) and attached to the seat or armrest of the wheelchair. Lateral knee guides should extend to the end of the knee for maximal control.
- Benefits of lateral knee guides:
  - Maintain alignment of LE
  - Reduce excessive abduction and ER
  - Assist patient in maintaining pelvic alignment
  - Improve trunk and UE position and function
  - Reduce forward sliding of pelvis on the seat of the wheelchair
- Limitations of lateral knee guides:
  - If they are too high (as needed), may interfere with transfers (if they are not removable)
  - Add weight to the wheelchair (i.e., the chair)

Medial Knee Block (Specialized Support)

- May be built into the cushion contours or fabricated separately (or as a removable flip-down block). Medial knee block must be positioned at the distal portion of the limb (between the condyles) for maximal control and should never be used to stabilize the pelvis on the seat by pressing it into the groin. Also, it should never be used to prevent the patient (client) from sliding off the front of the seat.
- Benefits of the medial knee block:
  - Prevents LE from moving into adduction
  - Prevents pelvic forward rotation (when used with both LEs oriented to one side, with one LE adducted and the other LE abducted)
  - Maintains broad and stable base of support

Table 3-57 Wheelchair's Postural Support System[13] (continued)

- Decreases spasticity (if wide enough)
- Maintains LE alignment

- Limitations of the medial knee block:
  - May interfere with transfers
  - Increases the weight of the wheelchair (i.e., the chair)

Anterior Knee Block (Specialized Support)

- The most effective way to maintain proper pelvic position on the seat. Needs the physician's approval if the patient's hips are subluxed, dislocated, or not properly formed.
- Benefits of the anterior knee block:
  - Helps maintain a broad and stable base of support
  - Improves pelvic alignment and functional use of the upper body
  - May facilitate trunk co-contraction, extension, and improved UE ROM (when used with a forward-sloped seat)
  - Reduces extensor tone
  - Increases stability
- Limitations of the anterior knee block:
  - May impose too much pressure at the hips and over the patella
  - Patient (client) may feel restricted

Mobility Training

Table 3-58 Wheelchair Training Elements

- Patient (client) and/or caregiver education in wheelchair use, safety, and maintenance
- Patient (client) and/or caregiver education in proper alignment and pressure relief activities (e.g., arm push-ups, weight shifting by leaning to one side and then the other side)
- Patient (client) and/or caregiver education in use of wheelchair's postural supports: positioning of supports; benefits and limitations of supports; care and maintenance of supports; schedule of use of supports
- Manual wheelchair propulsion training (using both UEs, using one UE, and using one UE and one LE): forward and backward propulsion on flat surfaces and uneven surfaces; turning by pushing harder with one hand than the other hand and taking sharp turns (by pulling one wheel backward while pushing the opposite wheel forward); negotiating obstacles (such as curbs and thresholds)
- Power wheelchair training: for driving skills and safety; use of switches (on and off and turns); use of joystick; safe stopping
- Management of wheelchair wheel locks: use of footrests and armrests; transfer safety with the wheelchair locked; transfers using removable or swing-away armrests; transfers using removable or swing-away leg rests
- Community mobility using the wheelchair practice: mobility when ascending ramps backward (by moving the center of gravity forward; forward lean of the trunk; using quick and short strokes for propulsion); mobility when descending ramps (by gripping the hand rims loosely; increasing the grip to control the speed of the descent; or/and descending in an advanced wheelie position by keeping the spine against the wheelchair back for steep ramps; using gloves)
- Wheelchair's curb negotiation practice:
  - How to pop up a wheelie (moving into a wheelie position): patient places one hand posteriorly on the hand rims and pulls the hand rims forward abruptly and forcefully; patient trunk and head are moved forward to keep the wheelchair from tipping backward
  - How to maintain balance in the wheelie position: the wheelchair tips farther back when the wheels are pushed forward; the wheelchair tips into upright position when the wheels are pulled back; the patient to come up onto balance on the rear wheels with the front casters off the ground
- Wheelchair curb ascent practice: patient (client) places front casters up on the curb; patient (client) pushes rear wheels up the curb; patient (client) uses momentum to assist

(*continues*)

Table 3-58 Wheelchair Training Elements (continued)

- Wheelchair curb descent practice: patient (client) can descend backward with forward head and trunk lean; patient (client) pushes rear wheels up the curb; patient (client) can descend forward in wheelie position
- Wheelchair ascending and descending stairs practice: using the wheelchair; assisted by buttocks bringing wheelchair behind; advanced techniques
- Patient (client) education and practice in how to fall safely and how to return to the wheelchair
- Patient (client) practice in how to transfer into a car (i.e., placing the wheelchair inside the car by pulling the wheelchair behind the car seat or using a wheelchair lift)
- Routine maintenance of the wheelchair: normal cleaning and upkeep; power-chair battery maintenance

SECTION 3-7

Musculoskeletal Intervention Strategies

APTA's Guide to Physical Therapist Practice[15] Intervention Categories Most Related to the Musculoskeletal System

Table 3-59 Patient or Client Instruction[15]

Provision of information, education, and training regarding the following:

- Health, wellness, and fitness programs
- Impairments in body functions and structures, activity limitations, and participation restrictions
- Pathology or health conditions
- Performance enhancement
- Plan of care
- Psychosocial influences on treatment such as fear–avoidance beliefs, behave change techniques
- Transitions across new settings
- Transitions to new roles

Table 3-60 Assistive Technology: Prescription, Application, and as Appropriate, Fabrication or Modification of Locomotive Aids, Orthotic and Prosthetic Devices[15]

This category of intervention may include any assistance required for the procurement or proper fitting of any durable medical equipment or appliances that may be of benefit for the improved functioning of the patient. Prescription, application, and as appropriate, fabrication of assistive technologies may include but not be limited to the following:

- Assistive devices for locomotion (i.e., crutches, canes, walkers, rollators, manual wheelchairs, power wheelchairs, power-operated vehicles)
- Orthoses (i.e., ankle foot orthoses [AFOs], knee-ankle-foot orthoses [KAFOs], body jackets, wrist splints, shoe inserts)
- Prostheses (i.e., transtibial, transfemoral, upper extremity prosthesis)
- Seating and positioning technologies (i.e., custom-molded seating, removable trunk supports, upper extremity support trays for wheelchairs, sidelyers, prone standers, manual or power reclining systems for wheel chairs)
- Other assistive technologies to improve safety, function, and independence, such as transfer devices (i.e., transfer boards, mechanical lifts/hoists) and adaptive bathroom equipment (i.e., raised toilet commodes, transfer benches, sliders, adaptive shower chairs and commodes)

Table 3-61 Biophysical Agents[15]

Biophysical agents is a very broad category pertaining to many of the modalities that are utilized in the physical therapy setting for the treatment objective of resolving any impairment or activity limitation that is adversely affecting function. These agents may include the following:

- Athermal agents
  - Pulsed electromagnetic fields
- Biofeedback
- Compression therapies
  - Compression bandaging
  - Compression garments
  - Taping
  - Total contact casting
  - Vasopneumatic compression devices

Table 3-61 Biophysical Agents[15] (continued)

- Cryotherapy
  - Cold packs
  - Ice massage
  - Vapocoolant spray
- Electrical stimulation (muscle and nerve)
  - Electrical muscle stimulation (EMS)
  - Electrical stimulation for tissue repair (ESTR)
  - Functional electrical stimulation (FES)
  - High-voltage pulsed current (HVPC)
  - Neuromuscular electrical stimulation (NMES)
  - Transcutaneous electrical nerve stimulation (TENS)
- Hydrotherapy
  - Contrast bath
  - Fluidotherapy
  - Pools
  - Pulsatile lavage
  - Whirlpool tanks
- Hyperbaric oxygen therapy
- Light agents
  - Infrared
  - Laser
  - Ultraviolet
- Mechanical devices
  - Continuous passive motion (CPM)
  - Standing frame
  - Tilt table
  - Traction devices
- Sound agents
  - Phonophoresis
  - Ultrasound
- Thermotherapy
  - Dry heat
  - Hot packs
  - Paraffin baths

Table 3-62 Functional Training in Self-Care and in Domestic Education, Work, Community, Social, and Civic Life[15]

Functional training in self-care pertains to integration or reintegration back to competent and safe basic ADLs, such as bed mobility, transfers, dressing, grooming, eating, etc.

Functional training in domestic life pertains to more complex return to ADLs and IADLs such as caring for dependents, maintaining a home, shopping, making accommodations for environmental barriers to the home, or travel.

Functional training in education pertains to integration or reintegration for the resumption of roles and functions in an educational environment and may include training to overcome environmental physical barriers, injury prevention, and use of assistive technology in the school environment.

Functional training in work life includes accommodations or modifications of work barriers. Training may include but is not limited to: education for injury prevention, workstation ergonomics, lifting /body mechanics, adaptive equipment for work seating/positioning, orthoses or prostheses application, and locomotion aids.

(*continues*)

Table 3-62 Functional Training in Self-Care and in Domestic Education, Work, Community, Social, and Civic Life[15] (continued)

Functional training in community, social, or civic life considers the social or recreational aspect of return to function in a safe and competent manner. Training may include public transportation use, return to banking, shopping, attending community or civic sponsored events (i.e., town hall meetings, church, garden or book club, library activities), and lastly, integration or reintegration into vocational or enjoyable pastimes (i.e., bowling, fitness classes, quilting, stamp collecting).

Functional training may include the following:

- ADL training
  - Bathing
  - Bed mobility and transfer training
  - Dressing
  - Eating
  - Grooming
  - Toileting
- Barrier accommodations or modifications
- Developmental activities
- Device and equipment use and training
  - Assistive and adaptive device or equipment training during IADL
  - Orthotic, protective, or supportive device or equipment training during IADL
  - Prosthetic device or equipment training during IADL
- Functional training programs
  - Back schools
  - Job coaching
  - Simulated environments and tasks
  - Task adaptation
  - Task training
  - Travel training
  - Work conditioning
  - Work hardening
- IADL training
  - Community service training
  - School and play activities training
  - Work training
- Injury prevention or reduction
  - Injury prevention education during domestic, education, work, community, social, and civic integration or reintegration
  - Injury prevention education with the use of devices and equipment
  - Safety awareness training during work, community, social, and civic life integration or reintegration

Table 3-63 Manual Therapy Techniques (Excludes Joint Mobilization)[15]

Manual therapy techniques may include the following:

- Manual lymphatic drainage
- Manual traction
- Massage
  - Connective tissue massage
  - Therapeutic massage
- Neural tissue mobilization
- Passive range of motion
- Proprioceptive neuromuscular facilitation (PNF)
- Neuro developmental techniques (NDT)

Table 3-64 Motor Function Training[15]

Motor function training activities may include the following:

- Balance training
  - Developmental activities training
  - Motor control training or retraining
  - Neuromuscular education or re-education
  - Perceptual training
  - Standardized, programmatic, and complementary exercise approaches
  - Task-specific performance training
  - Vestibular training
- Gait and locomotion training
  - Developmental activities training
  - Implement and device training
  - Perceptual training
  - Standardized, programmatic, and complementary exercise approaches
  - Training of specific components of gait
  - Wheelchair feature and propulsion training (manual and motorized wheelchairs)
- Posture training
  - Developmental activities training
  - Neuromuscular education or re-education
  - Postural awareness training
  - Postural control training
  - Postural stabilization activities
  - Vestibular training

Table 3-65 Therapeutic Exercises[15]

Therapeutic exercise may include the following:

- Aerobic capacity/endurance conditioning or reconditioning
  - Aquatic programs
  - Gait and locomotor training
  - Increased workload over time
  - Movement efficiency and energy conservation training
  - Walking and wheelchair propulsion programs
- Flexibility exercises
  - Muscle lengthening
  - Range of motion
  - Stretching
- Neuromotor development training
  - Developmental activities training
  - Motor training
  - Movement pattern training
  - Neuromuscular education or reeducation
- Relaxation
  - Breathing strategies
  - Movement strategies
  - Relaxation techniques
  - Standardized, programmatic, complementary exercise approaches

(*continues*)

Table 3-65 Therapeutic Exercises[15] (continued)

- Strength, power, and endurance training for head, neck, limb, pelvic-floor, trunk, and ventilator muscles
  - Active assistive, active, and resistive exercises (including concentric, dynamic/isotonic, eccentric, isokinetic, isometric, and plyometric)
  - Aquatic programs
  - Standardized, programmatic, or complementary exercise approaches
  - Task-specific performance training

Arthritic Disorders: Interventions

Table 3-66 Arthritic Disorders: Interventions

Indication	Interventions
Degenerative joint disease (DJD) or degenerative osteoarthritis: degeneration of articular cartilage with hypertrophy of the subchondral bone and joint capsule of weight-bearing joints.	Pain management and control of inflammation (physical agents and modalities); joint protection and function (splints, orthotics, gait training with assistive devices, and task modifications); measures to increase flexibility and strength (ROM, stretching, and strengthening exercises); patient education about joint protection. Precaution: resistive exercises.[16]
Rheumatoid arthritis: systemic disease characterized by a symmetric pattern of dysfunction in synovial tissues and articular cartilages of the joints of the hands, wrists, elbows, shoulders, knees, ankles, and feet. MCP and PIP joints are also affected (pannus formation and ulnar drift). DIP joints are spared.	Pain management and control of inflammation (physical agents and modalities); prevention of deformities and maintenance of ROM (splints and orthotic devices for ADLs); gait training with assistive devices and task modifications; measures to increase flexibility, strength, and endurance using ROM exercises, stretching exercises (HS, finger flexors, or biceps brachii), and strengthening exercises; patient education for joint protection and disease progression.
Systemic lupus erythematosus (SLE): progressive systemic inflammatory disease characterized by inflammation of and damage to connective tissue anywhere in the body. The most commonly affected areas include the skin, joints, nervous system, kidneys, lungs, and other organs. SLE presents with a butterfly rash across the nose, cheeks, and other exposed areas of the body.	Pain management (physical agents and modalities); measures to increase strength (aquatic therapy); measures to decrease chronic fatigue (activity pacing and energy conservation); joint protection (gait training with assistive devices); patient education related to postural awareness and daily walking.
Ankylosing spondylitis (called Marie Strumpell Bechterew, or rheumatoid spondylitis): progressive inflammatory disorder that initially affects the spine and the sacroiliac joints. Later, other joints away from the spine as well as organs (e.g., eyes, heart, lungs, and kidneys) can be affected. Posture is affected, resulting in kyphosis deformity of CS/TS and a decrease in lumbar lordosis.	Maintenance of proper posture: deep breathing and stretching exercises (back extension exercises); task modifications and ergonomic modifications (workplace); patient education related to posture awareness and proper sleeping patterns (on a firm mattress without pillows). Exercise programs are customized for the individual patient (swimming is preferred).

Table 3-66 Arthritic Disorders: Interventions (continued)

Indication	Interventions
Psoriatic arthritis: a chronic, erosive inflammatory disorder associated with psoriasis. Erosive degeneration occurs in the joints of the digits (ends of the fingers or toes) as well as the spine.	Joint protection and maintenance of joint mobility (splints and orthotics; gait training using assistive devices; stretching exercises); patient education related to joint protection.
Gout: chronic genetic disease of uric acid metabolism that occurs as an acute, episodic form of arthritis. It is observed at the knee and great toe of the foot, causing severe to excruciating pain.	Pain management and stress reduction (TENS and EMG biofeedback for relaxation); joint protection and maintenance of joint mobility (braces and orthotics; gait training with assistive devices); patient education related to the disease, relaxation and stress management to control pain, general fitness exercises, and joint protection; HEP for stretching and strengthening exercises (aquatic exercises are also recommended).
Fibromyalgia: nonspecific rheumatoid disorder characterized by general musculoskeletal pain localized to all muscles. Myofascial pain syndrome is localized to one or a few muscles. Fibromyalgia causes chronic pain with diffuse aching or burning in the muscles, stiffness, fatigue, disturbed sleep patterns, and depression.	Pain management and promotion of relaxation (TENS, MHP, massage, whirlpool, breathing exercises, EMG biofeedback for relaxation); flexibility improvement using a progressive graded exercise program (walking, biking, stationary bicycle, swimming, low-impact aerobics, or water aerobics).

Overuse Syndromes

Table 3-67 Tendonitis, Tendinosis, and Bursitis: Interventions

Indication	Interventions
Rotator cuff tendonitis (RCT), also called pitcher's shoulder, shoulder impingement syndrome, swimmer's shoulder, and tennis shoulder: progressive overuse disorder caused mostly by sports. It results from mechanical impingement of the distal attachment of the rotator cuff on the anterior acromion or coracoacromial ligament with repetitive overhead activities.	Pain management and joint protection using physical agents and modalities such as ice massage, ice pack, MHP, ES, US, phonophoresis, and iontophoresis. Patient education: no shoulder flexion or abduction between 60º and 120º (painful arch); joint protection; modification of ADLs. Measures to improve flexibility: stretching exercises (posterior capsule). Measures to increase strength: Codman's pendulum exercises (in the beginning), AAROM; first strengthen scapular stabilizers and then rotator cuff muscles.

(*continues*)

Table 3-67 Tendonitis, Tendinosis, and Bursitis: Interventions (continued)

Indication	Interventions
Rotator cuff tendinosis is an overuse condition that results in degeneration of the tendon's collagen that hasn't been given the adequate amount of time to heal. It is usually caused by repetitive straining of the tissues. **This condition is not associated with an acute inflammatory process**[20]. It is often related to overhead activities, which result in impingement of the distal attachment of the rotator cuff on the anterior acromion or coracoaccromial ligament.	Activity modification and rest throughout the work shift need to be incorporated into patient education; along with workstation ergonomic assessment or biomechanical recommendations to reduce overuse on the chronically injured tissue; Stretching; eccentric strengthening; and cross friction massage to reboot organized collagen formation are interventions often used for the management of tendinosis.[20]
Lateral epicondylitis (tennis elbow), medial epicondylitis (golfer's elbow), and medial valgus stress overload (MVSO). Tennis elbow is chronic inflammation of the ECRB tendon. Golfer's elbow is chronic inflammation of the FCU tendon. MVSO is inflammation of the medial ulnar ligament and capsule from repetitive overuse. All are caused by sports or occupations or cumulative trauma from work injuries.	Acute: RICE, US, ES, phonophoresis, iontophoresis, gentle AROM, splint protection (bracing with counterforce brace for tennis elbow), patient education (to avoid repetitive motions and prevention), and stretching exercises. Subacute: progress with PREs as tolerated and pain free; gradual return to function training; task modifications if needed. For MVSO, avoid exercises in valgus position of elbow.
DeQuervain's tenosynovitis: inflammation of the EPB and abductor pollicis longus tendons at the first dorsal compartment of the hand from repetitive microtrauma.	Acute: RICE, US, phonophoresis, iontophoresis, ES, splint protection, activity modification, friction massage, stretching exercises, and patient education for activity modifications.
Anterior tibial periostitis (shin splints) and medial tibial stress syndrome (MTSS): overuse conditions caused by abnormal biomechanical alignment, poor conditioning, or improper training methods. Muscles involved can be the anterior tibialis and EHL for the anterior compartment, or the posterior tibialis for the posterior and medial compartment (MTSS).	Pain management and edema control (physical agents and modalities); activity modifications (orthotics, patient education related to proper training methods and prevention of recurrence); flexibility improvement (stretching exercises); strengthening exercises (dorsiflexors and evertors for anterior tibial periostitis and plantarflexors and invertors for MTSS).
Achilles tendinitis (Achilles tendinopathy), inflammation of the paratenon.	Acute tendinitis: activity modification, pain and inflammation reduction; gentle dorsiflexion stretching
Achilles tendinosis (Achilles tendinopathy), chronic degeneration of the tendon ***Not associated with an acute inflammatory response**[18]	Both conditions warrant eccentric strengthening, stretching, iontophoresis, foot orthoses, taping, heel lift, manual and low-level laser treatments.[18]
Subacromial/subdeltoid bursitis and trochanteric bursitis: caused by trauma, chronic overuse, inflammatory arthritis (such as RA), or biomechanical/gait abnormalities (for trochanteric bursitis). Athletes are prone to shoulder bursitis from overuse when the arm is at or above shoulder level. Also, hip bursitis is seen in runners or athletes who participate in running-oriented sports such as soccer or football.	Acute: RICE; joint protection (splint or brace); reduction of pain and inflammation (physical agents and modalities); promotion of functional activities (strengthening exercises); patient education related to proper usage and recurrence prevention. Shoulder bursitis: Codman's pendulum exercises and AAROM exercises in acute stage. Trochanteric bursitis: US is effective, and stretching exercises for ITB tightness.[16]

Table 3-67 Tendonitis, Tendinosis, and Bursitis: Interventions (continued)

Indication	Interventions
Patella Femoral Pain Syndrome (PFPS), also called chondromalacia patella, jumper's knee, fat pad syndrome: overuse disorder characterized by anterior knee pain especially with running, jumping, deep squatting, or stair climbing.[18]	Acute: Reduce pain and swelling; stretching and flexibility exercises; proximal hip stabilization exercises; balance/joint proprioception exercises (bilateral → unilateral); strengthening exercises avoiding knee flexion at 90° or greater, progressing to unilateral strengthening as pain and motor control improve.[18]
Carpal tunnel syndrome (CTS): tenosynovitis or inflamed tendons producing a compression syndrome of the median nerve (due to inflammation of tendons). Caused by occupations (carpenters, factory workers, or food processing workers) or during pregnancy. Patients may have thenar muscles atrophy and, in extreme cases, ape hand deformity.	Nonoperative: pain management and relief of aggravating factors (physical agents and modalities); patient education related to job/task modifications; joint protection and support (resting splints or night splints in 0–20° extension); return to function training (ROM, stretching and strengthening exercises). Postoperative: edema management (physical agents and modalities; soft-tissue mobilization of scar tissue); return to function (ROM exercises; ADLs; strengthening exercises of hand such as gripping exercises and UE exercises); desensitization of tissues; patient education related to CTS, scar-tissue massage, and job/task modifications to prevent recurrence.

Strains, Sprains, Dislocations, and Fractures: Interventions

Table 3-68 Strains, Sprains, Dislocations, and Fractures: Interventions

Indication	Interventions
Strains • Injuries to muscles and tendon from direct trauma, overstretch, or excessive muscular contraction • Three grades: ◦ 1: mild injury ◦ 2: moderate injury ◦ 3: severe injury • Common strains: ◦ Rotator cuff tears (RCT): degenerative strain, occurring over time with impingement at the acromion from repetitive use and trauma or falling on to an outstretched hand ◦ Hip strain (of HS, iliopsoas, adductors, and rectus femoris) ◦ HS strain: most common in runners ◦ Lumbar spine strain (from sudden violent contraction or fast stretch of combined extension/rotation)	Nonoperative: • Small tears: ◦ Pain management: RICE; physical agents and modalities ◦ Patient education for ADL modifications (no overhead activities for RCT) and recurrence prevention ◦ Stretching exercises: shoulder flexibility and abduction for RCT ◦ Strengthening exercises (postacute) • Hip strain main goals: ◦ Patient education to avoid in acute-phase full knee extension combined with forward flexion ◦ Gait training with crutches to limit HS irritation • For adductor longus strain: ◦ Avoid early aggressive stretching ◦ Large tears may need surgery

(*continues*)

Table 3-68 Strains, Sprains, Dislocations, and Fractures: Interventions (continued)

Indication	Interventions

	• For HS strain:
	  ○ Acute: PRICE; gentle PROM/AAROM
	  ○ Subacute—AROM; aquatic exercises and strength (submaximal isometrics)
	Postoperative (RCT):
	• Codman's pendulum
	• Shoulder isometrics
	• AAROM
	• Strength exercises
	• Gradual return to function training

Sprains
• Injuries to ligaments from direct or indirect trauma
• Three grades:
  ○ 1: mild
  ○ 2: moderate
  ○ 3: severe (may need surgery)
• Common sprains:
  ○ AC joint sprain: from direct fall on acromion or indirect from a fall on outstretched arm
  ○ MCP or IP joint sprain
  ○ Skier's thumb: rupture of ulnar collateral ligament of MCP from hyperextension of thumb in skiing
  ○ Knee sprains: ACL (most commonly sprained), PCL, MCL, LCL
  ○ Ankle sprains: lateral ligaments (ATF, CF, PTF) or medial ligament (deltoid ligament; rare); meniscal tear (sudden trauma or gradual degeneration)
  ○ Lumbar spine sprain: from sudden violent force or repeated stress
	Nonoperative:
	• RICE
	• Physical agents and modalities
	• NWB or WBAT
	• Braces, splints and orthotics for immobilization and weight-bearing reduction; isometrics
	• CPM machine, PROM, AAROM, AROM; isotonic exercises
	• CKC exercises
	• Isokinetic and isotonic exercises
	• General conditioning program (especially for LS)
	• Cycling and stair climbing activities
	• Proprioception, balance, and coordination
	• Patient education to prevent recurrence (especially for LS for lifting and sitting)
	• Return to prior level of function training
	Postoperative:
	• Follows similar path as nonoperative care, except for WB status and postoperative precautions (such as for ACL reconstruction-no knee extension in final 40° extension and no OKC knee extension with resistance placed distally)
	• Meniscal repair: NWB and no knee flexion from 90–100° for 4–6 weeks; no squats for 3–6 months

Dislocations • Glenohumeral subluxation (partial dislocation); glenohumeral dislocation: at shoulder joint in abduction, extension, and ER (for anterior dislocation); abduction, flexion, and IR (for posterior dislocation) • Anterior dislocations are more common; posterior are rare • Common types: ○ Bankart lesion: an avulsion of the capsule and anterior labrum from the glenoid rim with disruption of medial scapular periosteum	Nonoperative: • Immobilization (braces, orthotics, slings) • Physical agents and modalities • Strengthening exercises of uninvolved joints and general conditioning • Patient education for precautions (for anterior lesion-no shoulder abduction and ER) and activity modifications • Codman's pendulum • Active assistive stretching exercises (flexion)

Table 3-68 Strains, Sprains, Dislocations, and Fractures: Interventions (continued)

Indication	Interventions
○ Perthes lesion: similar to Bankart except the medial scapular periosteum remains intact ○ Hill-Sachs lesion: a compression fracture from impaction of the posterolateral humeral head against the anterior/inferior glenoid rim (may result in a loose body)	• Strengthening exercises (isometrics, T-band) of rotator cuff (concentrate on infraspinatus and teres minor), scapular stabilizers and anterior shoulder muscles • Precautions when starting isotonic resistive exercises • Proprioceptive exercises • CKC exercises Postoperative: • Similar to nonoperative care, but varies considering the procedure and the patient
Fractures • Scapular and clavicular fracture: from direct or indirect trauma • Proximal humerus fracture: of humeral head, lesser or greater tuberosity or humeral shaft • Supracondylar fracture: transverse fracture distal one-third of humerus, often seen in children • Intercondylar fracture: of the articular surface of the elbow • Radial head fracture: from a fall on the outstretched arm • Olecranon fracture: from a fall on olecranon • Elbow fracture • Colles' fracture: from a fall onto an outstretched arm; distal radius displaced dorsal = dinner fork deformity • Smith's fracture: from a fall onto an outstretched arm with the elbow supinated; the distal radius is displaced ventrally • Scaphoid fracture: from a fall onto an outstretched arm in a younger person • Boxer's fracture: neck of fifth metacarpal • Bennet's fracture: proximal to first metacarpal • Mallet finger: avulsion fracture or tendon injury of the extensor tendon = DIP joint flexion contracture • Patellar fracture • Hip fracture: most common in geriatric patients; if untreated, can cause avascular necrosis of the hip • Pelvis and acetabulum fracture • Ankle fracture: unimalleolar, bimalleolar, or trimalleolar • Distal tibia fracture • Calcaneal fracture: from a fall from a height • Talus fracture: from a fall from a height and landing on foot on crouched position • Compression fracture: osteoporosis traumatic events	Nonoperative: • Pain management and swelling reduction: physical agents and modalities; in UEs may use compression pump for lymphedema • Immobilization: casts, splints, orthotics, or slings • Activity modification • Mobility training: transfers; gait training with assistive devices and NWB/PWB or TTWB; balance training • Patient education on signs of circulatory problems (especially in wrist fractures) and to prevent recurrence and for safety • Functional use of extremity: ROM exercises; adaptive equipment • Functional activities of nonimmobilized joints • Restoration of motion post immobilization: ROM exercises • Strengthening exercises after immobilization Postoperative: • Mobility training: transfers; gait training with assistive devices and NWB/PWB or TTWB as per MD/DO; balance training • Patient education for surgical complications or precautions, to prevent recurrence, and for safety • Functional use of extremity: ROM exercises; ADLs; strengthening exercises using isometrics first and then isotonics; CKC exercises first and then OKC exercises • Functional activities of nonimmobilized joints

Thoracic Outlet Syndrome, Adhesive Capsulitis, Low Back Disorders, Plantar Fasciitis, and Arthroplasties: Interventions

Table 3-69 Thoracic Outlet Syndrome, Adhesive Capsulitis, Low Back Pain Symptoms, Plantar Fasciitis, and Arthroplasties: Interventions

Indication	Interventions*
Thoracic Outlet Syndrome (TOS) • Compression of the neurovascular bundle (brachial plexus, subclavian artery/vein, vagus and phrenic nerves, sympathetic trunk) in thoracic outlet, between bony and soft tissue structures • Compression occurs when the size or shape of the thoracic outlet is altered • Causes of TOS: ◦ Poor or strenuous posture, trauma, or constant muscle tension in shoulder girdle: caused by drooping shoulder and forward head postures, carrying heavy loads, or osteoporosis ◦ Repetitive overhead movements such as in athletes (swimmers, tennis and volleyball players, or baseball pitchers) or occupations (electricians and painters)	• Pain management: physical agents and modalities • Patient education for task modifications (work, play, or sleep) and avoidance of repetitive movements • Postural retraining, including postural awareness and correction • Stretching exercises of the anterior scalenes and pectoralis minor • Strengthening exercises, including scapular stabilization such as scapular retraction and seated rowing exercises with a T-band or tubing[5] • The PT may need to create a personalized intervention program specific to the patient's symptoms • Vascular or neurologic TOS may require surgery
Adhesive Capsulitis (Frozen Shoulder) • Restriction in shoulder ROM secondary to inflammation and fibrosis of shoulder capsule, usually following injury or repetitive microtrauma • Has a capsular pattern of limitation such as ER, abduction and flexion, and least restricted in IR • Primary: idiopathic (occurs spontaneously) • Secondary: post trauma or immobilization	Early acute stage: • Cryotherapy • Thermotherapy • US • TENS • EMG biofeedback for muscle relaxation • Codman's pendulum • AAROM with wand and pulleys in pain-free mode • Isometric exercises Subacute stage: • Restoration of normal scapular motion: stretching exercises; scapular stabilization strengthening exercises • Recovery of function: strengthening exercises using isotonic first and then PREs for deltoid, rotator cuff, and upper arm muscles • Postural reeducation to avoid shoulder protraction and kyphotic postures

Table 3-69 Thoracic Outlet Syndrome, Adhesive Capsulitis, Low Back Pain Symptoms, Plantar Fasciitis, and Arthroplasties: Interventions (continued)

Indication	Interventions*
Lumbar Stenosis • Narrowing of spinal canal secondary to osteoarthritis • Produces pain (from nerve root compression) in LS extension • Lumbar spondylolysis: bony defect in the lumbar vertebrae (can be a fracture of pars interarticularis) • Lumbar spondylolisthesis: one superior vertebrae slipping over the inferior vertebrae (usually at L4–L5 and L5–S1) • Causes of spondylolisthesis: congenital, mechanical (or isthmic is most common), trauma (young patients need cast), or degenerative.	• Precaution for all: no extension exercises (produces increased symptoms) • Interventions depend on symptoms • Stenosis: ◦ William's flexion exercises ◦ Postural reeducation ◦ Patient education for lifting techniques, sitting, and sleeping ◦ Physical conditioning • Nonoperative spondylolisthesis: ◦ Pain management and measures to decrease swelling: physical agents and modalities ◦ Joint protection: lumbar corset, orthoses ◦ Abdominal muscle strengthening: lumbar stabilization exercises; curl-ups ◦ Tasks or activities modifications[13] • Postoperative care (for patients with radicular symptoms or high-grade slippage): ◦ Patient education for precautions: no lumbar extension ◦ LE circulation: ankle pumps ◦ Orthosis ◦ Gait training ◦ ROM exercises ◦ Strengthening exercises: UEs and LEs ◦ LS strengthening exercises: after bone healing ◦ Return to function training
Lumbar Disc: Herniated Nucleus Pulposus (HNP) • Causes: ◦ Disc protrusion: nucleus bulges against intact annulus ◦ Extruded disc: nucleus extends through annulus but nuclear material is confined by the posterior longitudinal ligament ◦ Sequestrated disc: nucleus is free within the spinal canal • Signs and symptoms: ◦ Radicular signs: posterior thigh pain and numbness going down the knee and pain in buttocks radiating down to legs ◦ Peripheralization: repeated forward flexion causes symptoms to radiate down the legs ◦ Centralization: repeated movements or positions cause symptoms to move away from the legs toward lumbar spine midline	Nonoperative: • Pain modulation: physical agents and modalities; lumbar traction-patient prone for posterior HNP • Joint protection: corset or orthosis • Measures to increase flexibility: stretching exercises either in flexion or extension, depending on centralization • Patient education about HNP, proper body mechanics, and posture • Measures to increase strength: William's flexion or McKenzie extension exercises depending on centralization • Measures to increase cardiovascular fitness • Task modifications: work, play, or school • Postural reeducation • Return to function training: ADLs; balance training

(*continues*)

Table 3-69 Thoracic Outlet Syndrome, Adhesive Capsulitis, Low Back Pain Symptoms, Plantar Fasciitis, and Arthroplasties: Interventions (continued)

Indication	Interventions*
	Postoperative: • Patient education for postoperative precautions: no bending, lifting, or trunk rotation; no sitting for more than 1 hour at a time; proper posture • Bed mobility and transfers: log-roll technique • Gait training with walker or crutches • LE circulation: ankle pumps • Isometrics: ensure proper breathing; avoid Valsalva maneuver • CKC exercises • ROM and strengthening exercises • General conditioning • Return to function training
Spondylolysis[20] • Causes: ◦ Stress fracture or fracture of the pars interarticularis of the posterior aspect of the vertebra **Spondylolistheses[20]** • Causes: ◦ Bilateral fracturing of the pars interarticularis resulting in anterior slippage due to instability of a superior vertebra over an inferior vertebra ◦ Commonly found at L4 -L5 and L5-S1 levels ◦ There are five types (I – V) of spondylolistheses which describes the pathology in greater detail ◦ There are 4 grades (determined by radiographic imaging) which indicate the severity of the anterior slippage. These grades range from: Grade I: 0–25% (least severe) Graded II: 25–50% Grade III: 50–75% Grade IV: 75–100% (most severe) • Signs and symptoms: ◦ Pain at the level of the belt line ◦ Low back spasming ◦ Radicular symptoms if nerve root compression occurs	Nonoperative • Precautions for both: no extension exercises (may cause more anterior migration of the vertebra) • Pain, inflammation and/or spasm modulation: biophysical agents and modalities • Interventions: focus on spinal stabilization, abdominal and paravertebral strengthening exercises in neutral spine; stretching exercises of the trunk and lower extremities Operative • No rehabilitation until radiographic confirmation for adequate healing is received from the surgeon • No extension while in the TLSO brace; gradual return to spinal stabilization, abdominal strengthening, lower extremity and trunk flexibility strengthening, lumbar spine ROM, with an emphasis on neutral spine and gradual return to functional activities

Table 3-69 Thoracic Outlet Syndrome, Adhesive Capsulitis, Low Back Pain Symptoms, Plantar Fasciitis, and Arthroplasties: Interventions (continued)

Indication	Interventions*
Scoliosis • Lateral curvature of the cervical, thoracic, or lumbar spine • Causes: idiopathic or neuromuscular • Structural: irreversible lateral curvature of spine with fixed vertebral rotation; forward flexion of more than 25° causes a hump • Nonstructural: reversible; forward flexion of more than 25° decreases the curvature • Most common nonstructural: "S" curve (right thoracic, left lumbar curve) in adolescent females • Surgery is indicated when curve is in excess of 40°	Nonoperative: • Stretching exercises: tight muscles on concave side • Strengthening exercises: all muscles on convex side • Bracing: TLSO and/or Milwaukee brace for curves less than 40° • Shoe lift: for mild scoliosis • Postural reeducation: postural awareness • Breathing exercises • Aquatic therapy Postoperative: • Postoperative brace: TLSO • Effective cough and pulmonary hygiene postoperatively • Gait training • Activity limitation for several months
Plantar Fasciitis • Chronic inflammation of plantar aponeurosis (with or without calcaneal heel spur) • Causes: ◦ Biomechanical: abnormal inward twisting or rolling of the foot ◦ High arches, flat feet, tight calf muscles, or tight tendons at the back of the heel ◦ Excessive pronation (most common) ◦ Repetitive activities: prolonged walking on hard or irregular surfaces or running	• Increase proper mechanical alignment: eliminate the causes • Physical agents and modalities: for pain and swelling • Stretching exercises: calf stretching and toe extension stretching exercises • Friction massage • Patient education regarding selection of footwear • Orthotic fitting • Strengthening exercises after pain and swelling have subsided: intrinsic and extrinsic muscles of the foot • General body conditioning: best is in the pool to decrease weight-bearing ability
Total Hip Arthroplasty (THA) or Total Hip Replacement (THR) • Replacement of femoral head and acetabulum with prostheses • Can be cemented or noncemented; noncemented femoral stem can cause persistent thigh pain and antalgic gait for up to 2 years postoperatively • Hemiarthroplasty: replacement of femoral head with a bipolar prosthesis • Indications for THA: osteoarthritis, rheumatoid arthritis, fracture, pain, reduced ambulation, and reduced ADLs	• Patient education for THA precautions: ◦ Do not lie on the surgical site ◦ Do not cross the legs ◦ Do not sit on low surfaces such that the hips are higher than 90° ◦ Use a raised toilet seat ◦ Do not bend down to pick up objects from the floor ◦ Do not turn the toes in/out ◦ Anterolateral THA: no ER ◦ Posterolateral THA: no IR

(*continues*)

Table 3-69 Thoracic Outlet Syndrome, Adhesive Capsulitis, Low Back Pain Symptoms, Plantar Fasciitis, and Arthroplasties: Interventions (continued)

Indication	Interventions*
	• LE circulation: ankle pumps • Isometrics: proper breathing; avoid Valsalva maneuver • Bed mobility and transfers • Gait training with assistive devices: PWB or TTWB or WBAT as per MD/DO • AROM exercises: knee flexion and uninvolved LE exercises for SLR and isometrics • Balance exercises: single-leg standing; balance board • Proprioceptive training • Aquatic therapy: cardiovascular program with weight-bearing restrictions • Return to function training
Total Knee Arthroplasty (TKA) or Total Knee Replacement (TKR) • Replacement of degenerated articular surfaces of tibia, femur, and/or patella with metal, plastic, or combination prosthesis • Can be cemented (may loosen in time with active patients) or noncemented (longer weight-bearing restrictions to allow the surrounding bone to grow into prosthesis) • Indications for TKA: osteoarthritis, RA, pain, and reduced function	• CPM • LE circulation: ankle pumps • Isometrics: proper breathing • Bed mobility and transfers • Gait training with assistive device: PWB, WBAT as per MD/DO • Patellar mobilization • ROM exercises: AAROM exercises such as SLRs; SAQ exercises • Isotonic exercises: knee extension exercises • Stationary bike • Treadmill • CKC exercises • Balance training: balance board • Proprioceptive training • Endurance training • Aquatic therapy: cardiovascular program with weight-bearing restrictions • Return to function training
Total Shoulder Replacement (TSA)[17] • Replacement of a fractured or necrotic proximal humerus with prosthesis • Traditional TSA: Humeral head is replaced with a ball and stem prosthesis and glenoid fossa lined with a plastic cup • Hemiarthroplasty: only the humeral head is replaced with a metal ball	• Shoulder sling • Gentle AAROM exercises • Isometrics: for rotator cuff repair-no deltoid exercises • Strengthening exercises of wrist, hand, and elbow • Codman's pendulum • Scapular ROM exercises

Table 3-69 Thoracic Outlet Syndrome, Adhesive Capsulitis, Low Back Pain Symptoms, Plantar Fasciitis, and Arthroplasties: Interventions (continued)

Indication	Interventions*
• Reverse TSA: metal ball and plastic socket are reversed. The ball is placed on the glenoid fossa and the plastic cup is placed on the humerus. Rotator Cuff arthropathy usually results in need for this technique (Longer rehabilitation is needed due to the need for additional rotator cuff repairs) • Indications for TSA: osteoarthritis, avascular necrosis, osteoporosis, and rheumatoid arthritis	• Scapular stabilization exercises • HEP: wand, pulleys, or cane exercises • Light PREs: by week 6 postoperatively without rotator cuff repair • Return to function training: by 6 months postoperatively without rotator cuff repair

* Physician protocol always takes precedence over general guidelines for interventions

Table 3-70 Common Medications Used for Musculoskeletal Pathologies[19,20]

*Classes of Drugs	Purpose of Medication	*Common Side Effects	PTA Implications
Antibiotics • Penicillin (Amoxil) • Cephalosporins (Keflex) • Tetracyclines (Sumycin) • Antifolate = sulfonamides (Bactrim) • Quinolones (Cipro, Levaquin) • Other (Vancomycin)	• Prevention of infections prophylactically • Commonly used pre- and post-operatively to inhibit the growth of bacteria • Commonly used after joint surgeries or traumatic injuries/skin trauma • Can be used for skin infections (Cellulitis, osteomyelitis, staph infection)	• Nausea/vomiting • Diarrhea • Rashes • Yeast infections / urinary tract infection	• Never provide dosing or discontinuation instructions to the patient—**defer all medication related questions to the appropriate healthcare professional.** • Some antibiotics affect blood sugar levels. • Some antibiotics affect blood-clotting mechanisms. • Wash hands frequently and between patient encounters. • Use proper PPE and sanitize equipment after working with patients with suspected infection. • Prolonged quinolone use may predispose some individuals to tendinopathies/tendon rupture.

(*continues*)

Table 3-70 Common Medications Used for Musculoskeletal Pathologies[19,20] (continued)

*Classes of Drugs	Purpose of Medication	*Common Side Effects	PTA Implications
Analgesics **Opioid** • Morphine (Roxanol) • Oxycodone (Oxycontin) • Hydrocodone/APAP (Norco,Vicodin) • Codeine/APAP (Tylenol #2, #3, #4) *APAP = any drug with Tylenol included in it	• Decrease pain by blocking the signals related to the CNS • Creates a feeling of euphoria • Often used post-surgically/post-traumatically for acute and chronic pain • Treats nociceptive pain	• Orthostatic hypotension • Dizziness • Drowsiness • Constipation • Impaired judgement • Nausea/vomiting • Allergic reactions • Physical dependence • Addiction	• Increased fall risk due to orthostatic hypotension, dizziness, drowsiness. • Pain masking may result in over stressing healing tissues. • Impaired judgment may result in patient's willingness to do more than they are capable of OR more than they should tolerate (compliance with weight bearing restrictions, precautions/ contraindications).
Non-Opioid Acetaminophen (Tylenol, Excedrin)	• Antipyretic • Anti-inflammatory for mild →moderate nociceptive pain relief • Commonly used over-the-counter (OTC) medications for headaches, menstrual cramps, muscle soreness, fevers, sore throats	• Liver toxicity (associated with long term use or alcohol consumption of more than three beverages/ day)	• Safe to use with patients taking Coumadin. • Sx & Sx of liver toxicity: Jaundice (skin, eyes); right upper belly pain; dark urine color/gray colored or pale stool; extreme nausea and/ or diarrhea

Table 3-70 Common Medications Used for Musculoskeletal Pathologies[19,20] (continued)

*Classes of Drugs	Purpose of Medication	*Common Side Effects	PTA Implications
Non–steroidal Anti-Inflammatory • Aspirin (Bayer, Ecotrin)	• Antipyretic • Anti-inflammatory for mild→ moderate acute nociceptive pain and chronic pain • Commonly used over-the-counter (OTC) medications for headaches, menstrual cramps, muscle soreness, fevers, sore throats, osteoarthritis, rheumatoid arthritis, sprain, strains, bursitis • Sometimes used for anti-coagulation as per physician instruction	• Reye Syndrome (children/adolescents) • Antiplatelet effects • Nausea/vomiting • Acute kidney injury (especially with dehydration or elderly or patients with known kidney dysfunction) • Increased risk of GI bleeding/bleeding if taken with Coumadin	• ↑ Risk of bruising/ bleeding • GI bleeds (prolonged use) • Sx & Sx of acute kidney injury:distal edema in bilateral feet and hands • Sx & Sx GI Bleeds = bloody vomit, coffee ground appearance when vomiting, blood in stool or melena • Increased risk of bruising/bleeding during rehabilitation
Nonsteroidal Anti-Inflammatory (NSAIDS) • Ibuprofen (Advil, Motrin) • Naproxen (Aleve, Midol) • Ketoprofen (Orudis)	• Antipyretic • Anti-inflammatory for mild→ moderate acute nociceptive pain and chronic pain • Commonly used over-the-counter (OTC) medications for headaches, menstrual cramps, muscle soreness, fevers, sore throats, osteoarthritis, rheumatoid arthritis, sprain, strains, bursitis • May sometimes be prescribed by the physician in higher dosages	• Nausea/vomiting • Upset stomach • Acute kidney injury (especially with dehydration or elderly or patients with known kidney dysfunction) • Increased risk of GI bleeding/bleeding if taken with Coumadin or aspirin products	• Sx & Sx acute kidney injury:distal edema in bilateral feet and hands • Sx & Sx GI bleeds = bloody vomit, coffee ground appearance when vomiting, blood in stool or melena • Increased risk of bruising/bleeding during rehabilitation

(*continues*)

Table 3-70 Common Medications Used for Musculoskeletal Pathologies[19,20] (continued)

*Classes of Drugs	Purpose of Medication	*Common Side Effects	PTA Implications
Nonsteroidal Anti-Inflammatory COX-2 (Cyclooxygenase-2 Inhibitors)			
• Celecoxib (Celebrex) *prescription only	• Non-inflammatory agent that is safer on the stomach lining • Osteoarthritis/ rheumatoid arthritis • menstrual cramps, muscle soreness, fevers, sore throats, osteoarthritis, rheumatoid arthritis, sprain, strains,bursitis	• Nausea/vomiting • Upset stomach • Bleeding risk • Hypertension • Increased risk of GI bleeding/bleeding if taken with Coumadin or aspirin products • Acute kidney injury (especially with dehydration or elderly or patients with known kidney dysfunction)	• Sx & Sx acute kidney injury:distal edema in bilateral feet and hands • Sx & Sx GI bleeds = bloody vomit, coffee ground appearance when vomiting, blood in stool or melena • Increased risk of bruising/bleeding during rehabilitation
Anti-inflammatory			
Corticosteroids/glucocorticoids)			
• Cortisone • Dexamethasone (Decadron) • Methylprednisolone (Solu-Medrol) • Prednisone (Prelone)	• Suppress and reduce inflammation • Commonly used for inflammation associated to joint pain; tendonitis; bursitis pulmonary dysfunctions or exacerbations of autoimmune diseases • Targets nociceptive pain	• Elevated blood glucose levels (diabetic patients and those at high risk for diabetes) • ↑ risk of infection • ↑ risk of osteoporosis • Muscle weakness • ↑ risk of glaucoma/ cataracts • Stomach ulcers • Impaired wound healing • Insomnia • Mood changes/ psychiatric disturbances • Abnormal fat distribution to face, abdomen, upper back • edema	• Monitor glucose reactions in patients undergoing iontophoresis if dexamethasone or another steroid is being used or during therapeutic exercise • Avoid scheduling PT on same day as injection to avoid pain masking with treatment and allow inflammation reduction to occur without additional tissue stressing at the targeted injection region • Wear PPE if the patient is immunocompromised and on steroids • Observe for any mood or personality changes • Observe for osteonecrosis, tendon rupture or skin atrophy at the injection sites especially with long term use

Table 3-70 Common Medications Used for Musculoskeletal Pathologies[19,20] (continued)

*Classes of Drugs	Purpose of Medication	*Common Side Effects	PTA Implications
Neuropathic Pain Medications			
Anti-Convulsants • Gabapentin (Neurotin) • Pregabalin (Lyrica) **Anti-Depressants** • Duloxetine (Cymbalta) • Amitriptyline (Elavil) • Venlafaxine (Effexor)	• Blocks or slows nerve conduction • Indicated more for chronic non-inflammatory pain and neuropathic pain • Sometimes may be used with a fast-acting pain reliever for breakthrough pain • Used with patients with diabetic neuropathies; trigeminal nerve dysfunction; fibromyalgia, epilepsy, or depression	• Dizziness • Edema • Dry mouth • Drowsiness/fatigue • Nausea vomiting • Angioedema (Lyrica) • Confusion • Blurred vision • Hypertension (Effexor) • Bleeding risk (Cymbalta, Effexor) • Elevated glucose levels (Cymbalta, Effexor) • Suicide warning	• Pain relief effects may not be observed or reported for several weeks after they are prescribed, as these medications are often extended-release, designed to be taken daily as opposed to round-the-clock dosing • ↑ fall risk • Observe for bilateral distal edema hands and feet = kidney dysfunction • Suicidal thoughts/ tendencies • Sx & Sx of angioedema = swelling of the eyes, lips, bilateral hands and/or feet, and throat (difficulty breathing, swallowing, new onset of hoarseness since taking the medication)
Bisphosphonates • Alendronate (Fosamax) • Ibandronate (Boniva) • Zoledronic Acid (Reclast) • Risedronate (Actonel)	• Prevention and/ or treatment of osteoporosis to improve bone density	• Back pain • Severe joint pain • GERD/esophageal pain if patient does not follow instruction to sit upright x 30 minutes after ingestion • Osteonecrosis of jaw (new onset of jaw pain)	• Avoid interventions in supine position for at least 30–45 minutes after taking the drug • Be aware of any new reports of increasing muscle, bone, joint, jaw pain and inform supervising PT on record

(*continues*)

Table 3-70 Common Medications Used for Musculoskeletal Pathologies[19,20] (continued)

*Classes of Drugs	Purpose of Medication	*Common Side Effects	PTA Implications
Anticoagulants • Heparin • Warafin • Coumadin • Lovenox (does not require PT-INR monitoring)	• Prevention of DVT, PE, stroke, atrial fibrillation, or other cardiovascular related conditions	• Bruising/bleeding • Dizziness • Anemia • Nausea/vomiting • Flatulence	• Check PT-INR levels prior to treatment • PT-INR > 3.0 check with nursing or MD office before proceeding with treatment • PT-INR > 6.0 hold PT • Sx & Sx of excessive blood thinning: nosebleeds, blood shot eyes, skin bruising • ↑ Fall risk if dizziness occurs

* 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.

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