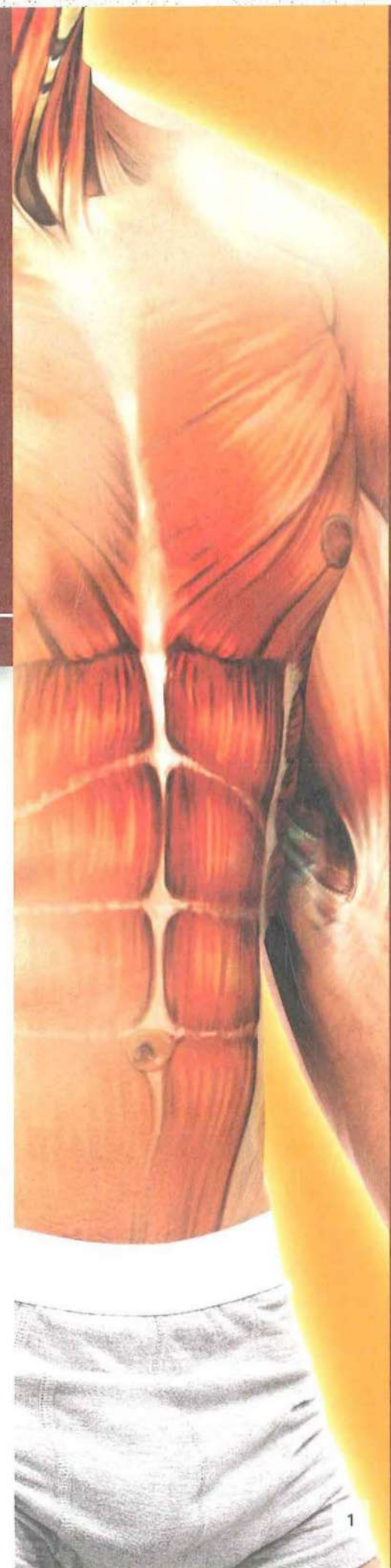




# Musculoskeletal Physical Therapy

ROBERT ROWE

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## Anatomy and Biomechanics of the Musculoskeletal System

### General Principles of Biomechanics

1. Levers. Rotations of a rigid surface about an axis. There are three types of levers.
  - a. First-class lever occurs when two forces are applied on either side of an axis.
    - (1) The effort is the force that attempts to cause movement.
    - (2) The resistance is the force that opposes movement.
    - (3) Example in human body is the contraction of triceps at elbow joint.
  - b. Second-class lever occurs when two forces are applied on one side of an axis.
    - (1) Resistance lies between the effort force and the axis of rotation.
    - (2) Few examples in human body (toe raises).
  - c. Third-class lever occurs when two forces are applied on one side of an axis.
    - (1) The effort force lies closer to the axis than the resistance force.
    - (2) Most muscles in the human body are third-class levers (elbow flexion).
2. Selected kinematics.
  - a. Arthrokinematics is defined as the movement between joint surfaces.
  - b. Three motions describe the movement of one joint surface on another.
    - (1) Roll consists of one joint surface rolling on another, such as a tire rolling on the road (e.g., movement between the femoral and tibial articular surfaces of knee).
    - (2) Glide consists of a pure translatory motion of one surface gliding on another, as when a braked wheel skids (e.g., movement of the joint surface of the proximal phalanx at the head of the metacarpal bone of the hand).
    - (3) Spin consists of a rotation of the movable component of the joint (e.g., movement between joint surfaces of radial head with humerus).
    - (4) Combinations of all three motions can occur at joints (e.g., between joint surfaces of humerus and scapula of shoulder).
  - c. Osteokinematics: movement between two bones.
  - d. Convex-concave rule describes relationship between arthrokinematics and osteokinematics.
    - (1) When a convex surface is moving on a fixed concave surface, the convex surface moves opposite to the direction of the shaft of the bony lever.
    - (2) When a concave surface moves on a fixed convex surface, the concave articulating surface moves in the same direction as the bony lever (see Table 1-1).
    - (3) In the spine, the convex rule applies at the atlanto-occipital joint. Below the second vertebra, the concave rule applies.
3. Capsular positions.
  - a. Resting or loose-packed position (see Table 1-2).
    - (1) Joint position where capsule and other soft tissues are in most relaxed position.
    - (2) Minimal joint surface contact.
    - (3) May perform joint play and mobilization techniques in this joint position.
  - b. Close-packed position (see Table 1-2).
    - (1) Joint position where capsule and other soft tissues are maximally tensed.
    - (2) Maximal contact between joint surfaces.
    - (3) Joint play and mobilization cannot be properly performed in this position.
  - c. Selected capsular patterns (see Table 1-3).
  - d. End-feels.
    - (1) Normal physiological end-feel.
      - (a) Soft: occurs with soft tissue approximation.
      - (b) Firm: capsular and ligamentous stretching.
      - (c) Hard: when bone and/or cartilage meet.
    - (2) Pathological end-feel.
      - (a) Boggy: edema, joint swelling.
      - (b) Firm with decreased elasticity: fibrosis of soft tissues.
      - (c) Rubbery: muscle spasm.
      - (d) Empty: loose, then very hard; associated with muscle guarding or patient avoiding painful part of range.
      - (e) Hypermobility: end-feel at a later time than on opposite side.
  - e. Grading of accessory joint movement.
    - (1) Accessory joint movement or joint play is graded to assess arthrokinematic motion of the joint and/or when it is impractical or impossible to measure joint motion with a goniometer (see Table 1-4).
    - (2) Although interrater reliability is poor, intrarater reliability is acceptable.
    - (3) Data gleaned provides clinician with more specific data on source of patient's problem.



Table 1-1

| Concave-Convex Rule Application |                        |  |                                     |
|---------------------------------|------------------------|--|-------------------------------------|
| ARTICULATION                    | FUNCTION               | MOVING COMPONENT OF ARTICULATION       | RELATIONSHIP OF CONVEX/CONCAVE RULE |
| Fingers                         | Flexion/extension      | Distal phalanx                         | Concave moving on Convex            |
| Metacarpal-phalangeal           | Abduction/adduction    | Proximal phalanx                       | Concave moving on Convex            |
| Wrist                           | Flexion/extension      | Capitate, scaphoid, lunate, triquetrum | Convex moving on Concave            |
|                                 |                        | Trapezoid                              | Concave moving on Convex            |
| Radioulnar                      |                        |  |                                     |
| Distal                          | Pronation/supination   | Radius                                 | Concave moving on Convex            |
| Proximal                        | Pronation/supination   | Radius                                 | Convex moving on Concave            |
| Humeroradial                    | Flexion/extension      | Radius                                 | Concave moving on Convex            |
| Humeroulnar                     | Flexion/extension      | Ulna                                   | Concave moving on Convex            |
| Glenohumeral                    | All movements          | Humerus                                | Convex moving on Concave            |
| Sternoclavicular                | Elevation/depression   | Clavicle                               | Convex moving on Concave            |
|                                 | Protraction/retraction | Clavicle                               | Concave moving on Convex            |
| Acromioclavicular               | All movements          | Scapula                                | Concave moving on Convex            |
| Toes                            | Flexion/extension      | Distal phalanx                         | Concave moving on Convex            |
| Metatarsal-phalangeal           | Abduction/adduction    | Proximal phalanx                       | Concave moving on Convex            |
| Ankle/Foot                      |                        |  |                                     |
| Subtalar                        | All movements          | Navicular, cuneiform                   | Concave moving on Convex            |
|                                 | Inversion/eversion     | Cuboid, calcaneus                      | Convex moving on Concave            |
| Talocrural                      | Dorsal/plantar flexion | Talus                                  | Convex moving on Concave            |
| Tibiofibular                    | All movements          | Fibular head                           | Concave moving on Convex            |
| Knee                            | All movements          | Tibia                                  | Concave moving on Convex            |
| Hip                             | All movements          | Femur                                  | Convex moving on Concave            |
| Temporomandibular               | All movements          | Mandible                               | Convex moving on Concave            |

Adapted from Kaltenborn FM: Manual Mobilization of the Extremity Joints, 4th ed. FM Kaltenborn, 1989.

Table 1-2

| Joint Positions           |  |  |
|---------------------------|--|--|
| ARTICULATIONS             | RESTING POSITION   | CLOSE-PACKED POSITION  |
| Vertebral                 | Midway between flexion and extension   | Maximal extension  |
| Temporomandibular         | Jaw slightly open (freeway space)  | Maximal retrusion (mouth closed with teeth clenched) or maximal anterior position mouth maximally opened |
| Sternoclavicular          | Arm resting by side  | Arm maximally elevated   |
| Acromioclavicular         | Arm resting by side  | Arm abducted 90°   |
| Glenohumeral              | 55°–70° abduction; 30° horizontal adduction; neutral rotation                          | Maximum abduction and ER   |
| Elbow                     |  |  |
| Humeroulnar               | 70° flexion and 10° supination   | Full extension and supination  |
| Humeroradial              | Full extension and supination  | 90° flexion and 5° supination  |
| Forearm                   |  |  |
| Proximal radioulnar       | 70° flexion and 35° supination   | 5° supination and full extension   |
| Distal radioulnar         | 10° supination   | 5° supination  |
| Radio/ulnocarpal          | Neutral with slight ulnar deviation  | Full extension with radial deviation   |
| Hand                      |  |  |
| Midcarpal                 | Neutral with slight flexion and ulnar deviation  | Full extension   |
| Carpometacarpal (2–5)     | Midway between flexion/and extension, mid flexion, and mid extension                   | Full opposition  |
| Trapeziometacarpal        | Midway between flexion/extension and between abduction/adduction                       | Full opposition  |
| Metacarpophalangeal (MCP) | First MCP joint: slight flexion<br>MCP joints 2–5: slight flexion with ulnar deviation | First MCP joint: full extension<br>MCP joints 2–5: full flexion  |
| Interphalangeal (IP)      | Proximal IP joints: 10° flexion<br>Distal IP joints: 30° flexion                       | Full extension   |

(Continued)



Table 1-2

| Joint Positions (Continued) |   |  |
|-----------------------------|---|--|
| ARTICULATIONS               | RESTING POSITION  | CLOSE-PACKED POSITION  |
| Hip                         | 30° flexion, 30° abduction, and slight lateral rotation             | Ligamentous: full extension, abduction, and internal rotation<br>Bony: 90° flexion, slight abduction, and slight ER<br>Full extension and ER |
| Knee                        | 25° flexion   |  |
| Ankle/Foot                  |   | Full dorsiflexion  |
| Talocrural                  | Mid inversion/eversion and 10° plantar flexion                      | Full inversion   |
| Subtalar                    | Midway between extremes of range of motion with 10° plantar flexion | Full supination  |
| Midtarsal                   | Midway between extremes of range of motion with 10° plantar flexion | Full supination  |
| Tarsometatarsal             | Midway between supination and pronation                             |  |
| Toes                        |   | Full extension   |
| Metatarsophalangeal         | Neutral (extension 10°)   | Full extension   |
| Interphalangeal             | Slight flexion  |  |

Adapted from Herfing DH, Kessler RM: Management of Common Musculoskeletal Disorders: Physical Therapy Principles and Methods, 3rd ed. Lippincott, 1996.

Table 1-3

| Capsular Patterns                           |  |
|---|--|
| ARTICULATIONS                               | RELATIVE LIMITATIONS OF MOVEMENT   |
| Temporomandibular                           | Limited mouth opening  |
| Upper cervical spine (occiput-C2)           |  |
| Occipitoatlantal joint                      | Forward flexion limited greater than extension   |
| Atlantoatlantal joint                       | Limitation with rotation   |
| Lower cervical spine (C3-T2)                | Limitation of all motions except flexion (side-bending and rotation equally limited and both greater than extension) |
| Glenohumeral                                | Greater limitation of ER, followed by abduction and internal rotation  |
| Sternoclavicular                            | Full elevation limited; pain at extreme range of motion  |
| Acromioclavicular                           | Full elevation limited; pain at extreme range of motion  |
| Humeroulnar                                 | Loss of flexion more so than extension   |
| Humeroradial                                | Loss of flexion more so than extension   |
| Proximal radioulnar                         | Limitation: pronation = supination   |
| Distal radioulnar                           | Limitation: pronation = supination   |
| Wrist                                       | Limitation: flexion = extension  |
| Midcarpal                                   | Limitation: equal all directions   |
| Trapeziometacarpal                          | Limitation: abduction more so than extension   |
| Carpometacarpals II-V                       | Equally restricted all directions  |
| Upper extremity digits                      | Limitation: flexion > extension  |
| Thoracic Spine                              | Limitation of side-bending and rotation > loss of extension > flexion  |
| Lumbar spine                                | Marked and equal limitation of side-bending and rotation; loss of extension > flexion                                |
| Sacroiliac, symphysis pubis, sacrococcygeal | Pain when joints are stressed  |
| Hip   | Limited flexion/internal rotation; some limitation of abduction; no or little limitation of adduction and ER         |
| Knee  | Flexion grossly limited; slight limitation of extension  |
| Tibiofibular (Proximal & Distal)            | Pain when joint is stressed  |
| Talocrural                                  | Loss of plantarflexion greater than dorsiflexion   |
| Talocalcaneal (subtalar)                    | Increasing limitations of varus; joint fixed in valgus (inversion > eversion)  |
| Midtarsal                                   | Supination > pronation (limited dorsiflexion, plantar flexion, adduction, and medial rotation)                       |
| First metatarsophalangeal                   | Marked limitation of extension; slight limitation of flexion   |
| Metatarsophalangeal (II-V)                  | Variable; tend toward flexion restrictions   |
| Interphalangeal                             | Tend toward extension restrictions   |

Adapted from Herfing DH, Kessler RM: Management of Common Musculoskeletal Disorders: Physical Therapy Principles and Methods, 3rd ed. 1996.

Table 1-4

| Manual Grading of Accessory Joint Motion |                            |
|--|----------------------------|
| ASSESSED GRADE OF MOVEMENT               | CLASSIFICATION OF JOINT    |
| 0  | Ankylosed                  |
| 1  | Considerable hypomobility  |
| 2  | Slight hypomobility        |
| 3  | Normal                     |
| 4  | Slight hypermobility       |
| 5  | Considerable hypermobility |
| 6  | Unstable                   |

Adapted from Grieve GP: *Mobilization of the Spine: A Primary Handbook of Clinical Method*, 5th ed. Churchill Livingstone, 1991.

#### 4. Muscle substitutions.

- Occur when muscles have become shortened/lengthened, weakened, lost endurance, developed impaired coordination, or paralyzed.
- Stronger muscles compensate for loss of motion.
- Common muscle substitutions:
  - Use of scapular stabilizers to initiate shoulder motion when shoulder abductors are weakened (reverse scapulothoracic rhythm).
  - Use of lateral trunk muscles or tensor fascia latae (TFL) when hip abductors are weak.
  - Use of passive finger flexion by contraction of wrist extensors when finger flexors are weak (tenodesis).
  - Use of long head of biceps, coracobrachialis, and anterior deltoid when pectoralis major is weak.
  - Use of lower back extensors, adductor magnus, and quadratus lumborum when hip extensors are weak.
  - Use of lower abdominal, lower obliques, hip adductors, and latissimus dorsi when hip flexors are weak.

## Functional Anatomy and Biomechanics

Figures 1-1, 1-2, 1-3, and 1-4.

### 1. Shoulder region.

- Osteology (humerus, scapula, and clavicle).
  - Humerus (see Figure 1-5).
    - Proximal end of humerus is approximately half a spheroid.
    - Articular surface is covered by hyaline cartilage.

- Head is retroverted  $20^{\circ}$ – $30^{\circ}$ .
- Longitudinal axis of head is  $135^{\circ}$  from axis of neck.

### (2) Scapula.

- Large, flat triangular bone that sits over second to seventh ribs.
- Costal surface and a dorsal surface.
- Three angles: medial, superior, and lateral.
- Lateral angle bears glenoid fossa, which faces anteriorly, laterally, and superiorly.
  - Pear shape of fossa allows for freer range of motion (ROM) in abduction and flexion.
  - Concave shape receives convex humeral head.
  - Orientation of the glenoid fossa places true abduction at  $30^{\circ}$  anterior to frontal plane.

### (3) Clavicle.

- Extends laterally and links manubrium to acromion.
- Connects shoulder complex to axial skeleton.

### b. Arthrology (glenohumeral, sternoclavicular, acromioclavicular, and scapulothoracic).

#### (1) Glenohumeral joint.

- Convex humeral head articulates with concave glenoid fossa.
- Glenoid fossa very shallow.

#### (2) Sternoclavicular joint.

- Convex (superior/inferior) and concave (anterior/posterior) articulates with reciprocal shape of sternum.
- Both articulations covered with fibrocartilage.

#### (3) Acromioclavicular joint.

- A plane joint with relatively flat surfaces.

#### (4) Scapulothoracic joint.

- A "clinical" articulation.

### c. Muscles (depressors, elevators, protractors, retractors, internal rotators, external rotators, flexors, abductors, adductors, and extensors) (see Table 1-5).

### d. Noncontractile structures (acromioclavicular, trapezoid, conoid, and sternoclavicular ligament, subacromial bursa, shoulder capsule, glenoid labrum and associated nerves and vessels).

#### (1) Capsule.

- Attaches medially to glenoid margin, glenoid labrum, coracoid process.
- Attaches laterally to humeral anatomical neck and descends approximately 1 cm on the shaft.
- Supported by tendons of supraspinatus, infraspinatus, teres minor, subscapularis, and long head of triceps below.
- Inferiorly capsule is least supported and most lax.



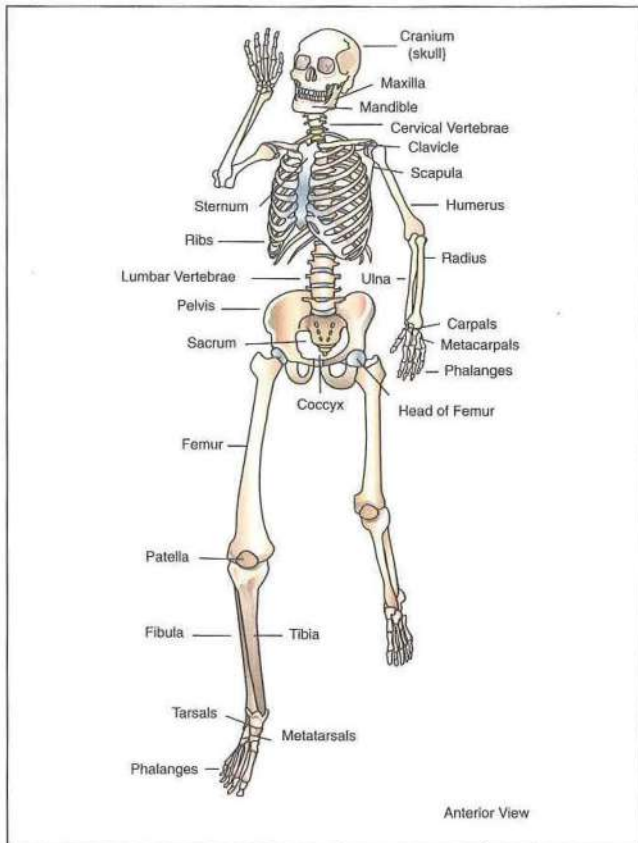


Figure 1-1 Skeletal system—anterior view.

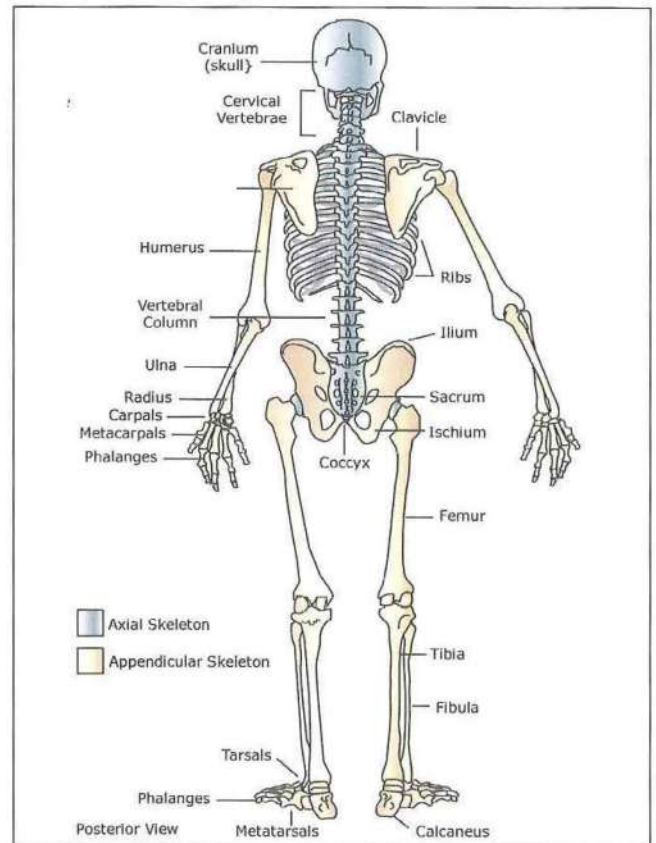


Figure 1-2 Skeletal system—posterior view.

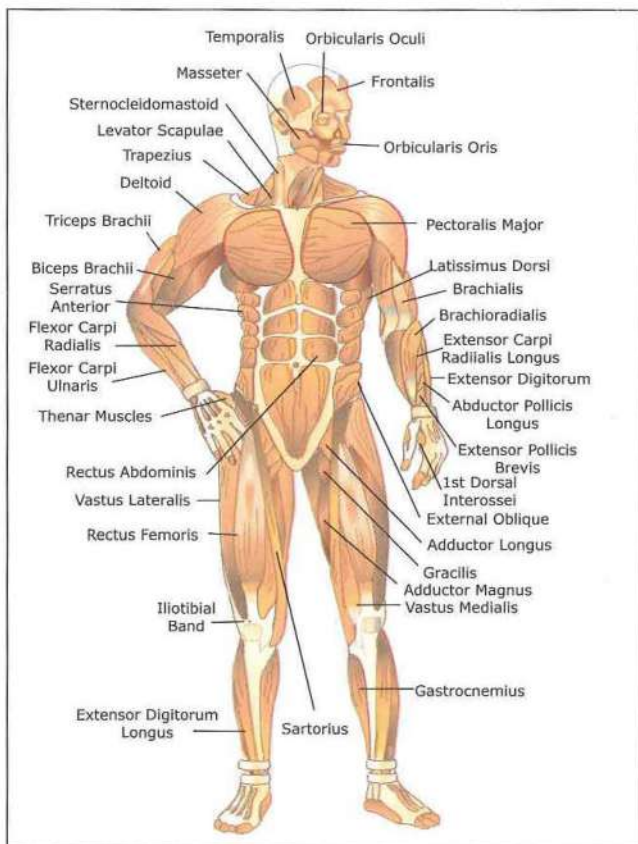


Figure 1-3 Muscular system—anterior view.

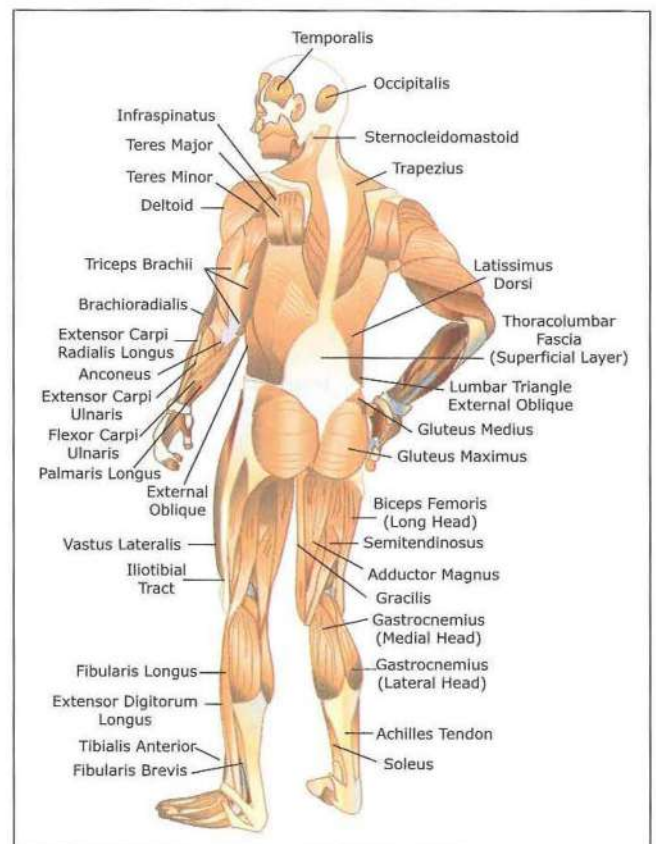
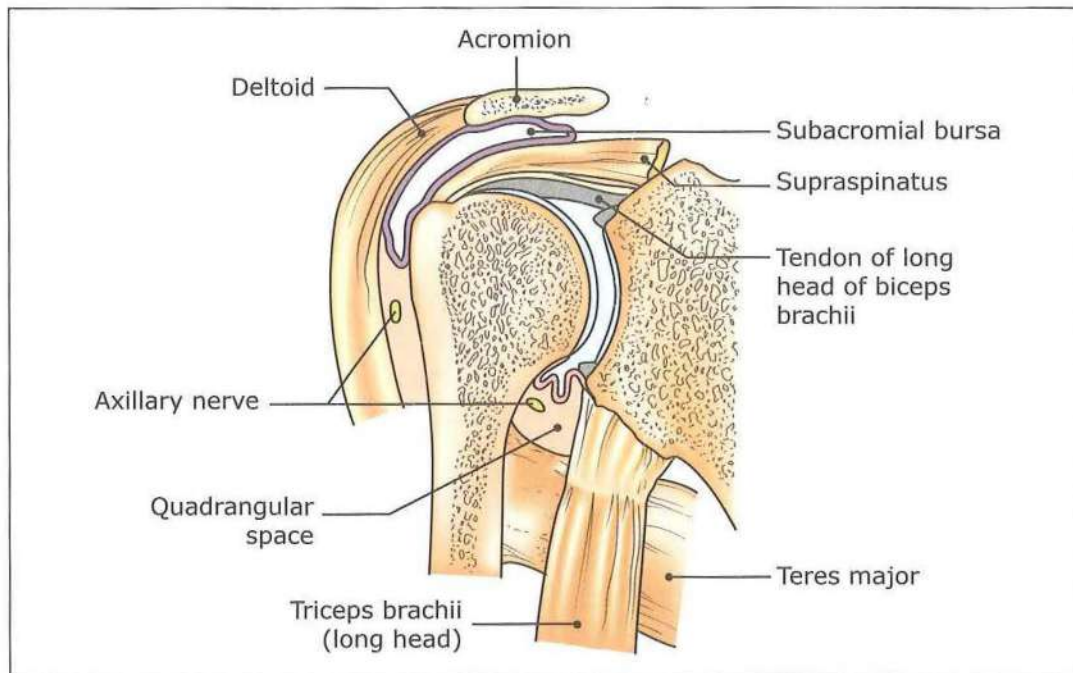


Figure 1-4 Muscular system—posterior view.



**Figure 1-5** Coronal section of shoulder.

**Table 1-5**

| Shoulder Girdle and Upper Extremity Muscular and Neurological Screening |   |          |          |              |                                  |
|---|---|----------|----------|--------------|----------------------------------|
| ACTION TO BE TESTED   | MUSCLES   | MYOTOMES | REFLEXES | CORD SEGMENT | NERVES                           |
| Neck flexion<br>Neck extension<br>Neck rotation<br>Neck lateral bending | Sternocleidomastoid,<br>trapezius, other deep<br>neck muscles |          |          | C1–C4        | Cervical spinal accessory        |
| Shoulder shrug, scapular<br>upward rotation                             | Upper trapezius   | C4       |          | C1–C4        | Spinal accessory                 |
| Shoulder horizontal<br>adduction  | Pect. major/minor   |          |          | C5–C8, T1    | Medial/lateral pectoral          |
| Scapular downward rotation  | Pectoralis minor  |          |          | C8–T1        | Medial pectoral                  |
| Shoulder protraction, scapular<br>upward rotation                       | Serratus anterior   |          |          | C5–C7        | Long thoracic                    |
| Scapular elevation, downward<br>rotation                                | Levator scapula   |          |          | C5           | Dorsal scapular                  |
| Scapular adduction, elevation,<br>downward rotation                     | Rhomboids   |          |          | C4–C5        | Dorsal scapular                  |
| Shoulder abduction  | Supraspinatus   |          |          | C4–C6        | Suprascapular                    |
| Shoulder lateral rotation   | Infraspinatus   |          |          | C4–C6        | Suprascapular                    |
| Shoulder medial rotation,<br>adduction                                  | Latissimus dorsi, teres major,<br>and subscapularis           |          |          | C5–C8        | Subscapular and<br>thoracodorsal |
| Shoulder abduction, flexion,<br>extension                               | Deltoid   | C5       |          | C5–C6        | Axillary                         |
| Shoulder lateral rotation   | Teres minor   |          |          | C4–C5        | Axillary                         |
| Elbow flexion, forearm<br>supination                                    | Biceps brachii  | C6       | C5       | C5–C6        | Musculocutaneous                 |
| Shoulder flexion, adduction   | Coracobrachialis  |          |          | C6–C7        | Musculocutaneous                 |

(Continued)



Table 1-5

| Shoulder Girdle and Upper Extremity Muscular and Neurological Screening (Continued) |  |          |          |              |                                |
|---|--|----------|----------|--------------|--------------------------------|
| ACTION TO BE TESTED   | MUSCLES  | MYOTOMES | REFLEXES | CORD SEGMENT | NERVES                         |
| Elbow flexion   | Brachialis   |          |          | C5–C6        | Musculocutaneous               |
| 4th and 5th digit DIP flexion   | Flexor digitorum (ulnar part)                                  |          |          | C7–T1        | Ulnar profundus                |
| Wrist ulnar flexion   | Flexor carpi ulnaris   | C7       |          | C7–T1        | Ulnar                          |
| Thumb adduction   | Adductor pollicis  |          |          | C8–T1        | Ulnar                          |
| 5th digit abduction   | Abductor digiti  |          |          | C8–T1        | Ulnar quinti                   |
| 5th digit opposition  | Opponens digiti  |          |          | C7–T1        | Ulnar quinti                   |
| 5th digit MCP flexion   | Flexor digiti quinti   |          |          | C7–T1        | Ulnar brevis                   |
| 2nd–5th digit MCP flexion, adduction, abduction                                     | Interossei   | T1       |          | C8–T1        | Ulnar                          |
| Forearm pronation   | Pronator teres, pronator quadratus                             |          |          | C6–C7        | Median                         |
| Wrist radial flexion  | Flexor carpi radialis  |          |          | C6–C7        | Median                         |
| Wrist flexion   | Palmaris longus  |          |          | C7–T1        | Median                         |
| 2nd–5th digit proximal IP flexion   | Flexor digitorum sublimis                                      |          |          | C7–T1        | Median                         |
| Thumb IP flexion  | Flexor pollicis longus   |          |          | C7–T1        | Median                         |
| 2nd–3rd digit distal IP flexion   | Flexor digitorum   |          |          | C7–T1        | Median profundus (radial part) |
| Thumb abduction   | Abductor pollicis brevis                                       |          |          | C6–T1        | Median                         |
| Thumb MCP flexion   | Flexor pollicis brevis   |          |          | C6–T1        | Median/ulnar                   |
| Thumb opposition  | Opponens pollicis  |          |          | C8–T1        | Median                         |
| 2nd–5th digit MCP flexion, IP extension   | Lumbricals   |          |          | C8–T1        | Median/ulnar                   |
| Elbow flexion   | Brachioradialis  |          | C6       | C5–C6        | Radial                         |
| Elbow extension   | Triceps brachii, anconeus                                      |          | C7       | C6–C8        | Radial                         |
| Wrist radial extension  | Extensor carpi radialis  |          |          | C6–C8        | Radial                         |
| 2nd–5th digit MCP, IP extension   | Extensor digitorum communis<br>extensor digiti quinti proprius |          |          | C6–C8        | Radial                         |
| Wrist ulnar extension   | Extensor carpi ulnaris   |          |          | C6–C8        | Radial                         |
| Forearm supination  | Supinator  |          |          | C5–C6        | Radial                         |
| Thumb MCP abduction   | Abductor pollicis longus                                       | C8       |          | C7–C8        | Radial                         |
| Thumb extension   | Extensor pollicis longus/brevis                                |          |          | C6–C8        | Radial                         |
| 2nd digit extension   | Extensor indicis proprius                                      |          |          | C6–C8        | Radial                         |

Adapted from Chusid JG: Correlative Neuroanatomy and Functional Neurology. Lange Medical Publications, 1970; Kendall FP, McCreary EK, Provance PG: Muscles Testing and Function, 4th ed. Williams & Wilkins, 1993.

## (2) Ligaments.

## (a) Coracohumeral ligament.

- Base of coracoid process to greater and lesser tubercle of humerus.
- Primary function to reinforce biceps tendon, reinforce superior capsule, and prevent caudal dislocation of humerus. Taut with external rotation (ER).

## (b) Coracoacromial ligament.

- Strong triangular ligament runs from coracoid to acromion.
- Not a "true" ligament; connects two points of same bone.

## (c) Glenohumeral ligaments.

- Three bands (superior, middle, and inferior) located on anterior glenohumeral joint.
- Reinforce anterior glenohumeral capsule.

- (d) Transverse humeral ligament.
- Broad band passing over top of bicipital groove.
  - Acts as a retinaculum for long biceps tendon.
- (3) Labrum.
- (a) Glenoid labrum is a fibrocartilaginous ring that deepens glenoid fossa.
  - (b) Attached to capsule superiorly and inferiorly as well as to the long head of the biceps tendon superiorly.
  - (c) Internal surface covered with articular cartilage, which is thicker peripherally and thinner centrally.
  - (d) Aids in lubrication, as in meniscus of knee, and serves to protect the bone.
- (4) Bursae.
- (a) Multiple bursae found within this region.
  - (b) Primary bursa involved with pathology is subacromial bursa between deltoid and capsule. Also runs under acromion and coracoacromial ligament and between the supraspinatus tendon.
- e. Shoulder biomechanics.
- (1) Glenohumeral joint arthrokinematics/osteokinematics.
    - (a) Occurs in opposite directions. With elevation of humerus, head of humerus moves in an inferior direction because of convex moving on concave.
    - (b) Rolling-gliding occurs during elevation of the humerus, so that the instantaneous center of rotation varies considerably during the complete range.
    - (c) At approximately 75° of elevation, ER (conjoint rotation) occurs, preventing compression of greater tubercle against the acromion.
  - (2) Scapulothoracic and glenohumeral rhythm (scapulohumeral rhythm) is the ratio of movement of the glenohumeral with the scapulothoracic joint.
    - (a) With 180° of abduction, there is a 2:1 ratio of movement between the two joints.
    - (b) First 30°–60° of elevation occurs mainly in the glenohumeral joint.
    - (c) 120° of movement occurs at glenohumeral joint.
    - (d) 60° of movement occurs at scapulothoracic joint.
  - (3) Requirements of full elevation.
    - (a) Scapular stabilization.
    - (b) Inferior glide of humerus.
    - (c) ER of humerus.
    - (d) Rotation of the clavicle at sternoclavicular joint.
    - (e) Scapular abduction and lateral rotation of acromioclavicular joint.
    - (f) Straightening of thoracic kyphosis.
2. Elbow region.
- a. Osteology and arthrology (ulnohumeral, radiohumeral, superior, and inferior radioulnar).
    - (1) Humeroulnar joint (see Figure 1-6).
      - (a) Distal end humerus (trochlea) articulates with proximal end of ulna.
      - (b) Trochlea and trochlear notch face anteriorly at a 45° angle, allowing space between ulna and humerus during flexion.
    - (2) Humeroradial joint.
      - (a) Distal end humerus (capitulum) articulates with concave oval facet of proximal radius.
    - (3) Proximal radioulnar joint.
      - (a) Radial head is ovoid and cone-shaped.
      - (b) Medial radius articulates with radial notch (of ulna).
    - (4) Distal radioulnar joint.
      - (a) Convex ulna articulates with concave radius (opposite to proximal articulation of these two bones).
  - b. Muscles (flexors, extensors, supinators, and pronators) (see Table 1-5).
  - c. Noncontractile structures (medial collateral ligament, radial collateral ligament, annular ligament, elbow capsule, associated bursae, nerves, and vessels).
    - (1) Capsule.
      - (a) Encloses entire elbow joint complex. It is thin, both anteriorly and posteriorly. Continuous medially with ulnar collateral ligament and laterally with radial collateral ligament.
    - (2) Ligaments.
      - (a) Ulnar collateral.
        - Ligament is triangular shaped consisting of three parts.
        - Reinforces humeroulnar joint medially.
      - (b) Radial collateral.
        - Ligament is fan shaped and runs from lateral epicondyle of humerus to annular ligament.
        - Reinforces humeroradial joint laterally.
      - (c) Annular.
        - An osteofibrous ring attached to medial ulna and encircles radial head.
        - Cone shaped, inner surface is lined with fibrocartilage.
        - Protects radial head, especially in semi-flexion, where it is very unstable. Taut in extremes of pronation and supination.