Chapter 3:
Applied Kinesiology

ACE Personal Trainer Manual
Third Edition
Introduction

• Kinesiology is the study of the body’s infinite number of movements, positions, and postures and is grounded in the principles of two (2) sciences: anatomy and mechanics.

• Biomechanics is mechanics applied to living things.
Biomechanics

• Motion is a change in an object’s position in relation to another object.

• It is necessary to choose a reference point to determine whether an object is moving or at rest.

• There are two (2) primary reference points in the body: the joints and segments.
Biomechanics

- Segments are body parts between two (2) joints. Ex., upper-arm segment between the shoulder & elbow

- There are four (4) basic types of motion:
  1. Rotary (tied down at a fixed point)
  2. Translatory (moves in straight line, same direction & speed)
  3. Curvilinear (rotary & translatory work together for the motion)
  4. General plane motion (motions are simultaneously linear & rotary)
Biomechanics

- A force is something that tends to cause motion. Simply stated, it is a push or pull exerted by one object on another.
  - Motive force - causes an increase in speed or a change in direction
  - Resistive force - resists the motion of another external force
Biomechanics

- There are several terms used in kinesiology to describe the various muscular actions as it relates to force:
  - Concentric - muscle acts as the motive force and shortens as it creates muscle tension
  - Eccentric - muscle acts as the resistive force and lengthens as it creates muscle tension
  - Isometric - muscle tension is created but no apparent change in length occurs
Biomechanics

- Flexion and extension occur in the sagittal plane.
Biomechanics

• Abduction and adduction occur in the frontal plane.
Biomechanics

• Body segments work as a system of levers as they rotate around the joints. A lever is a rigid bar with a fixed point around which it rotates when an external force is applied.

• The axis of rotation is the imaginary line or point about which the lever rotates. It intersects the center of the joint and is perpendicular to the plane of movement.
Physical Laws Affecting Motion

- Overuse and stress injuries can result from the body’s inability to withstand impact and reaction forces.
- Overuse and stress injuries can occur in weight-training activities which involve momentum:

  The force of the tissues involved in stopping the motion must match the mass of the weight and body segment multiplied by the acceleration of the weight and body segment.
Biomechanics

- More resistance can be created with the same amount of weight by moving the weight farther from the working joint.

- To lessen the resistance as fatigue occurs, move the weight closer to the working joint.
Biomechanics

- There are several kinds of muscle fiber arrangements:
  - Penniform (fibers lie diagonal to the line of pull)
  - Longitudinal (fibers run in the same direction as the muscle)

- The line of pull is generally thought of as a straight line between the muscle’s two (2) points of attachment.

- Most of the body’s muscles are penniform muscles which are designed for higher force production than longitudinal.
Balance & Alignment

- The body’s center of gravity is the point at which its mass is considered to concentrate and where it is balanced on either side in all planes (frontal, sagittal, transverse).

- The body’s center of mass is also considered to be its center of gravity.
Balance & Alignment

- To maintain balance without moving, a person’s line of gravity must fall within the base of support.

- A large, wide base of support is more stable than a small, narrow one; thus, standing with one’s feet apart and toes turned out is more stable than placing them parallel and close together.
Posture & Muscle Imbalance

• Neutral alignment occurs when the parts of the body are balanced and symmetrical around the line of gravity: the right and left halves of the body are mirror images of each other and the body is balanced from the front to the back allowing the spine to display its natural curves.
Posture & Muscle Imbalance

- Muscular imbalances manifest themselves in a person’s posture and alignment and are frequently influenced by work and standing, sitting, and moving habits.
Posture & Muscle Imbalance

• Kyphosis-lordosis - increase in the normal inward curve of the low back, often accompanied by a protruding abdomen and buttocks, outward curve of the thoracic spine, rounded shoulders, and forward-tilted head.
Posture & Muscle Imbalance

- Scoliosis is a lateral curve of the spine. There are usually two curves on opposite sides of the spine that compensate for each other.
# Posture & Muscle Imbalance

<table>
<thead>
<tr>
<th>Malalignment</th>
<th>Possible Tight Muscles</th>
<th>Possible Weak Muscles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lordosis</td>
<td>Lower back (erectors), hip flexors</td>
<td>Abdominals (especially obliques), hip extensors</td>
</tr>
<tr>
<td>Flat-Back</td>
<td>Upper abdominals, hip extensors</td>
<td>Lower back (erectors), hip flexors</td>
</tr>
<tr>
<td>Sway-Back</td>
<td>Upper abdominals, hip flexors</td>
<td>Oblique abdominals, hip extensors</td>
</tr>
<tr>
<td>Kyphosis</td>
<td>Internal oblique, shoulder adductors (pectoralis and latissimus), intercostals</td>
<td>Erector spinae of the thoracic spine, scapular adductors (mid &amp; lower trapezius)</td>
</tr>
<tr>
<td>Forward-Head</td>
<td>Cervical extensors, upper trapezius</td>
<td>Neck flexors</td>
</tr>
</tbody>
</table>
Human Motion Terminology

- **Agonist (prime mover)** - a muscle that causes a desired motion.

- **Antagonist** - muscles that have the potential to oppose the action of the agonist.

Ex., if shoulder flexion is the desired action (without gravity as a factor), the shoulder flexors are the agonists and the shoulder extensors are the antagonists.
Human Motion Terminology

• Synergist - muscles that assist the agonist in causing a desired action; may act as joint stabilizers or may neutralize rotation.

• Co-contraction - when the agonist and antagonists contract together and a joint must be stabilized.

• Stabilizer - muscles that must co-contract to protect a joint and maintain alignment.
Human Motion Terminology

- **Isometric** - no visible movement occurs and resistance matches the muscular tension.
  
  Ex., bodybuilders use isometric action when they strike a pose to show their muscle development.

- **Concentric** - the muscle shortens and overcomes a resistive force.
  
  Ex., the biceps brachii act concentrically in the up-phase of a biceps curl with a dumbbell.

- **Eccentric** - the muscle lengthens and produces force; “putting on the brakes.”
  
  Ex., the biceps brachii act eccentrically in the return phase of a biceps curl performed with a dumbbell.
Muscles & Movements of the Pelvis & Lower Extremity

Pelvis & Lumbar Spine

• Neutral spine is the central position of the lumbar spine and pelvis, not flexed, extended, tilted, or rotated.

• Hyperextension is the extreme or excessive extension of the joint.

• Motion of the lumbar spine includes flexion, extension, hyperextension, lateral flexion, and rotation.
Muscles & Movements of the Pelvis & Lower Extremity

Lumbar Extensors

• The erector spinae muscles extend, hyperextend, and laterally flex the spine.

• To strengthen the erector spinae muscles, use an extension machine or flex forward over the edge of a bench, table, or stability ball for full range of motion.
Muscles & Movements of the Pelvis & Lower Extremity

Lumbar Extensors

• To stretch the erector spinae, lie supine with the hips and knees flexed toward the shoulders.

• An important part of training the lumbar muscles is holding the lower back in neutral when lifting heavy objects and performing squats and lunges, particularly when using resistance.
Muscles & Movements of the Pelvis & Lower Extremity

Lumbar Flexors

- The most superficial of the abdominal muscles are the external obliques.

- The aponeurosis forms the outer layer of the connective-tissue sheath that covers the rectus abdominis muscle.
Muscles & Movements of the Pelvis & Lower Extremity

Lumbar Flexors

- The deepest abdominal muscle is the transversus abdominis.

- One way to train the abdominals to stabilize the pelvis against the changing resistance of moving arms & legs is the “press-and-reach” exercise.
Muscles & Movements of the Pelvis & Lower Extremity

Muscles Acting to Tilt the Pelvis

• Active anterior pelvic tilt is achieved by contraction of the iliopsoas muscle and/or the lower-back muscles, depending on the body’s position relative to gravity.

• The tilt-and-curl is an exercise used to train the abdominals to actively flex the spine through the full range of motion.
Muscles Acting at the Hip Joint

Anterior Hip Muscles

- The anterior hip muscles include:
  - Iliopsoas
  - Rectus femoris
  - Sartorius
  - Tensor fasciae latae
  - Pectineus

- The iliopsoas is actually three (3) muscles:
  1. Psoas major
  2. Psoas minor
  3. Iliacus
Muscles Acting at the Hip Joint

Posterior Hip Muscles

• The hip extensor muscles include:
  – Gluteus maximus
  – Hamstrings (biceps femoris, semimembranosus, semitendinosus)

• The largest muscle in this group is the gluteus maximus.
Muscles Acting at the Hip Joint

Posterior Hip Muscles

• To stretch the hamstrings, combine an anterior tilt of the pelvis with hip flexion and knee extension.
Muscles Acting at the Hip Joint

Medial Hip Muscles

• The muscles located medial to the hip joint adduct and internally rotate the hip. They include:
  - Pectineus
  - Adductor magnus, minimis, longus, & brevis
  - Gracilis

• These muscles function primarily as thigh stabilizers, especially during movement such as lunges.
Muscles Acting at the Hip Joint

Medial Hip Muscles

• The medial hip muscles can be trained by doing squats with the knees held together or by placing a ball between the knees.
Muscles Acting at the Knee Joint

The knee is a hinge joint, so for general training purposes, primary motions are flexion & extension.
Muscles Acting at the Knee Joint

Anterior Muscles

• The knee extensors are the four (4) quadriceps muscles:
  - Rectus femoris
  - Vastus medialis
  - Vastus intermedius
  - Vastus lateralis
Muscles Acting at the Knee Joint

Anterior Muscles

• During a squat, the hip & knee extensors contract eccentrically to control hip & knee flexion to the down-phase of the movement.

• The motive forces are the weight of the torso and upper body.

• The resistive forces are the eccentric contractions of the hip and knee extensors.
Muscles Acting at the Knee Joint

Anterior Muscles

• The best way to avoid a knee injury in squats & lunges is to limit the degree of knee flexion to no more than 90 degrees.
Muscles Acting at the Knee Joint

Posterior Muscles

- The primary knee flexors are the hamstrings.

- The secondary knee flexors include the gastrocnemius, sartorius, gracilis, and popliteus.

- The popliteus is a stabilizer that prevents knee dislocation when a squatting position is maintained. It also unlocks the knee by inwardly rotating from the anatomical position.
Muscles Acting at the Knee Joint

Posterior Muscles Acting at the Ankle

- The primary function of the plantarflexors is to rotate the leg (and everything above it) around the ankle.

- The gastronomies and soleus both work to elevate the heel; however, the soleus works to elevate the heel when the knee is bent.
Muscles Acting at the Knee Joint

Anterior Muscles Acting at the Ankle

• The dorsiflexors are the first line of defense in high-impact activities with regard to shock absorption.

• The dorsiflexors also control foot movements important to balance during walking & running, particularly on uneven ground.

• Toe-tapping will provide a thorough warm-up & strengthening of the dorsiflexors.
Upper-Body Muscles

- Shoulder and upper-arm movements are the result of a combination of movements of several joints, primarily the scapulae and the glenohumeral joint. This synchronization is known as scapulohumeral movement.

- Retraction - scapular adduction

- Protraction - scapular abduction
Upper-Body Muscles

- Posterior shoulder girdle muscles connect the scapula to the back of the head & torso, particularly the spine. They include:
  - Trapezius
  - Rhomboids major & minor
  - Levator scapulae
Upper-Body Muscles

- Anterior shoulder girdle muscles attach the scapulae to the front of the chest. They include:
  - Serratus anterior
  - Pectoralis minor
Upper-Body Muscles

- The shoulder is called the glenohumeral joint. It is the articulation between the glenoid fossa of the scapula and the humerus. It is a multiaxial joint.
Upper-Body Muscles

- The rotator cuff muscles rotate the shoulder joint and are located on the scapula. They are stabilizers as well as movers.

- The rotator cuff muscles can be remembered as SITS:
  - S - supraspinatus
  - I - infraspinatus
  - T - teres minor
  - S - subscapularis