ACE Personal Trainer Exam Review Course

Foundational Knowledge- Applied Sciences for Domains I,II and III

ACE and the Exam

A. About ACE

1) ACE is dedicated to promoting physical activity and protecting consumers against unsafe and ineffective fitness products and instruction

2) ACE sponsors university-based exercise science research that targets fitness products and trends

3) One of only a few certifying organizations to be accredited by the National Commission for Certifying Agencies (NCCA)

http://www.acefitness.org/aboutace/accreditation.aspx

B. What makes ACE different?

1) ACE exams are legally defensible

2) ACE develops its study materials without using the actual exam

3) Rather than teaching answers to the exam, ACE prepares you to be a safe and effective personal trainer

C. About the ACE exam

1) Multiple-choice portion (accounts for 75% of total exam score)
   a. 150 questions
2) Written simulation portion (accounts for 25% of total exam score)
   a. Two client scenarios designed to simulate situations that a personal trainer might encounter in actual practice
   b. 1 hour to complete

3) Number of correct answers to pass the exam
   a. The number will vary because each version of the exam has a different level of difficulty
   b. For example: a candidate may have to answer 67% of the questions correctly on one version and 70% on another version

4) How is the exam developed?
   a. Questions are written using the Personal Trainer Exam Content Outline
   b. Exam content
      1. Client interview and assessment (32%)
      2. Program design and implementation (33%)
      3. Program progression, modification and maintenance (27%)
      4. Professional role and responsibility (8%)

*NOTE: Applied Sciences are foundational knowledge to Domains I, II and III. To view the complete and most current exam content outline visit

http://www.acefitness.org/ptexamcontent/ExamOutlineUpdates.pdf

5) Who administers the exam?
   a. CASTLE Worldwide, Inc., an independent, professional testing company
   b. Ensures exam security and integrity, and eliminates bias
6) Eligibility requirements for the exam
a. 18 years of age
b. Current CPR

----END----
Unit Goal:
The student will analyze complex problems to determine the best solutions to challenges dealing with exercise physiology, kinesiology and elementary biomechanics, anatomy, motor learning and control, nutrition and healthy eating, weight management, stress management, and basic behavioral sciences.

Objectives:

Upon completion of the *Foundational Knowledge-Applied Sciences* module the student will be able to:

1) Discuss applications of cardiorespiratory physiology
2) Discuss applications of metabolism
3) Discuss applications of general physiology
4) Discuss applications of the musculoskeletal system and principles of mechanics and physics
5) Discuss weight management
6) Discuss applied sciences as they relate to the personal trainer

**Applied Science –Foundational Outline**

I. **Fitness**

A. Being active improves health: 30 minutes of accumulated physical activity on most days of the week

B. Being “fit” goes beyond health and requires a comprehensive exercise program including the following components

1) ______________________________
2) ______________________________
3) ______________________________
4) ______________________________

II. **Cardiorespiratory Physiology**

A. Components of the cardiorespiratory system

1) Blood: carries nutrients, gases, waste, and hormones
   a. ________–glucose/glycogen, triglycerides, and amino acids
   b. ________–oxygen and carbon dioxide (carried in red blood cells on the protein hemoglobin)
   c. ________–lactic acid and other metabolic by-products
   d. ________–sympathetic and parasympathetic nervous system activation
2) Blood vessels: transport system for blood throughout the body
   a. __________–carry oxygenated blood away from the heart
      (with the exception of the ________________)
   b. __________–carry de-oxygenated blood to the heart
      (with the exception of the ________________)
   c. __________–tiny vessels across which the exchange of
gases, nutrients, and waste occurs between the blood and
   the cells of the body

3) Heart: four-chambered pump responsible for distributing
   blood to the lungs and to the rest of the body
   a. Right side–receives ____________ returning from
      the body
   b. Left side–receives ______________ returning from the
      lungs
   c. __________–the two upper chambers of the heart
   d. __________–two lower chambers of the heart
   e. Blood distribution
      1. The left and right sides of the heart contract
         ________________
      2. At the same time the blood from the right ventricle
         is pumped to the lungs through the pulmonary
         arteries, blood from the left ventricle is ejected to
         the rest of the body through the aorta
   f. __________–contraction phase of the cardiac cycle
   g. __________–relaxation phase of the cardiac cycle
      1. During diastole, the heart muscle itself is supplied
         with oxygen through the coronary arteries
      2. _KEY POINT:_ Having a high level of cardiorespiratory fitness
         means the heart spends more time in diastole at rest
         and at submaximal exercise due, in part, to a
         decreased resting heart rate (RHR)
4) Lungs: encase the smaller branches of the trachea that allow gas exchange between the blood and the atmosphere

5) Airways: transport system for carrying gases into and out of the body (commonly referred to as the bronchial tree)
   a. _______—microscopic ducts responsible for gas exchange in the lungs
   b. The lungs contain an estimated 300 million alveoli providing a surface area of approximately 750 square feet

B. Cardiorespiratory responses to acute aerobic exercise

1) _______ heart rate (HR)

2) _______ stroke volume (SV)
   a. The amount of blood pumped from each ventricle each time the heart beats
   b. Measured in mL per beat

3) _______ cardiac output
   a. Cardiac output = HR x SV
   b. A typical cardiac output at rest:
      60 bpm x 70 mL/beat = 4200 mL/min
      (approximately 1 gallon of blood per minute)
4) __________ breathing rate

5) __________ systolic blood pressure
   a. Due to the cardiovascular system attempting to increase O₂ delivery to the muscles
   b. However, blood pressure greater than 250/115 mmHg is an indication to terminate exercise (hypertensive response)

6) ______________________________ in diastolic blood pressure
   a. Due to the dilation of vessels in the muscles and the skin
   b. This decreases _______ resistance (which is an important benefit for individuals suffering from heart disease, hypertension, diabetes, and peripheral vascular disease)

7) Blood is __________ from the viscera to the working muscles
   a. __________ of vessels that supply blood to the exercising muscles
   b. __________ of vessels that supply blood to the abdominal area

8) __________ extraction of oxygen from the blood into the working tissues
   a. A normal, healthy person is able to load the blood with more O₂ in the lungs than he or she is able to use at the cellular level
   b. Therefore, the more efficiently an individual can extract O₂ from the __________ in the capillaries, the greater his or her physical working capacity

KEY POINT:

C. Cardiorespiratory adaptations due to regular aerobic exercise

1) __________ RHR
   a. With consistent exercise (as few as three months of regular aerobic training), the interior dimensions of the ventricles ____________, allowing them to hold more blood
b. The same cardiac output can be maintained at a lower HR due to the greater SV

2) ________ relative working HR
   a. Since a given intensity requires a given amount of O₂, HR at any given intensity will be ______ due to increased SV
   b. A trained individual will have to work at __________ to achieve the same HR he or she achieved prior to exercise training

3) ________ VO₂max as SV increases
   a. VO₂max is a measure of the body’s ability to consume (respiratory system), deliver (cardiovascular system), and utilize oxygen at the cellular level

   b. VO₂max depends on two factors
      1. The delivery of O₂ to the ___________ by the blood (cardiac output)
      2. The ability to extract the O₂ at the capillaries and use it in the __________

4) ________ O₂ extraction at the cellular level
   a. Improved ability to remain “aerobic” at higher intensities
   b. Increased capillary density
   c. Increased mitochondrial density
   d. Increased ability to create adenosine triphosphate (ATP)

5) ________ fatty acid oxidation at any submaximal intensity

6) _____ glycogen is stored in trained muscles and ____ lactic acid is produced

7) ________ tolerance to lactic acid produced during exercise
III. Environmental Concerns with Exercise

A. Altitude
1) Due to decreases in atmospheric (i.e., barometric) pressure at altitude, the partial pressure of oxygen declines and HR and respiration rate __________
2) During exercise, HR may increase up to 50% higher than normal
3) Decrease exercise pace so client can complete session without becoming exhausted
4) It can take up to _______________ to acclimate to a new altitude

B. Heat
1) Due to increased ________________________________, venous return and SV decrease
2) At any given exercise pace, HR will be _______ as the heart tries to maintain cardiac output to meet the needs of the working muscles while also redirecting blood to the skin to aid cooling
3) Producing sweat so that it may evaporate from the skin is the body’s primary cooling mechanism
4) High humidity does not allow sweat to ________________
5) The main concerns of exercising in the heat are sweat evaporation and consumption of _________________ every _____________ during exercise

C. Cold
1) Exercising in the cold causes the kidneys to __________ urine production, risking dehydration
2) Heat production during exercise is usually enough to prevent hypothermia
3) When exercise stops, however, the client needs to be protected from the cold
4) Keys to exercising in the cold are ______________________ and _____________________
### IV. Metabolism

#### A. Energy production

1) **ATP**

   a. Manufactured by the ________________ in the muscle cell
   
   b. ATP is the energy source used to drive ________________

   c. Fatty acids and glucose are used to produce ATP

   d. Amino acids are not a preferred energy source, but are used in an undernourished individual

#### B. Energy systems available during exercise

<table>
<thead>
<tr>
<th>Energy System</th>
<th>Substrate</th>
<th>Limitation to Produce ATP</th>
<th>Primary Use</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ANAEROBIC</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphagen</td>
<td>Creatine phosphate (CP) Stored ATP</td>
<td>Muscle stores very little CP and ATP</td>
<td>High-intensity, short-duration activities; less than 10 seconds to fatigue</td>
</tr>
<tr>
<td>Anaerobic glycolysis</td>
<td>Glucose and glycogen</td>
<td>Lactic acid build-up causes rapid fatigue</td>
<td>High-intensity, short-duration activities; from 1–3 minutes to fatigue</td>
</tr>
<tr>
<td><strong>AEROBIC</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fatty acids, glucose, and glycogen</td>
<td>Depletion of muscle glycogen; insufficient O₂ delivery</td>
<td>Long-duration, sub-anaerobic threshold activities; longer than 3 minutes to fatigue</td>
</tr>
</tbody>
</table>
C. Which primary energy system is associated with the following activities?

<table>
<thead>
<tr>
<th>Activity</th>
<th>Primary Energy System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bench press: 8–12 reps, 70–80% 1RM</td>
<td></td>
</tr>
<tr>
<td>Plyometric jump squat</td>
<td></td>
</tr>
<tr>
<td>Cycling at 70% heart-rate reserve for 20 minutes</td>
<td></td>
</tr>
<tr>
<td>Sprinting at 90% VO2max for 60 seconds</td>
<td></td>
</tr>
<tr>
<td>Power clean</td>
<td></td>
</tr>
<tr>
<td>Sitting, taking notes</td>
<td></td>
</tr>
</tbody>
</table>

D. Metabolic equivalent (MET)

1) A system for classifying physical activities based on their intensities (in other words, based on their requirement for ________________

2) 1 MET = resting O2 consumption, which is approximately ________________

3) Physicians commonly prescribe exercise in terms of METs for cardiac rehabilitation patients

4) To determine the VO2 equivalent of any MET value, simply multiply the MET value by 3.5
   a. For example, a typical step aerobics class is about 7 METs
   b. Therefore, the O2 consumption for a typical step aerobics class is: 3.5 mL/kg/min x 7 METs = 24.5 mL/kg/min

E. Metabolism and exercise

1) Two terms are commonly used when describing metabolic rate, ________________ (BMR) and ________________ (RMR)
2) BMR is the body’s minimum daily energy requirement for normal function
   a. Assessed after an overnight stay in a lab where subject has been fasting for 12 hours and sleeping for 8 hours at a constant temperature
   b. Consists of energy used for ________________________________
   c. Measured in calories
3) RMR is a more common measurement than BMR
   a. Assessed after an overnight fast and 8 hours of sleep
   b. The sleep is at home and the measurement is in the lab
   c. BMR is usually ________________ than RMR
   d. RMR typically ranges from ___________ for women to ___________ for men
4) Effect of regular exercise
   a. Moderate aerobic exercise plus strength training
      __________ BMR to a greater degree than aerobic exercise alone
   b. Aerobic training _________ caloric expenditure during the activity and uses body fat for fuel
   c. Strength training may _________ lean mass and cause an _________ in caloric requirement by 7–10 calories per day for each additional pound of lean mass

**KEY POINT:**
   d. Therefore, both aerobic exercise and strength training are recommended for ______________________
5) BMR tends to __________ with age
   a. For each decade after age 25, ______________________________
   b. Some decline still occurs in individuals who exercise regularly
   c. Training may attenuate or slow the decline
V. General Physiology

A. Neuromuscular anatomy

1) ___________: conducts impulses from the __________________ (CNS) to the periphery, signaling muscles to contract or relax

2) ___________: a motor nerve and all its associated muscle fibers
   a. All fibers comprising a motor unit are ____________ (they are either all fast-twitch or all slow-twitch)
   b. Motor units made up of 5–10 fibers are responsible for fine, delicate movements such as blinking the eye
   c. Motor units made up of thousands of fibers are responsible for forceful movements such as jumping

B. Musculoskeletal anatomy

1) ____________: a muscle cell

2) _______: a contractile protein in a muscle fiber; there are many myofibrils arranged in patterns within a muscle fiber

3) _______: the functional contracting unit of the muscle cell
   a. Myofibrils are made up of several repeating sarcomeres along the length of the muscle cell
   b. The area between the ____________
4) ______________: contractile protein filaments within the myofibril; they generate muscle contraction by sliding past one another

5) Muscle contraction
   a. An electronic impulse from the brain to the muscle is transmitted to cause contraction
   b. Contraction occurs due to the interaction of the actin and myosin filaments, which causes shortening of the individual muscle fibers

6) Sliding filament theory
   a. For muscle contraction to occur there must be two factors present
      1. __________________________________________________________________
      2. ____________________________________________________________________
b. When these two factors are present, tiny projections from the myosin filament attach to the actin filament forming a ________________

c. The myosin pulls the actin toward the center of the sarcomere, and the individual muscle fiber shortens

7) Discontinuation of contraction occurs when
   a. ________________________________________________
   b. ________________________________________________
   c. ________________________________________________
   d. ________________________________________________
8) Muscle spindles
   a. Sensory receptors that lie parallel to the muscle fibers
   b. Respond to muscle fibers being over-stretched by causing a
      ______________________
   c. Component of the _________________________________

9) Golgi tendon organs
   a. Sensory receptors located in the muscle tendon
   b. Respond to extreme muscle tension by causing the
      ______________________
   c. Component of _________________________________

10) Connective tissue
    a. ______________________
    b. ______________________
    c. ______________________
    d. ______________________

C. All-or-none theory
   1) When a single muscle fiber shortens, it generates its ___________
      ______________________; there is no gradation of force
   2) When a motor unit is stimulated, all the muscle fibers it innervates
      contract with ______________________
   3) The amount of force generated during a muscle group’s
      contraction depends on the following:
      a. The size of the individual muscle fibers contracting
         (_______________________________)
      b. The number of muscle fibers recruited
         (_______________________________)
      c. The length of the muscle fiber prior to contraction
      d. The speed of contraction
D. The length-tension relationship
1) The amount of force that a muscle can exert is related to its length

2) Peak force production is usually seen at ______________________________

3) At approximate resting length, more of the myosin cross-bridge heads can align with active actin receptor sites

KEY POINT: 4) Therefore, clients with poor posture who have chronically shortened or lengthened muscle groups are not able to ______________

E. Force vs. velocity
1) A maximal force contraction is dependent on ______________________________

2) The ______ the speed of contraction, the ______ the number of connected myosin and actin cross-bridges

3) An optimal speed of contraction while lifting weights appears to be ______________ concentric, followed by ______________ eccentric
### F. Muscle fiber types

<table>
<thead>
<tr>
<th>Slow-twitch (Type I, Oxidative)</th>
<th>Fast-twitch (Type II, Glycolytic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Contract ________________</td>
<td>● Contract ________________</td>
</tr>
<tr>
<td>● Contract ________________</td>
<td>● Contract ________________</td>
</tr>
<tr>
<td>● Fatigue ________________</td>
<td>● Fatigue ________________</td>
</tr>
<tr>
<td>● Primary energy system is __________</td>
<td>● Primary energy system is __________</td>
</tr>
<tr>
<td>● Used in ________________</td>
<td>● Used in ________________</td>
</tr>
</tbody>
</table>

- Fast-twitch fibers are further classified into type IIa and type IIb
- Type IIa fibers are slightly more oxidative than type IIb
- It is possible to increase either the oxidative qualities or the glycolytic qualities of type IIa fibers through training
- However, muscle fibers cannot be changed from one type to another

1) Muscles contain a mixture of fast-twitch and slow-twitch fibers
(______________________________)

2) Different fiber types are recruited for different activities

### G. Muscular adaptations to regular resistance training

1) Neural adaptations
   a. __________ recruitment patterns
   b. __________ motor learning
   c. Neural adaptations are responsible for gains in strength with little or no change in muscle cross-sectional area (or hypertrophy) after as much as six weeks of training

2) Hypertrophy of ________________ fibers

3) __________ size and number of actin and myosin

4) __________ lean body mass
5) __________ connective tissue strength
6) __________ risk for joint injury
7) __________ bone density

VI. Stress and Exercise

A. Chronic stress has many negative effects on the body

<table>
<thead>
<tr>
<th>Physiological System</th>
<th>Effects of Stress</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tension headache, neck and shoulder discomfort, and back pain</td>
</tr>
<tr>
<td></td>
<td>Premature coronary artery disease (CAD), hypertension, increased platelet adhesiveness, and heart attack</td>
</tr>
<tr>
<td></td>
<td>Suppression of T-cell function, increased vulnerability to infections and viral illnesses</td>
</tr>
<tr>
<td></td>
<td>Impaired memory and neural degeneration</td>
</tr>
<tr>
<td></td>
<td>Stomach ache, nausea, constipation, and diarrhea</td>
</tr>
</tbody>
</table>

B. These negative changes primarily occur due to elevated levels of stress hormones (__________________________________________________)

C. Exercise may help ____________________________ and alleviate these symptoms

VII. Basic Anatomy and Kinesiology

A. Refer to the *ACE Personal Trainer Manual* (pp. 39–69) and/or the Exam Review Supplemental Course Materials for detailed descriptions and illustrations of the skeletal system, joint articulations, and the muscular system
**Plane** | **Movement** | **Exercise Examples**
---|---|---
**Sagittal:** | Flexion/extension | Seated biceps curl, Lying hamstrings curl, Seated cable lat row, Abdominal crunch
Bisects the body into right and left portions

**Frontal:** | Adduction/abduction, Inversion/eversion, Elevation/depression | Standing hip adduction, Seated side lateral raise, Standing trunk side bend, Shoulder shrug
Bisects the body into front and back portions

**Transverse:** | Rotation, Supination/pronation (forearm), Horizontal flexion/extension | Oblique abdominal crunch, External arm rotation, Seated machine chest press, Prone dumbbell rear pull
Bisects the body into top and bottom portions
E. Muscular actions—named after the muscle’s apparent length during the action

1) Isometric (____________________________________________)
   a. ________________________________________________
   b. ________________________________________________
   c. Examples
      1. Wall sit
      2. Plank

2) Concentric (____________________________________________)
   a. ________________________________________________
   b. Examples
      1. Up-phase of biceps brachii curl
      2. Up-phase of push-up

3) Eccentric (____________________________________________)
   a. Muscle produces force as it lengthens, returning toward resting position
   b. ________________________________________________
   c. Examples
      1. Down-phase of biceps brachii curl
      2. Down-phase of push-up

F. Levers
1) A lever is a rigid bar (_______) with a fixed point around which it rotates when an external force is applied to it
2) The fixed point is the fulcrum (_______)

G. Torque
1) ________________________________________________
2) Result of a force acting on a lever at some distance from the fulcrum
3) ________________________________________________
H. Muscular roles

1) Agonist (_____________________________________________)
   a. Causes a desired motion
   b. Opposite of antagonist

2) Antagonist (___________________________________________)
   a. Acts in opposition to the action of the agonist
   b. ________________________________________________

3) Synergist
   a. Can act as an assister, stabilizer, or co-contractor
   b. Assister
      1. __________________________________________
         __________________________________________
      2. Example: the teres major is involved in all the same
         actions as the latissimus dorsi but due to its smaller
         size and position it can only contribute a fraction of
         the amount of force
   c. Stabilizer
      1. Example: when all portions of the trapezius
         contract to stabilize the scapulae during a side
         lateral arm raise
      2. This allows the scapula to become a stable base for
         efficient arm movement
   d. Co-contractor
      1. Example: when the gluteus maximus contracts
         to counteract the hip flexion that occurs while rising
         from a low squat
      2. This allows the rectus femoris to extend the knee as
         a person is rising without inclining the trunk
         forward
e. In the table below, fill in the action and role of the associated muscle group

**Sample Problem 1**

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Movement</th>
<th>Action</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latissimus dorsi</td>
<td><strong>Seated lat pull-down (down-phase)</strong></td>
<td>Shoulder extension and arm adduction</td>
<td></td>
</tr>
<tr>
<td>Teres major</td>
<td></td>
<td>Shoulder extension and arm adduction</td>
<td></td>
</tr>
<tr>
<td>Posterior deltoid</td>
<td></td>
<td>Shoulder extension and arm adduction</td>
<td></td>
</tr>
<tr>
<td>Middle trapezius</td>
<td></td>
<td>Scapulae adduction</td>
<td></td>
</tr>
<tr>
<td>Rhomboids (major and minor)</td>
<td></td>
<td>Scapulae adduction</td>
<td></td>
</tr>
<tr>
<td>Biceps brachii</td>
<td></td>
<td>Elbow flexion</td>
<td></td>
</tr>
<tr>
<td>Erector spinae</td>
<td></td>
<td>Spinal stabilization</td>
<td></td>
</tr>
<tr>
<td>Abdominals</td>
<td></td>
<td>Spinal stabilization</td>
<td></td>
</tr>
</tbody>
</table>

**Seated lat pull-down (up-phase)**

<table>
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<th>Movement</th>
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<td>Spinal stabilization</td>
<td></td>
</tr>
<tr>
<td>Abdominals</td>
<td></td>
<td>Spinal stabilization</td>
<td></td>
</tr>
</tbody>
</table>

**VIII. Weight Management**

A. Energy balance equations

1) Neutral calorie balance
   a. Calories consumed = calories expended
b. _________________________

2) Positive calorie balance
a. Calories consumed > calories expended
b. _________________________

3) Negative calorie balance
a. Calories consumed < calories expended
b. _________________________

B. Rate of weight loss
1) Regular exercise and proper nutrition results in the best long-term weight loss
2) One pound of fat = __________________________
3) For realistic weight loss, ACSM recommends
   a. ________________________________________________
   b. ________________________________________________
4) An average person can expect to lose ____________ per week
5) An obese person can expect to lose ___________ per week

Sample Problem 2
Your client creates a caloric deficit by walking three miles, five times per week. Assuming her caloric intake remains constant and she expends 100 calories per mile, how many weeks will it take her to lose 10 pounds?

**Step 1:**
Determine mileage per week:

**Step 2:**
Determine caloric expenditure per week:

**Step 3:**
Determine caloric deficit required for 10 lb body-fat loss:

**Step 4:**
Determine the number of weeks required to reach goal:
C. National Institutes of Health recommendations for safe and effective weight loss (www.nih.gov)

1) Healthy eating plans that reduce calories but do not rule out

2) Regular physical activity and/or exercise instruction

3) Tips on __________________ that also consider your cultural needs

4) Slow and steady weight loss of about ____________________________
   ____________________________ (weight loss may be faster at the start of a program)

5) Medical care if you are planning to lose weight by following a special formula diet, such as a very-low-calorie diet

6) A plan to keep the weight off after you have lost it

IX. Nutrition

A. Scope of practice

1) As a fitness professional, it is within your scope to make dietary suggestions using the __________________ (www.usda.gov) and the ____________________________ (www.nal.usda.gov/fnic); this information updates the Food Guide Pyramid released in 1992 and the 2000 Dietary Guidelines for Healthy Americans.
B. My Pyramid Food Guidance System

1) Emphasizing a variety of foods and proper portion sizes will help clients gain control of their nutritional habits

2) Approximate daily energy intakes

<table>
<thead>
<tr>
<th>Calories</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,600</td>
<td>Sedentary women and older adults</td>
</tr>
<tr>
<td>2,200</td>
<td>Active teenage girls, active women, and sedentary men</td>
</tr>
<tr>
<td>2,800</td>
<td>Active teenage boys, active men, and very active women</td>
</tr>
</tbody>
</table>
C. Updated physical activity recommendations (2005 Dietary Guidelines for Americans)

1) To reduce the risk of chronic disease in adulthood: engage in at least 30 minutes of moderate-intensity physical activity, above usual activity, at work or home on most days of the week

2) For most people, greater health benefits can be obtained by engaging in physical activity of more vigorous intensity or longer duration

3) To help manage body weight and prevent gradual, unhealthy body weight gain in adulthood: engage in approximately 60 minutes of moderate- to vigorous-intensity activity on most days of the week while not exceeding caloric intake requirements

4) To sustain weight loss in adulthood: participate in at least 60 to 90 minutes of daily moderate-intensity physical activity while not exceeding caloric intake requirements. Some people may need to consult with a healthcare provider before participating in this level of activity
D. Food labels (www.americanheart.org)—no slide

1) Understanding food labels will help you educate your client about total daily nutrient and caloric intakes

![Nutrition Facts Table]

- **Serving Size:** Is your serving the same size as the one on the label? If you eat double the serving size listed, you need to double the nutrient and caloric values. If you eat one-half the serving size shown here, cut the nutrient and caloric values in half.
- **Calories:** Are you overweight? Cut back a little on calories! Look here to see how a serving of this food adds to your daily total. A 5' 10, 138-lb active woman needs about 2,200 calories each day. A 5' 10, 174-lb active man needs about 2,500. How about you?
- **Total Carbohydrate:** When you cut down on fat, you can eat more Carbohydrates. Carbohydrates are in foods like bread, potatoes, fruits and vegetables. Choose these often! They give you more nutrients like sugars like Sode pop and candy.
- **Dietary Fiber:** Grandmother called it “roughage,” but her advice to eat more is still up-to-date! That goes for both soluble and insoluble kinds of dietary fiber. Fruits, vegetables, whole-grain foods, and beans and peas are all good sources and can help reduce the risk of heart disease and cancer.
- **Protein:** Most Americans eat more than they need. Where there is animal protein, there is also fat and cholesterol. Eat small servings of lean meat, fish, and poultry. Use skim or low-fat milk, yogurt, and cheese. Try vegetable proteins like beans, grains, and cereals.

**Vitamins and Minerals**

Your goal here is 100% of each for the day. Don't count on one food to do it all. Let a combination of foods add up to a winning score.

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

<table>
<thead>
<tr>
<th>Calories</th>
<th>2,000</th>
<th>2,500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Fat</td>
<td>Less than 65g</td>
<td>80g</td>
</tr>
<tr>
<td>Sat Fat</td>
<td>Less than 20g</td>
<td>25g</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>Less than 300mg</td>
<td>300mg</td>
</tr>
<tr>
<td>Sodium</td>
<td>Less than 2,400mg</td>
<td>2,400mg</td>
</tr>
<tr>
<td>Total Carbohydrate</td>
<td>300g</td>
<td>375g</td>
</tr>
<tr>
<td>Fiber</td>
<td>25g</td>
<td>30g</td>
</tr>
</tbody>
</table>

Calories per gram:

- Fat 9
- Carbohydrate 4
- Protein 4

*(More nutrients may be listed on some labels)*

mg = milligrams (1,000 mg = 1 g)
g = grams (about 28 g = 1 ounce)

**Saturated Fat**

A new kind of fat? No — saturated fat is part of the total fat in food. It is listed separately because it’s the key player in raising blood cholesterol and your risk of heart disease. Eat less!

**Cholesterol**

Too much cholesterol — a second cousin to fat — can lead to heart disease. Challenge yourself to eat less than 300 mg each day.

**Sodium**

You call it "salt," the label calls it "sodium." Either way, it may add up to high blood pressure in some people. So, keep your sodium intake low — 2,400 to 3,000 mg or less each day. (The American Heart Association recommends no more than 3,000 mg sodium per day for healthy adults.)

**Daily Value**

Feel like you're drowning in numbers? Let the Daily Value be your guide. Daily Values are listed for people who eat 2,000 or 2,500 calories each day. If you eat more, your personal daily value may be higher than what's listed on the label. If you eat less, your personal daily value may be lower. For fat, saturated fat, cholesterol and sodium, choose foods with a low % Daily Value. For total carbohydrates, dietary fiber, vitamins and minerals, your daily value goal is to reach 100% of each.

Figure 8.3
How to read the new food label.
Source: American Heart Association
Sample Problem 3

Using the food label in the previous illustration, determine the percentage of calories that comes from fat.

Step 1:
Determine the number of calories provided by the fat grams in the serving:

Step 2:
Determine the percentage of calories that comes from fat:

Step 3:
Determine the percentage by multiplying the decimal by 100%:

E. Sample USDA Food Guide and the Dietary Approaches to Stopping Hypertension (DASH) Eating Plan at the 2,000 calorie level

(www.usda.gov and www.nal.usda.gov/fnic)\textsuperscript{a}

<table>
<thead>
<tr>
<th>Food Groups &amp; Subgroups</th>
<th>USDA Food Guide Amount\textsuperscript{b}</th>
<th>DASH Eating Plan Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit Group</td>
<td>2 cups (4 servings)</td>
<td>2 to 2.5 cups (4 to 5 servings)</td>
</tr>
<tr>
<td>Vegetable Group</td>
<td>2.5 cups (5 servings)</td>
<td>2 to 2.5 cups (4 to 5 servings)</td>
</tr>
<tr>
<td>• Dark green vegetables</td>
<td>3 cups/week</td>
<td></td>
</tr>
<tr>
<td>• Orange vegetables</td>
<td>2 cups/week</td>
<td></td>
</tr>
<tr>
<td>• Legumes (dry beans)</td>
<td>3 cups/week</td>
<td></td>
</tr>
<tr>
<td>• Starchy vegetables</td>
<td>3 cups/week</td>
<td></td>
</tr>
<tr>
<td>• Other vegetables</td>
<td>6.5 cups/week</td>
<td></td>
</tr>
<tr>
<td>Grain Group</td>
<td>6 ounce-equivalents</td>
<td>7 to 8 ounce-equivalents</td>
</tr>
<tr>
<td>• Whole grains</td>
<td>3 ounce-equivalents</td>
<td>(7 to 8 servings)</td>
</tr>
<tr>
<td>• Other grains</td>
<td>3 ounce-equivalents</td>
<td></td>
</tr>
<tr>
<td>Meat &amp; Beans Group</td>
<td>5.5 ounce-equivalents</td>
<td>• 6 ounces or less:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>meat, poultry fish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 4 to 5 servings per week:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>nuts, seeds, and dry beans\textsuperscript{c}</td>
</tr>
<tr>
<td>Milk Group</td>
<td>3 cups</td>
<td>2 to 3 cups</td>
</tr>
<tr>
<td>Oils</td>
<td>24 grams (6 tsp)</td>
<td>8 to 12 grams (2 to 3 tsp)</td>
</tr>
<tr>
<td>Discretionary Calorie Allowance</td>
<td>267 calories</td>
<td></td>
</tr>
<tr>
<td>• Example of distribution:</td>
<td>Solid fat\textsuperscript{d}</td>
<td></td>
</tr>
<tr>
<td></td>
<td>18 grams</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Added sugars</td>
<td>~ 2 tsp (5 Tbsp per week)</td>
</tr>
</tbody>
</table>

\textsuperscript{a} All servings are per day unless otherwise noted. USDA vegetable subgroup amounts and amounts of DASH nuts, seeds, and dry beans are per week.

\textsuperscript{b} The 2,000-calorie USDA Food Guide is appropriate for many sedentary males 51 to 70 years of age, sedentary females 19 to 30 years of age, and for some other gender/age groups who are more physically active.

\textsuperscript{c} In the DASH Eating Plan, nuts, seeds, and dry beans are a separate food group from meat, poultry, and fish.

\textsuperscript{d} The oils listed in this table are not considered to be part of discretionary calories because they are a major source of vitamin E and polyunsaturated fatty acids, including the essential fatty acids, in the food pattern. In contrast, solid fats (i.e., saturated and \textit{trans} fats) are listed separately as a source of discretionary calories.

SOURCE: Dietary Guidelines for Americans, 2005
X. Sample Exam–Foundational Knowledge-Foundational Knowledge-Applied Sciences (20 minutes)

1) To lose 8 pounds in one month, your client would have to have a deficit of approximately how many calories?
   a. 12,000  
   b. 20,000  
   c. 28,000  
   d. 36,000


2) A physiological response that an individual may experience while exercising at an altitude of 2,700 meters (8,000 feet) is an increase in ____________.
   a. Maximal heart rate  
   b. a-VO₂ difference  
   c. Hemoglobin saturation  
   d. Respiratory rate


3) Cardiac output is the product of ____________.
   a. Heart rate and blood pressure  
   b. Stroke volume and heart rate  
   c. Stroke volume and blood pressure  
   d. Systolic blood pressure and heart rate

   *ACE Personal Trainer Manual, 3rd ed., p. 4; 2nd ed., p. 5*

4) The role of exercise in stress management appears to be an increase in the ability to normalize which of the following adrenal gland products?
   a. Norepinephrine  
   b. Glucagon  
   c. Growth hormone  
   d. Antidiuretic hormone

   *ACE Personal Trainer Manual, 3rd ed., p. 331*

5) During systole the heart is ____________.
   a. Resting  
   b. Contracting  
   c. Suffering an attack  
   d. Filling with blood

   *ACE Personal Trainer Manual, 3rd ed., p. 4; 2nd ed., p. 4*

6) Alveoli serve which of the following functions in the lungs?
   a. They ensure that air flows completely through the lungs.  
   b. They prevent dust and pollens from entering the lungs.  
   c. They help expand and contract the lungs.  
   d. They allow for exchange of carbon dioxide and oxygen.

   *ACE Personal Trainer Manual, 3rd ed., p. 35; 2nd ed., p. 36*
7) The oxidative energy system produces ATP in structures called ____________.
   a. Alveoli
   b. Capillaries
   c. Mitochondria
   d. Atria

*ACE Personal Trainer Manual, 3rd ed., p. 6; 2nd ed., p. 6*

8) Maximal oxygen consumption is (VO₂max) ____________.
   a. The best measure of the capacity of the cardiorespiratory system
   b. The velocity of the oxygen flowing through the blood
   c. Solely determined by genetics
   d. Very difficult to predict

*ACE Personal Trainer Manual, 3rd ed., p. 9; 2nd ed., p. 9*

9) Which of the following options is an adaptation associated with regular (chronic) aerobic exercise?
   a. Increased blood triglycerides
   b. Increased diastolic blood pressure
   c. Increased heart rate
   d. Increased ability to utilize oxygen

*ACE Personal Trainer Manual, 3rd ed., p. 10; 2nd ed., p. 10*

10) Regular endurance exercise contributes to better control of body fat by ____________.
    a. Decreasing caloric requirements
    b. Decreasing daily energy expenditure
    c. Increasing caloric intake
    d. Increasing daily energy expenditure


11) Muscle fibers are ____________.
    a. Motor nerves attached to muscle cells
    b. Protein structures within muscle cells
    c. Enzymes that facilitate metabolism within the muscle cells
    d. Individual muscle cells


12) An antagonist muscle is one that ____________.
    a. Is stretched when an agonist muscle contracts
    b. Assists the agonist producing the prime movement
    c. Shortens as it contracts
    d. Lifts resistance against the pull of gravity

*ACE Personal Trainer Manual, 3rd ed., p. 49; 2nd ed., p. 49*
13) A motor unit contains ____________.
   a. A tendon and a muscle fiber  
   b. Fast and slow-twitch muscle fibers  
   c. A motor nerve connected to muscle fibers  
   d. A motor nerve connected to a tendon  
   *ACE Personal Trainer Manual, 3rd ed., p. 21; 2nd ed., p. 21*

14) According to the MyPyramid Food Guidance System, the recommended amount of vegetables per day for an average 2,000-calorie diet is ________.
   a. 1 cup  
   b. 3 ounces  
   c. 6 ounces  
   d. 2.5 cups  
   *MyPyramid Food Guidance System, USDA (www.mypyramid.gov)*

15) A daily intake of approximately 2,200 calories is most likely appropriate for which of the following groups?
   a. Active women  
   b. Older adults  
   c. Active men  
   d. Moderately-active teenage boys  
   *MyPyramid Food Guidance System, USDA (www.mypyramid.gov)*
FOUNDATIONAL KNOWLEDGE- APPLIED SCIENCES
SAMPLE PROBLEM ANSWER KEY

Sample Problem 1

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Movement</th>
<th>Action</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latissimus dorsi</td>
<td>Shoulder extension and arm adduction</td>
<td>Concentric</td>
<td>Agonist</td>
</tr>
<tr>
<td>Teres major</td>
<td>Shoulder extension and arm adduction</td>
<td>Concentric</td>
<td>Synergist</td>
</tr>
<tr>
<td>Posterior deltoid</td>
<td>Shoulder extension and arm adduction</td>
<td>Concentric</td>
<td>Synergist</td>
</tr>
<tr>
<td>Middle trapezius</td>
<td>Scapulae adduction</td>
<td>Concentric</td>
<td>Agonist</td>
</tr>
<tr>
<td>Rhomboids</td>
<td>Scapulae adduction</td>
<td>Concentric</td>
<td>Agonist</td>
</tr>
<tr>
<td>Biceps brachii</td>
<td>Elbow flexion</td>
<td>Concentric</td>
<td>Agonist</td>
</tr>
<tr>
<td>Erector spinae</td>
<td>Spinal stabilization</td>
<td>Isometric</td>
<td>Synergist</td>
</tr>
<tr>
<td>Abdominals</td>
<td>Spinal stabilization</td>
<td>Isometric</td>
<td>Synergist</td>
</tr>
</tbody>
</table>

Seated lat pull-down (up-phase)

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Movement</th>
<th>Action</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latissimus dorsi</td>
<td>Shoulder flexion and arm abduction</td>
<td>Eccentric</td>
<td>Agonist</td>
</tr>
<tr>
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<td>Synergist</td>
</tr>
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<td>Eccentric</td>
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</tr>
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<tr>
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<td>Agonist</td>
</tr>
<tr>
<td>Biceps brachii</td>
<td>Elbow extension</td>
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<td>Agonist</td>
</tr>
<tr>
<td>Erector spinae</td>
<td>Spinal stabilization</td>
<td>Isometric</td>
<td>Synergist</td>
</tr>
<tr>
<td>Abdominals</td>
<td>Spinal stabilization</td>
<td>Isometric</td>
<td>Synergist</td>
</tr>
</tbody>
</table>

Sample Problem 2

Your client creates a caloric deficit by walking three miles, five times per week. Assuming her caloric intake remains constant and she expends 100 calories per mile, how many weeks will it take her to lose 10 pounds?

Step 1: Determine mileage per week: 3 miles x 5 times per week = 15 miles per week

Step 2: Determine caloric expenditure per week: 15 miles x 100 cal per mile = 1,500 cal per week

Step 3: Determine caloric deficit required for 10 lb body-fat loss: 10 lb x 3,500 cal/lb = 35,000 cal

Step 4: Determine the number of weeks required to reach goal: 35,000 cal ÷ 1,500 cal/week = 23.3 weeks

Sample Problem 3

Using the food label in the previous illustration, determine the percentage of calories that comes from fat.

Step 1: Determine the number of calories provided by the fat grams in the serving: 3 g x 9 cal/g = 27 cal

Step 2: Determine the percentage of calories that comes from fat by dividing 27 cal by the total calories in the serving: 27 cal ÷ 90 cal = .3

Step 3: Determine the percentage by multiplying the decimal by 100%: .3 x 100% = 30% cal from fat
Neutral Anatomical Position

- Standing with erect posture, face forward, open hands, and palms forward (supinated)
- Used as a reference point and not the normal way of standing
- The “zero” position for measuring most of the movements of the joints

Basic Bony Structure
Vertebral column (24 individual vertebrae)
- The 24 non-fused vertebrae (cervical, thoracic, and lumbar) articulate with each other at facet joints and intervertebral discs
- Articulation at the very top is at the axis with the occiput of the skull

Cervical vertebrae (7)
- “Cervix” is Latin for “neck”
- Atlas and axis
  - “Atlas” is the Greek mythological Titan who supported the world on his shoulders; in the 16th century, Vesalius gave this name to the 1st cervical vertebra, which supports the head
  - “Axis” is Latin for “pivot”; this is the name of the 2nd cervical vertebra

Thoracic vertebrae (12)
- “Thorax” is Greek for “chest”
- Attached to the 12 ribs

Lumbar vertebrae (5)
- “Lumbar” is Latin for “loin”
- Largest, to absorb body weight and ground reaction forces

Sacrum (5 fused vertebrae)
- “Sacrum” is Latin for “sacred”; this keystone of the pelvis was thought to survive after death and form a part of the body after resurrection
- Wedge-shaped piece of spine
- Articulates with L5 and both ilium (sacroiliac joints)

Coccyx (3–5 fused vertebrae)
- “Coccyx” is Greek for “cuckoo”; supposedly, the coccyx resembles the beak of a cuckoo bird
- Articulates with the sacrum
- “Tailbone”

Rib cage
- 12 ribs
- Ribs articulate with the thoracic vertebrae and the sternum

- Pelvic girdle
  - Comprised of the ilium, ischium, sacrum, and coccyx
  - Pubic symphysis is the cartilaginous joint between the two ilium

- Shoulder girdle
  - Clavicle
    - “Clavicle” is Latin for “key”; the clavicle resembles a key in shape
    - Articulates with the sternum and the scapula
    - Commonly called the “collar bone”
  - Scapulae
    - “Scapula” is Latin for “shoulder blade”
    - Articulate with clavicles and humeri
    - The scapulae and rib cage do not articulate in terms of their bony structures, but scapulae do slide over the back of the rib cage via their connection through musculature

- Hip joint
  - Articulation of the femur and acetabulum of pelvis
  - “Acetabulum” is Greek for “vinegar bowl”; this cup-shaped part of the hip was thought to resemble a small vinegar cruet of Roman times

- Knee joint
  - Articulation of femur, patella, and tibia
  - Modified hinge joint
  - “Femur” is Latin for “thigh”
  - “Patella” is Latin for “little plate”
  - “Tibia” is Latin for “flute”; the bone resembles a flute in shape
  - The fibula rests outside of the knee articulation
    - “Fibula” is Latin for “a clasp or pin”
    - The fibula, as it lines up next to the tibia, resembles the clasp arm of a safety pin

- Ankle joint
  - Articulation of the fibula and tibia with the talus
  - Hinge joint
  - Allows only plantarflexion and dorsiflexion in a slightly oblique angle
  - “Talus” is Latin for “ankle”

- Subtalar joint
  - Articulation of the talus and the navicular bones
    - “Navicular” is Latin for “little boat”; the bone resembles a boat in shape
    - Allows inversion and eversion
  - Articulation of the talus and the calcaneus bones
    - “Calcaneus” is Latin for “relating to the heel”
    - Allows inversion and eversion

- Glenohumeral (shoulder) joint
  - Articulation of the humerus with the glenoid fossa
  - “Humerus” is Latin for “shoulder bone”
  - “Glenoid” is Greek for “joint socket”
  - Not a true ball-and-socket joint because most of the “socket” is composed of cartilage, not bone, as in the hip

- Elbow
Articulation of the humerus with the ulna and radius
“Ulna” is Latin for “forearm”
“Radius” is Latin for “spoke of a wheel”; the head of the radius resembles a little wheel
At the humerus and ulna junction, only flexion and extension occur (true hinge joint)
At the humerus and radius junction, only supination and pronation occur

Movements Available at Various Joints

- **Flexion**
  - Decreasing the angle of a joint
  - Movement in the sagittal plane
  - Usually movement in the anterior direction except at the knee and ankle joints

- **Extension**
  - Increasing the angle of a joint
  - Movement in the sagittal plane
  - Usually movement in the posterior direction except at the knee and ankle joints

- **Adduction**
  - Toward the midline of the body (movement in the frontal plane)
  - Horizontal adduction (a.k.a. horizontal flexion) of the shoulder joint (movement in the transverse plane)
  - Adduction of the foot involves movement of the forefoot toward the midline of the body (movement in the transverse plane)

- **Abduction**
  - Away from the midline of the body (movement in the frontal plane)
  - Horizontal abduction (a.k.a. horizontal extension) of the shoulder joint (movement in the transverse plane)
  - Abduction of the foot involves movement of the forefoot away from the midline of the body (movement in the transverse plane)

- **Lateral flexion**
  - Movements of the head, neck, and trunk in side-bending
  - Movement in the frontal plane

- **Lateral/external rotation**
  - Anterior surface of the limbs (humerus and femur) moving away from the midline
  - Movement in the transverse plane

- **Medial/internal rotation**
  - Anterior surface of the limbs (humerus and femur) moving toward the midline
  - Movement in the transverse plane

- **Rotation of the pelvis and thorax**
  - Clockwise or counter-clockwise
  - Movement in the transverse plane

- **Pronation of the forearm**
  - From anatomical position, turning palms posteriorly (facing back)
  - Moving only at the elbow, not the shoulder joint
  - Movement in the transverse plane

- **Supination of the forearm**
  - From neutral wrist position, turning palms anteriorly (facing front)
Moving only at the elbow, not the shoulder joint
Movement in the transverse plane

- Supination of the foot
  - Inversion (standing on the outside of the feet)
  - Dorsiflexion (moving dorsal surface of the foot toward anterior surface of the tibia)
  - Combination of three movements
    - Ankle dorsiflexion (sagittal)
    - Foot inversion (frontal)
    - Foot adduction (transverse)

- Pronation of the foot
  - Eversion (standing on the inside of the feet)
  - Plantarflexion (moving dorsal surface of foot away from anterior surface of the tibia)
  - Combination of three movements
    - Ankle plantarflexion (sagittal)
    - Foot eversion (frontal)
    - Foot abduction (transverse)

- Tilt of pelvis
  - Anterior
  - Posterior
  - Lateral

- Tilt of head
  - Anterior
  - Posterior
  - Lateral

- Movements of the scapulae
  - Adduction
    - Scapula glides toward vertebral column
    - “Retraction”
  - Abduction
    - Scapula glides away from vertebral column following the contour of the rib cage
    - “Protraction”
  - Elevation (scapula glides toward the head)
  - Depression (scapula glides toward the feet)
  - Upward rotation
    - Movement in the frontal plane in which the inferior angle of the scapula moves laterally
    - The glenoid fossa moves cranially (as when raising the arms overhead)
  - Downward rotation
    - Movement in the frontal plane in which the inferior angle of the scapula moves medially
    - The glenoid fossa moves caudally (as in lowering the arms down to sides from overhead)
  - Anterior tilt
    - Movement in the sagittal plane in which the top of the scapula moves down and forward
    - Bottom of scapula moves back and up
    - Associated with elevation

Gross Anatomy Review—Major Muscle Groups
I. Muscles that Act on the Scapulae

The main action of these muscles is to fixate the scapula. When the scapula is immobilized, it serves as a stable point of origin for the muscles that move the humerus.

4 posterior muscles:
Trapezius
Rhomboid major
Rhomboid minor
Levator scapulae

1) Trapezius
When all parts of the trapezius are working together, they tend to pull upward and adduct the scapula at the same time. The trapezius fixates the scapulae for deltoid action. This muscle is always used in preventing
the glenoid fossa from being pulled down during the lifting of objects with the arms. Carrying an object on the tip of the shoulder (such as a purse) also calls this muscle into action.

**ORIGIN**
Part I: base of skull, occipital protuberance
Part II: ligaments of neck
Part III: spines of 7th cervical and upper 3 thoracic vertebrae
Part IV: spines of the 4th through 12th thoracic vertebrae

**INSERTION**
Part I: posterior aspect of outer third of clavicle
Part II: border of the acromion process
Part III: upper border of the scapular spine
Part IV: triangular space at the base of the spine

**ACTIONS**
Part I: elevation of scapula; a thin and relatively weak portion
Part II: elevation, upward rotation, and adduction of scapula; stronger, thicker portion of the muscle
Part III: adduction of the scapula
Part IV: depression, adduction, and upward rotation of the scapula

2) **Rhomboid major***

Both rhomboid major and minor muscles are used powerfully in pull-up movements. As one hangs from a horizontal bar, suspended by the hands, the scapulae tend to be pulled away from the top of the chest.

When the pull-up movement begins, the rhomboids draw the medial border of the scapulae down and back toward the spinal column.

**ORIGIN**: spinous processes of the 2nd through 5th thoracic vertebrae

**INSERTION**: medial border of the scapula, below the spine of the scapula

**ACTIONS**
Adduction of scapula
Downward rotation of the scapula

3) **Rhomboid minor***

**ORIGIN**: spinous processes of the 7th cervical and 1st thoracic vertebral

**INSERTION**: medial border of the scapula, below the spine of the scapula

**ACTIONS**
Adduction of scapula
Downward rotation of the scapula

*The rhomboid major and minor work together

4) **Levator scapula**

Fixation of the scapulae by the pectoralis minor allows the levator scapulae to bilaterally extend the neck or unilaterally flex the neck to one side.
ORIGIN: transverse processes of the upper 4 cervical vertebrae  
INSERTION: medial border of the scapula above the base of the scapular spine  
ACTION: elevates the medial margin of the scapula

2 anterior muscles:
Pectoralis minor  
Serratus anterior

1) Pectoralis minor
Pectoralis minor works together with the serratus anterior to abduct the scapulae in movements of pushing with the hands.
It also acts as an antagonist to the trapezius, rhomboids, and levator scapulae.
ORIGIN: outer surfaces of the 3rd–5th ribs  
INSERTION: coracoid process  
ACTIONS  
Abduction of scapula  
Downward rotation of scapula

2) Serratus anterior
Serratus anterior works together with the pectoralis minor to abduct the scapulae in movements of pushing with the hands. It also acts as an antagonist to the rhomboids.
ORIGIN: lateral portion of the upper 9 ribs  
INSERTION: whole medial border of the costal aspect of the scapula  
ACTIONS  
Abduction of scapula  
Upward rotation of scapula

II. Muscles that Act on the Shoulder
Nine muscles cross the shoulder joint and insert on the humerus. Seven arise from the scapulae. Two arise from the axial skeleton and have no attachments on the scapulae.
Seven scapular muscles:

Rotator cuff:
- Supraspinatus
- Infraspinatus
- Teres minor
- Subscapularis

Deltoid

Teres major

Coracobrachialis (not shown)

Rotator cuff muscles:
The rotator cuff is a group of muscles that surround the head of the humerus with the primary stabilizing function of holding the humeral head in the glenoid fossa. The lack of bone supporting the shoulder joint requires that these muscles and their associated tendons work as stabilizers to prevent subluxation or dislocation of the humeral head from the glenoid fossa. The muscles that comprise the rotator cuff can be remembered using the acronym S.I.T.S.

S = Supraspinatus
I = Infraspinatus  
T = Teres minor  
S = Subscapularis  

1) **Supraspinatus**

The supraspinatus holds the head of the humerus in the glenoid fossa and can be easily injured, especially with throwing movements.

**ORIGIN:** supraspinous fossa  
**INSERTION:** top of the greater tubercle of the humerus  
**ACTION:** weak abduction

2) **Infraspinatus**

This rotator cuff muscle works with another rotator cuff muscle, the teres minor, when the rhomboids stabilize the scapula, flattening it to the back so that the humerus may be externally rotated. This muscle helps hold the head of the humerus in the glenoid cavity in addition to externally rotating the bone.

**ORIGIN:** posterior surface of the scapula below the scapular spine  
**INSERTION:** greater tubercle of the humerus on the posterior side  
**ACTIONS**

Horizontal abduction (extension)  
Extension  
External rotation

3) **Teres minor**

This rotator cuff muscle works with another rotator cuff muscle, the infraspinatus, when the rhomboids stabilize the scapula, flattening it to the back so that the humerus may be externally rotated. This muscle helps hold the head of the humerus in the glenoid cavity in addition to externally rotating the bone.

**ORIGIN:** posterior, lateral surface of the scapula  
**INSERTION:** greater tubercle of the humerus on the posterior side  
**ACTIONS**

Horizontal abduction (extension)  
Extension  
External rotation

4) **Subscapularis**

Another rotator cuff muscle, the subscapularis holds the head of the humerus in the glenoid fossa from below. It also requires help from the rhomboids in stabilizing the scapulae to make it effective in its actions.

**ORIGIN:** entire anterior surface of the subscapular fossa  
**INSERTION:** lesser tubercle of the humerus  
**ACTIONS**
Extension
Internal rotation
Adduction

5) Deltoid
The trapezius fixes the scapulae as the deltoid pulls on the humerus. Any movement of the humerus on the scapula will involve all or part of the deltoid. Anterior and posterior fibers work antagonistically.

**ORIGIN:** front outer third of clavicle, border of the acromion, and lower edge of the spine of the scapula

**INSERTION:** deltoid tubercle on the middle outer surface of the humerus

**ACTIONS**
- True abduction of humerus: entire muscle
- Flexion and internal rotation: anterior fibers
- Horizontal adduction (flexion) and internal rotation: anterior fibers
- Extension and external rotation: posterior fibers
- Horizontal abduction (extension) and external rotation: posterior fibers

6) Teres major
This muscle is effective only when the rhomboids stabilize the scapulae or move the scapulae in a downward rotation. Otherwise, the scapulae would move forward to meet the arm. The teres major works with the latissimus dorsi and is said to be the latissimus dorsi’s “little helper.”

**ORIGIN:** lower third of the lateral border of the scapula

**INSERTION:** inner lip of the intertubercular groove of the humerus

**ACTIONS**
- Extension
- Internal rotation
- Adduction

7) Coracobrachialis

**ORIGIN:** coracoid process of scapula

**INSERTION:** medial, middle of humerus

**ACTIONS**
- Assists in flexion
- Assists in adduction

**Two muscles that arise from the axial skeleton:**

- Latissimus dorsi
- Pectoralis major

1) Latissimus dorsi
One of the most important, powerful extensor muscles of the humerus. When
the insertion is fixed (as when hanging by the arms) the latissimus dorsi can anteriorly tilt the pelvis as well as assist in lateral flexion of the spine.

**ORIGIN:** posterior crest of the ilium, back of the sacrum and spinous process of the lumbar and lower 6 thoracic vertebrae and slips from the lower 3 ribs

**INSERTION:** medial side of the intertubercular groove of the humerus

**ACTIONS**

Extension
Internal rotation
Horizontal abduction (extension)
Adduction

2) **Pectoralis major**
Works together with the latissimus dorsi to adduct the humerus from a raised position.

**ORIGIN:** inner half of the anterior surface of the clavicle, anterior surface of the costal cartilages of the first 6 ribs and adjoining portion of the sternum

**INSERTION:** outer lip of the intertubercular groove of the humerus

**ACTIONS**

Flexion
Extension
Horizontal adduction (flexion)
Internal rotation
Adduction

III. **Muscles that Act on the Elbow**
The biceps brachii and the triceps brachii do have origins on the scapulae, but their major actions focus on the elbow joint.

**Three anterior:**

1) **Biceps brachii**

2) **Brachialis**

3) **Brachioradialis**
With the elbow joint in a supinated position, the biceps brachii is most powerful and both flexes and supinates the joint. The pronated position decreases the effectiveness of the biceps, partly as a result of the disadvantageous pull of the muscle as the radius rotates. The same muscles are used in elbow joint flexion, whether the elbow is pronated or supinated.

**ORIGIN**

Long head: top of the glenoid fossa
Short head: top of the coracoid process

**INSERTION:** tuberosity of the radius

**ACTIONS**

Flexion of the elbow
Supination of the forearm
Weak flexion of the shoulder joint

2) **Brachialis**

The brachialis pulls on the ulna, which does not rotate, making it the only pure flexor of the elbow.

**ORIGIN:** lower half of the anterior portion of the humerus

**INSERTION:** coronoid process of the ulna

**ACTION:** true flexion of the elbow

3) **Brachioradialis**

This muscle is favored in its action of flexion when the mid-position between pronation and supination of the forearm is assumed.

**ORIGIN:** lower two-thirds of outer condyloid ridge of the humerus

**INSERTION:** outer surface of the lower end of the radius at the styloid process

**ACTIONS**

Flexion of the elbow

Pronation from the supinated position; supination from the pronated position

**One posterior:**

**Triceps brachii**

The long head is the only one that crosses the shoulder joint, originating from the scapula between the teres major and minor. This positioning allows the long head of the triceps to act as a weak synergist to the latissimus dorsi to extend and adduct the arm.

**ORIGIN**

Long head: lower edge of the glenoid process of the scapula
Lateral head: upper half of the posterior surface of the humerus
Medial head: lower two-thirds of the posterior surface of the humerus

**INSERTION**: olecranon process of the ulna

**ACTIONS**

Extension
Assists in extension of the shoulder (long head)

---

**IV. Muscles that Act on the Wrist**

The major muscles responsible for movements at the wrist have the bulk of their mass around the radius and ulna with long tendons leading to their insertions.

**Five anterior:**

- **Palmaris longus**
- **Flexor carpi radialis**
- **Flexor carpi ulnaris**
- **Pronator teres**
- **Pronator quadratus**

---

1) **Palmaris longus**

This muscle is a weak wrist flexor and is absent in some individuals.

**ORIGIN**: medial epicondyle of humerus

**INSERTION**: palmar aponeurosis

**ACTION**: weak flexion

2) **Flexor carpi radialis**

**ORIGIN**: medial epicondyle of humerus

**INSERTION**: bases of 2nd and 3rd metacarpals

**ACTION**: flexion

3) **Flexor carpi ulnaris**

---

**FIGURE 2.22**
Muscles of the hand and wrist.
**ORIGIN**: medial epicondyle of humerus

**INSERTION**: bases of 5th metacarpal

**ACTIONS**:
- Flexion
- Adduction

4) **Pronator teres**

**ORIGIN**: medial epicondyle of humerus and coronoid process of ulna

**INSERTION**: mid-lateral surface of the radius

**ACTIONS**:
- Pronation
- Assists in flexion

---

**Three posterior**:

**Extensor carpi radialis longus**

**Extensor carpi radialis brevis**

**Extensor carpi ulnaris**

1) **Extensor carpi radialis longus**

**ORIGIN**: lateral epicondyle of humerus

**INSERTION**: base of 2nd metacarpal
ACTIONS:
Extension
Abduction
2) Extensor carpi radialis brevis

ORIGIN: lateral epicondyle of humerus

INSERTION: base of 3rd metacarpal

ACTIONS:
Extension
Abduction

3) Extensor carpi ulnaris

ORIGIN: lateral epicondyle of humerus

INSERTION: base of 5th metacarpal

ACTIONS:
Extension
Adduction

V. The Trunk
The muscles of the trunk act to stabilize as well as move the spine.

Four anterior:
Rectus abdominis
External obliques
Internal obliques
Transversus abdominis

1) Rectus abdominis
The rectus abdominis controls
the tilt of the pelvis by pulling t

ORIGIN: crest of the pubis

INSERTION: cartilage of the 5th, 6th, and 7th ribs and the xiphoid process
ACTIONS
Flexion (bilaterally)
Lateral flexion (unilaterally)

2) **External obliques**
The oblique muscles work synergistically in rotation of the trunk. Rotation of the trunk to the right (combined with flexion) involves simultaneous contraction of the right internal oblique and the left external oblique.

**ORIGIN**: borders of the lower 8 ribs at the side of the chest interdigitating with the serratus anterior

**INSERTION**: front half of the crest of the ilium, the inguinal ligament, the crest of the pubis, and the fascia of the rectus abdominis

ACTIONS
Flexion (bilaterally)
Lateral flexion (unilaterally)
Contralateral rotation (unilaterally working with the opposite internal obliques)

3) **Internal obliques**

**ORIGIN**: upper half of the inguinal ligament, anterior two-thirds of the crest of the ilium and the thoracolumbar fascia

**INSERTION**: costal cartilages of the 8th, 9th, and 10th ribs and the linea alba

ACTIONS
Flexion (bilaterally)
Lateral flexion (unilaterally)
Ipsilateral rotation (unilaterally working with the opposite external obliques)

4) **Transversus abdominis**

This muscle tightens the thoracolumbar fascia and helps to stabilize the sacroiliac joints. Its fibers are oriented horizontally and contraction reduces the diameter of the abdomen (i.e., “sucking in the gut”).

**ORIGIN**: outer third of the inguinal ligament, inner rim of the crest of the ilium, inner surface of the cartilage of the lower 6 ribs, and the thoracolumbar fascia

**INSERTION**: crest of the pubis, the ilipectineal line, and the linea alba

ACTIONS
Compresses the abdominal cavity
Stabilizes the lumbo-pelvic region
Assists on forced expiration
Several pairings of muscles make up the posterior trunk. For convenience, they are collectively known as: Erector spinae

**Erector spinae**

**ORIGINS & INSERTIONS**: in general, these muscles attach the spinous and transverse processes of the vertebrae to each other and to the pelvis, ribs, and skull

**ACTIONS** (in general)

Extension (bilaterally)

Lateral flexion (unilaterally)

**Superficial layer:**

Spinalis capitis, cervicis, and thoracis

Longissimus capitis, cervicis, and thoracis

Iliocostalis cervicis, thoracis, and lumborum

**Deep layer:**

Semispinalis (1st layer) capitis, cervicis, and thoracis

Multifidi (2nd layer)

Rotatores (3rd layer)

Interspinales

Intertransversarii

VI. **Muscles that Act on the Hip**

Most of the muscles that act on the hip
Nine Anterior:
Iliopsoas
Sartorius
Rectus femoris
Tensor fasciae latae
Pectineus
Adductor brevis
Adductor longus
Adductor magnus
Gracilis

1) Iliopsoas
Consists of two separate muscles (the psoas major and the iliacus), but is often referred to as one muscle group because of the similarity of actions of the two muscles. When the thigh is fixed (as in when rising from a supine position to a sitting position) the iliopsoas pulls on the lumbar vertebrae and flexes the spine and pelvis on the femur. When the trunk is fixed (as in when lifting straight legs up from the floor in the supine position) the iliopsoas flexes the femur on the pelvis. In this position, the lumbar attachments of the psoas pull on the vertebrae and can create excessive lordosis and low-back pain in individuals who do not have enough abdominal strength to counterbalance this force. The abdominals can be used to prevent this lower-back strain by pulling upward on the pelvis and thus “flattening” the back.

**ORIGIN:** inner surface of ilium, base of the sacrum, and sides of the bodies of the last thoracic and all of the lumbar vertebrae

**INSERTION:** lesser trochanter of the femur

**ACTIONS**
Flexion
External rotation

2) Sartorius
This muscle is referred to as the “tailor’s muscle” because it is heavily involved in sitting cross-legged, which at one time was considered the tailor’s position. Sartorius is Latin for “tailor.”

**ORIGIN:** notch between the anterior-superior and anterior-inferior spines of the ilium

**INSERTION:** anterior medial condyle of the tibia

**ACTIONS**
Flexion of the hip  
Flexion of the knee  
Internal rotation of the knee  
External rotation of the hip as it flexes the hip and knee  

3) **Rectus femoris**  
This muscle is part of the quadriceps muscle group and is the only one that acts at both the hip and the knee (the other quadriceps muscles act only on the knee).  
**ORIGIN**: anterior-inferior iliac spine of the ilium  
**INSERTION**: tibial tuberosity via the patella and patellar ligament  
**ACTIONS**  
Flexion of the hip  
Extension of the knee  

4) **Tensor fasciae latae**  
The tensor fasciae latae (TFL) aids in preventing external rotation of the femur as the hip is flexed by other flexor muscles. This muscle is used weakly in directing the leg forward so that the foot is placed straight forward in walking and running. From the supine position, raising the leg with definite internal rotation will call it into action.  
**ORIGIN**: anterior iliac crest of the ilium  
**INSERTION**: iliotibial band of fascia quarter of the way down  
**ACTIONS**  
Flexion of the hip  
Horizontal abduction of the hip  
Tendency to internally rotate hip as is flexes  

5) **Pectineus**  
The pectineus tends to anteriorly tilt the pelvis when it contracts, which is countered by the abdominals to keep the anterior tilt in check. The pectineus is exercised together with the iliopsoas in leg raising and lowering.  
**ORIGIN**: space 1-inch wide on front of pubis just above the crest  
**INSERTION**: rough line leading from the lesser trochanter down to the linea aspera  
**ACTIONS**
Flexion
Adduction
6) **Adductor brevis**
   **ORIGIN**: front of the pubis just below the origin of the longus
   **INSERTION**: lesser trochanter of upper quarter of the linea aspera
   **ACTIONS**: Adduction
   External rotation as the hip adducts

7) **Adductor longus**
   **ORIGIN**: front of the pubis just below its crest
   **INSERTION**: middle third of the linea aspera
   **ACTIONS**: Adduction
   External rotation
   Assists in flexion

8) **Adductor magnus**
   **ORIGIN**: edge of the entire ramus of the pubis and the ischium, and the tuberosity of the ischium
   **INSERTION**: whole length of the linea aspera and inner condyloid ridge
   **ACTIONS**: Adduction
   External rotation as the hip adducts

9) **Gracilis**
   **ORIGIN**: inner edge of the descending ramus of the pubis
   **INSERTION**: anterior medial surface of the tibia below the condyle
   **ACTIONS**: Adduction of the hip
   Internal rotation of the hip
   Flexion of the knee
   Internal rotation of the knee

**Nine posterior:**
Gluteus maximus
Gluteus medius
Gluteus minimus

**Six deep lateral rotators:**
   - Piriformis
   - Gemellus inferior
1) **Gluteus maximus**
The gluteus maximus muscle comes into action when movement between the pelvis and femur approaches and goes beyond 15° of extension. It is not used extensively in ordinary walking. However, a strong action of the gluteus maximus occurs in running, hopping, and jumping.

**ORIGIN**: posterior quarter of the crest of the ilium, posterior surface of the sacrum near the ilium, and fascia of the lumbar area

**INSERTION**: gluteal line of femur and iliotibial band of fascia latae

**ACTIONS**: extension, external rotation, and assists in adduction (lower fibers)

2) **Gluteus medius**

**ORIGIN**: outer surface of the ilium just below the crest

**INSERTION**: posterior and middle surfaces of the greater trochanter of the femur

**ACTIONS**
Abduction

External rotation as the hip abducts (posterior fibers)

3) **Gluteus minimus**

Both the gluteus medius and minimus have important functions in walking. As the weight of the body is suspended on one leg, these muscles prevent the opposite hip from sagging. As the body ages, these muscles tend to lose their effectiveness but may be strengthened by activities that transfer weight from one foot to the other.

**ORIGIN**: outer surface of the ilium below the origin of the gluteus medius

**INSERTION**: anterior surface of the greater trochanter of the femur

**ACTIONS**
Abduction

Internal rotation as femur abducts

Six deep lateral rotators of the hip:
All insert on or near the greater trochanter of the femur and function to laterally rotate the thigh.

4) **Piriformis**
The sciatic nerve may pass through, or just inferior to, the piriformis and is associated with “sciatica.”
ORIGIN: anterior surface of sacrum
INSERTION: greater trochanter of femur
ACTIONS
External rotation
Abducts flexed thigh at hip
5) Gemellus superior
ORIGIN: posterior ischium (ischial spine)
INSERTION: greater trochanter of the femur
ACTION: external rotation

6) Gemellus inferior
Both gemelli lie parallel to the obturator internus and insert into a common tendon along with the obturator internus.
ORIGIN: ischial tuberosity
INSERTION: greater trochanter of femur
ACTION: external rotation
7) Obturator internus
ORIGIN: obturator foramen
INSERTION: greater trochanter of femur
ACTION: external rotation
8) Obturator externus
ORIGIN: obturator foramen
INSERTION: greater trochanter of femur
ACTION: external rotation
9) Quadratus femoris
ORIGIN: ischial tuberosity
INSERTION: just below greater trochanter of femur
ACTION: external rotation

VII. Muscles that Act on the Knee
Five anterior:

Quadriceps:
Rectus femoris
Vastus intermedius
Vastus lateralis
Vastus medialis
Sartorius

Quadriiceps:
1) Rectus femoris
ORIGIN: anterior-inferior iliac spine of the ilium
INSERTION: tibial tuberosity via the patella and patellar ligament
ACTIONS
Flexion of the hip
Extension of the knee
2) Vastus intermedius
ORIGIN: upper two-thirds of the anterior surface of femur
INSERTION: tibial tuberosity via the patella and patellar ligament
ACTION: extension of the knee
3) Vastus lateralis
ORIGIN: greater trochanter and lateral lip of the linea aspera
INSERTION: tibial tuberosity via the patella and patellar ligament
ACTION: extension of the knee
4) Vastus medialis
The vastus medialis extends most forcefully in the last 10 to 20° of extension, hence full extension of the knee joint is required to work it effectively.
ORIGIN: whole length of the linea aspera
INSERTION: tibial tuberosity via the patella and patellar ligament
ACTION: extension of the knee
5) Sartorius
ORIGIN: notch between the anterior-superior and anterior-inferior spines of the ilium
INSERTION: anterior medial condyle of the tibia
ACTIONS
Flexion of the hip
Flexion of the knee
Internal rotation of the knee
External rotation of the hip as it flexes the hip and knee

**Five posterior:**

Hamstrings:
- **Biceps femoris**
- **Semitendinosus**
- **Semimembranosus**

**Gastrocnemius**

**Popliteus**

Hamstrings:
1) **Biceps femoris**

**ORIGINS**
Long head: ischial tuberosity
Short head: lateral lip of linea aspera

**INSERTIONS**
Long head: lateral condyle of tibia
Short head: head of fibula

**ACTIONS**
Long head extends the hip
Knee flexion
External rotation of the knee

2) **Semitendinosus**

**ORIGIN:** ischial tuberosity

**INSERTION:** medial condyle of tibia

**ACTIONS**
Extends the hip
Flexes the knee
Internal rotation of the knee

3) **Semimembranosus**

**ORIGIN:** ischial tuberosity

*FIGURE 2.18*
Posterior musculature of the hip and knee, prime movers for hip extension (gluteus maximus and hamstrings) and knee flexion (hamstrings and gastrocnemius).
**INSERTION:** medial condyle of tibia

**ACTIONS**
- Extends the hip
- Flexes the knee
- Internal rotation of the knee

4) **Gastrocnemius**

**ORIGIN:** medial and lateral condyles of the femur

**INSERTION:** calcaneus via the calcaneus tendon (Achilles tendon)

**ACTIONS**
- Plantarflexes the ankle
- Flexes the knee

5) **Popliteus**

**ORIGIN:** posterior surface of lateral epicondyle of femur

**INSERTION:** upper, posterior medial surface of tibia

**ACTION:** flexes the knee

**One medial:**

Gracilis

**ORIGIN:** inner edge of the descending ramus of the pubis

**INSERTION:** anterior medial surface of the tibia below the condyle

**ACTIONS**
- Adduction of the hip
- Internal rotation of the hip
- Flexion of the knee
- Internal rotation of the knee

**VIII. Muscles that Act on the Foot and Ankle**

**Three anterior:**

Anterior tibialis

Extensor digitorum longus

Extensor hallucis longus

1) **Anterior tibialis**

**ORIGIN:** upper two-thirds of the lateral surface of tibia
and interosseous membrane

**INSERTION**: inner surface of medial cuneiform and the 1st metatarsal

**ACTIONS**: dorsiflexes the ankle; inverts the foot

2) **Extensor digitorum longus**

**ORIGIN**: lateral condyle of the tibia, proximal three-fourths of the fibula, and the interosseous membrane

**INSERTION**: middle and distal phalanges of the lateral four toes

**ACTIONS**

Dorsiflexes the ankle

Extends the toes

3) **Extensor hallucis longus**

**ORIGIN**: middle half of the medial fibula and adjoining interosseous membrane

**INSERTION**: distal phalanx of the great toe (“hallucis” refers to the great toe)

**ACTIONS**

Dorsiflexes the ankle

Inverts the foot

Extends the great toe

**Six posterior:**

Gastrocnemius

Soleus

Posterior tibialis

Flexor digitorum longus

Flexor hallucis longus

Plantaris

![Anatomical diagram of the posterior leg muscles]
1) **Gastrocnemius**
This muscle is more effective as a knee flexor if the foot is elevated (as in performing a supine hamstring curl). Additionally, it’s more effective as a plantarflexor of the foot if the knee is held in extension. This is observed when one sits too close to the wheel when driving a car. When the knees are flexed the gastrocnemius becomes an ineffective plantarflexor and it’s more difficult to depress the brakes. This muscle is the primary focus during standing calf work.
**ORIGIN:** medial and lateral condyles of the femur
**INSERTION:** calcaneus via the calcaneus tendon (Achilles tendon)
**ACTIONS**
- Plantarflexes the ankle
- Flexes the knee

2) **Soleus**
This muscle is worked during any movement with the body weight on the foot, whether the knee is flexed or extended.
**ORIGIN:** upper two-thirds of the posterior surfaces of the tibia and fibula
**INSERTION:** calcaneus via the calcaneus tendon (Achilles tendon)
**ACTION:** plantarflexes the ankle

3) **Tibialis posterior**
**ORIGIN:** posterior surface of the upper half of the interosseous membrane and the adjacent surfaces of the tibia and fibula
**INSERTION:** lower medial surfaces of the navicular and cuneiform bones, and bases of the 2 through 5 metatarsal bones
**ACTIONS**
- Plantarflexes the ankle
- Inverts the foot

4) **Flexor digitorum longus**
**ORIGIN:** posterior surface of middle one-third of tibia
**INSERTION:** plantar surface of the base of the 3rd phalange of the 2nd through 5th toes
**ACTIONS**
- Flexes toes 2 through 5
- Plantarflexes the ankle
- Inverts the foot

5) **Flexor hallucis longus**
**ORIGIN:** posterior surface of lower 2/3 of fibula

**INSERTION:** plantar surface of the base of the terminal phalange of the great toe

**ACTIONS**
- Flexes the great toe
- Inverts the foot
- Plantarflexes the ankle

6) **Plantaris**

**ORIGIN:** posterior surface of the lateral epicondyle of the femur

**INSERTION:** tuberosity of the calcaneus via the Achilles tendon

**ACTIONS**
- Plantarflexes the ankle
- Weak flexor of the knee

**Two lateral:**

- **Peroneus longus**
- **Peroneus brevis**

1) **Peroneus longus**

**ORIGIN:** upper two-thirds lateral surface of tibia and fibula

**INSERTION:** ventral surfaces of the 1st metatarsal and medial cuneiform

**ACTIONS**
- Plantarflexes the ankle
- Everts the foot

2) **Peroneus brevis**

**ORIGIN:** distal two-thirds of the fibula

**INSERTION:** tuberosity of the 5th metatarsal

**ACTIONS**
- Plantarflexes the ankle
- Everts the foot

---

**ANATOMY COLORING WORKBOOK**

Apply your knowledge of origins and insertions to draw each of the following muscles on the appropriate portion of the skeleton. It is helpful to use a different color for each muscle.
Left:
- Trapezius
- Posterior deltoid
- Gluteus maximus

Right:
- Rhomboids
- Levator scapulae
- Latissimus dorsi
- Teres major

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Erector spinae

**Lateral view:**
Pectoralis minor
Serratus anterior
External oblique

**Left:**
- Coracobrachialis
- Anterior/medial deltoid

**Center:**
- Rectus abdominis

**Right:**
- Pectoralis major
Left:
Internal oblique

Right:
Transversus abdominis

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Posterior rotator cuff:
Supraspinatus
Infraspinatus
Teres minor

**Left:**
Biceps brachii

**Right:**
Brachialis
Subscapularis
Triceps brachii

**Left** (anterior):
- Brachioradialis
- Pronator teres

**Right** (posterior):
- Ext. carpi radialis brevis
- Ext. carpi radialis longus
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**Left** (anterior):
- Palmaris longus
- Flexor carpi radialis
- Flexor carpi ulnaris

**Right** (posterior):
- Extensor carpi ulnaris
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**Left:**
- Pectineus
- Adductor brevis
- Adductor longus
- Extensor digitorum longus

**Right:**
- Adductor magnus
- Gracilis
- Extensor hallucis longus

**Left:**
- Iliopsoas
- Rectus femoris

**Right:**
- Sartorius
- Tensor fascia latae
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**Left:**
Piriformis
Obturator internus
Obturator externus
Posterior tibialis

**Right:**
Gemellus superior
Gemellus inferior
Quadratus femoris
Lateral view:
Gluteus minimus
Gluteus medius
Tensor fasciae latae
Peroneus brevis
Peroneus longus

**Left:**
- Vastus intermedius
- Anterior tibialis

**Right:**
- Vastus lateralis
- Vastus medialis
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**Left:**
- Semitendinosus
- Semimembranosus
- Soleus

**Right:**
- Biceps femoris
- Gastrocnemius

**Left:**
- Flexor digitorum longus
- Popliteus

**Right:**
- Flexor hallucis longus
- Plantaris
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