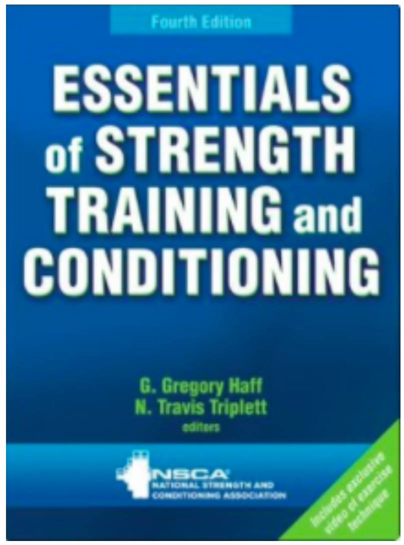
STUDY BOOK

Haff, G., & Triplett, N. T. (2016). *Essentials of strength training and conditioning*. Fourth edition. Champaign, IL: Human Kinetics.



ALL OF THESE NOTES CAME DIRECTLY FROM THE BOOK ITSELF. IN ORDER FOR THIS TO BE BENEFICIAL YOU NEED TO READ THE BOOK!

Chapter 1: Structure and Function of Body Systems

- **Learning Objectives:**
    - Describe both the macrostructure and microstructure of muscle and bone
    - Describe the sliding-filament theory of muscular contraction
    - Describe the specific morphological and physiological characteristics of different muscle fiber types and predict their relative involvement in different sport events
    - Describe the anatomical and physiological characteristics of the cardiovascular and respiratory systems

Musculoskeletal System (2)

- **Skeleton**
    - Muscles can only pull, not push; but through the system of bony levers, muscles' pulling force can be made into a pushing force.
    - *Axial Skeleton*: skull, vertebral column, ribs, sternum
    - *Appendicular skeleton*: appendages (arms, legs)
    - *Fibrous joints*: allow no movement (skull)
    - *Cartilaginous joints*: allow limited movement (vertebrae)
    - *Synovial joints*: allow considerable movement (elbow)
    - *Uniaxial joints:* rotating around one axis (hinge, elbow)
    - *Biaxial joints:* allow movement in two perpendicular axis (wrist, ankle)

- *Multiaxial joints:* allow movement in three perpendicular axis (shoulder, hip)

- **Musculoskeletal Macrostructure and Microstructure**
  - *Epimysium:* fibrous connective tissue that covers muscles
  - The tendon is attached to the bone. When a muscle contracts, it pulls on the tendon which moves the bone.
  - *Muscle fibers*: muscle cells. Grouped in bundles under epimysium (fasciculi)
  - *Perimysium:* connective tissue surrounding bundles of muscle fibers.
  - *Endomysium:* connective tissue surrounding individual muscle fibers.
  - *Neuromuscular junction*: junctions between nerve cell and the muscle fibers it innervates
  - *Motor unit:* the motor neuron and muscle fiber
  - *Sarcoplasm:* cytoplasm of the muscle fiber (protein, glycogen, fat, etc.)
  - *Myofibrils:* dominate sarcoplasm and contain apparatus that contracts the muscle cells.
  - *Myofilament:* consist of myosin and actin.
    - Myosin forms a cross link bridge with actin.
  - *Sarcomere:* combination of myosin and actin, smallest contractile unit of skeletal muscle.
  - Adjacent myosin filaments anchor each other at the M-bridge; actin filaments are aligned on both ends of the sarcomere and are anchored at the Z-line.
  - *I-band*: light, correspond with actin filament
  - *A-band:* dark, correspond with myosin filaments
  - *Z-line:* thin and dark, runs through the middle of the I-band
  - *H-zone:* area in center of sarcomere, only myosin
  - *Sarcoplasmic reticulum*: surrounds each myofibril, calcium ions stored in vesicles, regulation of calcium controls muscular contraction.
  - Discharge of action potential from motor nerve signals the release of calcium from the sarcoplasmic reticulum into the myofibril, causing tension development in the muscle.
- **Sliding-Filament Theory of Muscular Contraction**
  - Actin filaments at the ends of the sarcomere slide inward on the myosin. This pulls the Z-lines toward the center which shortens the muscle fiber.
  - Resting Phase
    - Little calcium is present in myofibril. There are still crosslinks between myosin and actin they are weak. Become much stronger with muscle tension.
  - Excitation-Contraction Coupling Phase
    - When sarcoplasmic reticulum releases calcium, it binds with troponin which causes a shift in tropomyosin. This causes the crosslink to have much more force.
    - The number of cross bridges formed at any instant dictates the force production of the muscle.
  - Contraction Phase
    - Energy for the pulling action comes from breakdown of ATP to ADP and phosphate through ATPase. (power stroke)

        - Calcium plays a role in regulating muscle contraction, glycolytic and oxidative energy metabolism, protein synthesis and degradation.
    - Recharge Phase
        - Shortening of the muscle only happens with binding of calcium to troponin, crosslink of myosin and actin, hydrolysis of ATP, dissociation of actin and myosin, resetting of myosin head.
    - Relaxation Phase
        - Stimulation of motor nerve stops. Calcium flows back into sarcoplasmic reticulum.

Neuromuscular System (8)

- **Activation of Muscles**
    - For more precise muscle movements (eye), a motor unit will control less muscle fibers. For less precise muscle movements (quadriceps), a motor unit will control more muscle fibers.
    - Arrival of an action potential at a nerve terminal causes the release of acetylcholine, which diffuses across neuromuscular junction, which excites the sarcolemma and releases calcium.
    - Brief contraction is known as a twitch. A single twitch does not produce much force, but rapid twitches produce greater force.
    - *Tetanus:* twitches begin to merge and fuse together. This is the maximum amount of force the motor unit can develop.
- **Muscle Fiber Types**
    - *Fast-twitch motor unit:* develops force and relaxes rapidly. I Have a short twitch time.
        - Type IIa and Type IIx
            - inefficient and fatigable, and have low aerobic power, but have rapid force development, high myosin ATPase activity and high anaerobic power.
        - Type IIa has a greater capacity for aerobic metabolism and more capillaries surrounding them than Type IIx and therefore show greater resistance to fatigue.
    - *Slow-twitch motor unit:* develops force and relaxes slowly. I Have a long twitch time.
        - Type I
            - Efficient and fatigue resistant, and have a high capacity for aerobic supply, but have limited potential for rapid force development, characterized by low myosin ATPase activity and low anaerobic power.
    - *Table pg. 10 comparing the two.
- **Proprioception**
    - *Proprioceptors:* specialized sensory receptors located in the joints, muscles, and tendons.
        - They provide CNS with information needed to maintain muscle tone and perform complex coordinated movements
- **Muscle Spindles**

- Proprioceptors that consist of several modified muscle fibers enclosed in a sheath of connective tissue.
- Provide information of muscle length and the rate of change in length.
- Indicate the degree to which the muscle must be activated in order to overcome a given resistance
- How can athletes improve force production?
    - Incorporate phases of training that use heavier loads in order to optimize neural recruitment
    - Increase the cross-sectional area of muscles involved in the desired activity
    - Perform multi muscle, multi joint exercises that can be done with more explosive actions to optimize fast-twitch muscle recruitment.

- **Golgi Tendon Organs**
    - Proprioceptors that are located in tendons at the end of extrafusal muscle fibers (Muscle spindle).
    - Activated when a tendon attached to an active muscle is stretched. As tension in the muscle increases, discharge of GTO increases.
    - Spindles facilitate activation of muscles, GTO inhibit muscle activation.
    - Protects muscles from excess tension.

Cardiovascular System (12)

- **Heart**
    - Right side pumps blood to the lungs, and the left side pumps the rest of the body.
- **Valves**
    - Tricuspid and mitral valves prevent flow of blood from the ventricles to atria during contraction.
    - Aortic and pulmonary valves prevent backflow into ventricles during relaxation
- **Conduction System**
    - *SA node:* pacemaker, where rhythmic electrical impulses are initiated
    - *AV node:* where impulse is delayed slightly before passing into the ventricles
    - *AV bundle*: conducts impulse to ventricles
- **Electrocardiogram**
    - *Depolarization:* reversal of membrane electrical potential, whereby the normally negative potential inside the membrane becomes slightly positive and the outside becomes slightly negative.
    - *Repolarization*: ventricles recover from the state of depolarization.
- **Arteries**
    - Pumps blood away from the heart. Strong muscular walls
- **Capillaries**
    - Facilitate exchange of oxygen, fluid, nutrients, electrolytes, hormones between blood and interstitial fluid. Walls are very thin.
- **Veins**
    - Carry blood to the heart. Walls are thin.
- **Blood**
    - Transports oxygen from lungs to the tissues for use in cellular metabolism and the removal of carbon dioxide.

- The oxygen transport is accomplished by hemoglobin in the blood

<u>Respiratory System</u> (15)

- Primary function is the exchange of oxygen to carbon dioxide.
- **Exchange of Air**
  - Muscles that elevate the rib cage during breathing are: external intercostals, sternocleidomastoids, anterior serrati, and the scaleni.
  - Muscles that depress chest during breathing are: abdominal muscles and internal intercostals.
- **Study Questions**: b, a, b, b, b

Chapter 2: Biomechanics of Resistance Exercise

- **Learning Objectives**
  - Identify the major components of skeletal musculature
  - Differentiate the various types of levers of the musculoskeletal system
  - Identify primary anatomical movements during sport activities and exercises
  - Calculate linear and rotational work and power
  - Describe the factors contributing to human strength and power
  - Evaluate resistive force and power patterns of exercise devices
  - Identify factors of importance for joint biomechanics with exercise.

<u>Skeletal Musculature</u> (20)

- A muscles origin is its proximal attachment, and its insertion is its distal attachment.
- *Fleshy attachments*: found at the proximal end of a muscles, muscle fibers are directly affixed to the bone, usually over a wide area so that force is distributed rather than localized.
- *Fibrous attachments:* blend into and are continuous with both the muscle sheaths and the connective tissue surrounding the bone; tendons.
- *Agonist:* muscle most directly involved in bringing about a movement. Prime mover.
- *Antagonist:* muscle that can slow down or stop the movement. Assists in joint stabilization.
- *Synergist*: assists indirectly in a movement
- **Levers of The Musculoskeletal System**
  - *First-class lever:* <u>E F R.</u>
  - *Second-class lever:* <u>E R F</u>. Mechanical advantage
  - *Third-class lever:* <u>R E F</u> Mechanical disadvantage
  - *Mechanical advantage:* ratio of the moment arm through which an applied force acts to that through which the resistive force acts.
    - Represented by a ratio greater than 1, allows the applied force to be less than the resistive force to produce an equal amount of torque.
    - Less than 1 indicated that one must apply greater muscle force than the amount of resistive force present, creating a disadvantage.
  - *Torque*: force x moment arm. Turning effect of an object.

- Most muscles in the human body are at a mechanical disadvantage. This causes the muscles and tendons to exhibit much higher forces than those exerted on the feet, hands, and ground.
- **Variations in Tendon Insertion**
  - A person with a tendon insertion farther from the joint center will be able to lift heavier weights because of the increased moment arm, this results in a larger mechanical advantage. However, this causes a loss in maximum speed because the muscles have to contract more to achieve a certain range of motion since the tendon is farther.

Human Strength & Power (25)

- **Positive Work and Power**
  - *Work (J):* force / displacement
  - *Power (W):* Work / time
  - Calculating work can be useful in quantifying the volume of a workout
- **Negative Work and Power**
  - When a force exerted on a weight in the direction opposite to the one in which the weight is moving is negative work and power. Happens during eccentric lowering of a weight.
- **Angular Work and Power**
  - Work = torque x angular displacement
- **Strength vs Power**
  - A sport that requires slow movements with high resistance, low-velocity strength is crucial. Sports with fast-movements and low resistance need high velocity strength.
- **Neural Control In Human Strength**
  - Affects maximal force output through recruitment (how many motor units are involved) and rate coding (how fast the motor units are firing).
  - Muscle force is greater when
    - More motor units are involved
    - Motor units are greater in size
    - Rate of firing is faster
  - Massive improvements in strength usually happen in first few weeks of training because our brain adapts to generate more force with a given amount of contractile tissue. After that improvements will not be as drastic. If you stick to training regimen, muscle hypertrophy will develop.
- **Muscle Cross-Sectional Area In Human Strength**
  - The force a muscle can produce is related to its cross-sectional area, rather than its volume.
- **Arrangement of Muscle Fibers In Human Strength**
  - Muscle forces can vary based partially on the alignment of muscle fibers.
  - *Pennate muscle*: has fibers that align obliquely with the tendon
  - *Angle of pennation*: is defined as the angle between the muscle fibers and an imaginary line between the muscles origin and insertion. 0 degrees is no pennation.
  - Angle of pennation increases as the muscle shortens.

- Muscles with greater pennation have more sarcomeres in parallel and fewer sarcomeres in series; they are therefore better able to generate force but have a lower maximal shortening velocity than non-pennate muscles.
- Lesser amounts of pennation can be advantageous for producing high velocities due to the greater number of sarcomeres in a row, at the expense of number of sarcomeres in parallel.
- Angle of pennation is hereditary but can be modified through training.

- **Muscle Length In Human Strength**
  - When muscle is at rest, actin and myosin filaments align next to each other so the maximal cross bridges are available.
  - When a muscle is stretched beyond its resting length, there are fewer actin and myosin filaments available which will result in the muscle not being able to produce as much force that it could at resting length.
  - When a muscle contracts too much past its resting length, the actin and myosin overlap thus causing less force to be generated
- **Muscle Contraction Velocity In Human Strength**
  - The force capability of muscle declines as the velocity of contraction increases.
- **Joint Angular Velocity In Human Strength**
  - *Concentric:* muscle shortens
  - *Eccentric:* Muscle lengthens
    - Increases the risk of soreness and injury because the forces acting within the muscle are less than external forces acting on tendons to stretch it.
  - *Isometric:* muscle length does not change
  - During isokinetic concentric exercise, torque capability declines as angular velocity increases.
  - During eccentric exercise, as the joint angular velocity increases, maximal torque capability increases until 90 degrees/sec. The greatest muscle force can be obtained through eccentric contraction.
- **Strength to Mass Ratio In Human Strength**
  - The ratio of strength of muscles involved in the movement to the mass of the body parts being accelerated is critical. The highest strength to mass ratio will result in the best performance.
- **Body Size In Human Strength**
  - Generally, the smaller the person the stronger they will be.
  - *Classic formula:* load lifted / body weight$^{2/3}$ which accounts for the relationship of cross-sectional area vs volume. This is best for medium sized athletes.

<u>**Sources of Resistance to Muscle Contraction**</u> **(33)**

- **Gravity**
  - $F_g=ma_g$
  - Always acts downward thus the moment arm of a weight is always horizontal
  - Proper form can affect the torque resistance and can shift the stress on certain muscles
  - Advantages of machines
    - Safety, design flexibility, ease of use
  - Advantages of free weights

        - Larger musculature is involved.
        - Promotes greater bone mineralization which helps prevent osteoporosis later in life.
        - Requires muscles to work in stabilization and support
        - Simulation of real-life activities
- **Inertia**
    - Can act in any direction
    - Athletes decelerate a bar by reducing upward force on the bar to less than br weight to let some or all of the bar's weight decelerate or pushing down against the bar using antagonist muscles.
    - When performing an explosive lift, a higher resistance is put on the muscles involved early in the lift, and less toward the end of the lift.
    - Resistance training exercises involving acceleration (explosiveness) produce desirable neuromuscular training effects
- **Friction**
    - $F_{Resitive} = k \times F_{normal}$
    - Resistive force encountered when one attempts to move an object while it is pressed against another object.
    - It takes more force to initiate a movement than to continue a movement
- **Fluid Resistance**
    - $F_{resistive} = k \times v$
    - Resistive force encountered by an object moving through a fluid
    - Crucial for sports like golf, baseball, swimming, sprinting
    - Two sources of fluid resistance:
        - Surface drag: friction of a fluid passing along the surface of an object
        - Form drag: way in which a fluid presses against the front or rear of an object passing through it. Cross-sectional areas have a major effect on this.
- **Elasticity**
    - $F_{resistive} = kx$
    - The more the elastic component is stretched, the greater the resistance.
    - Disadvantages:
        - Start the exercise with low force production and end with high force production. This is the opposite of many muscles and actions.
        - Limited ability to change resistance.
    - This has been used in improving vertical jump. However, the bands provide little resistance early in the jump when the large gluteal and quadriceps muscles are capable of exerting great force. Band provides greatest resistance when jumper in the air, rather than resist the muscles. Jumper returns to the ground at an increased speed which could result in an increased risk of injury.

<u>Joint Biomechanics: Concerns in Resistance Training</u> (37)

- **Back**
    - Advantage of standing upright is we are able to use our feet and hands. Disadvantage is our vertebral column is constantly under compressive stress.
    - In the standing position, any force we exert with the upper body must be transmitted through the back to the legs and ground. The back muscles are at a

mechanical disadvantage and must generate forces much greater than the weight of an object lifted. This is why the back is vulnerable to injury.
  - 85%-90% of all intervertebral disk herniations occur at the disk between the two lowest lumbar vertebrae. This is because of the extremely high compression of the discs during lifting.
  - When weight rests on the trunk, shoulders, and hands, and the trunk is inclined forward there is a great amount of torque on the lower back. These muscles often have to exert forces 10x more than what is lifted.
  - Neutral back lifting posture is better than rounded back when minimizing compressive forces on the intervertebral discs.
  - Uneven squeezing of the discs increases the risk of rupture.
  - *Fluid ball:* when abdominal fluids and tissue kept under pressure by tensing surrounding muscle. Weight lifting belts are good at doing this.
  - This reduces the forces required by the erector spinae and compressive forces on the disks.
  - If an athlete performs all exercises with a belt, the abdominal muscles that produce intra-abdominal pressure might not get enough training stimulus to develop optimally.
- **Shoulders**
  - Shoulder joint has the greatest range of motion in the body, this makes it the most vulnerable.
  - Glenoid labrum, joint synovium, capsules, ligaments, muscles, tendons, bursae, rotator cuff muscles, and pectorals all help keep the humeral ball in place. With all of these structures, it is easy to impinge some of them, causing tendonitis and inflammation.
- **Knees**
  - Prone to injury because of its location between two long levers.
  - The patella's main function is to hold the quadriceps tendon away from the knee axis of rotation, thereby increasing the moment arm of the quadriceps group and its mechanical advantage.
  - Tendonitis is a function of too much volume and intensity without appropriate progression.
- **Elbows & Wrists**
  - Concerns in wrist and elbow injuries are in overhead lifts and motions.
- **Study Questions:** c, d, a, a, c

Chapter 3: Bioenergetics of Exercise and Training

- **Learning Objectives**
  - Explain the basic energy systems available to supply ATP during exercise
  - Understand lactate accumulation, metabolic acidosis, and cellular manifestations of fatigue
  - Identify patterns of substrate depletion and repletion during various exercise intensities
  - Describe the bioenergetic factors that limit exercise performance
  - Develop training programs demonstrate the metabolic specificity of training

- Explain the metabolic demands of and recovery from interval training, high intensity interval training, and combination training to optimize work to rest ratios

Essential Terminology (44)

- *Bioenergetics:* flow of energy in a biological system. This usually means the conversion of macronutrients into biological usable forms of energy. The breakdown of chemical bonds is what provides the energy.
- *Catabolism*: breakdown of large molecules into small
- *Anabolism*: synthesis of larger molecules from smaller molecules. Building up process.
- *Exergonic reactions:* energy-releasing reactions, usually catabolic.
- *Endergonic reactions:* require energy and include anabolic processes and the contraction of muscle.
- *Metabolism:* The total of all the catabolic and anabolic reactions in a biological system.
- Energy derived from catabolic reactions is used to drive anabolic reactions through ATP. Muscle activity and muscle growth are not possible without ATP.
- *Hydrolysis:* breakdown of one ATP to yield energy, Requires one molecule of water.
- Hydrolysis of ATP is catalyzed by the presence of ATPase.
- In the muscle, myosin ATPase catalyzes ATP hydrolysis for crossbridge recycling. Calcium ATPase pumps calcium into the sarcoplasmic reticulum. Sodium-potassium ATPase for maintaining the sarcolemmal concentration gradient after depolarization.
- ATP stores large amounts of energy in the chemical bonds of the two terminal phosphate groups. Muscles need a constant supply of ATP. ATP-producing processes must occur in the cell.

Biological Energy Systems (44)

- *ATP molecule diagram pg.45
- Three systems exist to replenish ATP: Phosphagen, glycolysis, oxidative
- *Anaerobic:* processes do not require oxygen
- *Aerobic:* processes require oxygen
- Phosphagen and glycolytic systems are anaerobic systems that occur in the sarcoplasm of a muscle cell.
- The Krebs cycle, electron transport, and the rest of the oxidative system is aerobic and occurs in the mitochondria of muscle cells and require oxygen as the terminal electron acceptor.
- Only carbohydrates can be metabolized for energy without the direct involvement of oxygen. Therefore, it is critical during anaerobic metabolism.
- All three systems work all the time, however the magnitude of the contribution of each system to overall work performance is primarily dependent on the intensity of the activity and secondarily on the duration.

- **Phosphagen System**
  - Provides ATP for short-term, high intensity activities (resistance training, sprinting) and is highly active at the start of all exercises regardless of intensity.
  - Relies on the hydrolysis of ATP ad breakdown of creatine phosphate.

- ADP + CP < -- > ATP + Creatine. Enzyme: creatine kinase.
- Cannot be a supplier of energy for a long duration because creatine phosphate is stored in small amounts.
- ATP stores:
  - Body stores roughly 80-100g of ATP
  - ATP levels may decrease 50%-60% of pre exercise levels during experimentally induced muscle fatigue.
  - skeletal contractions of CP are 4-6x higher than ATP concentrations. This is good for rapidly replenishing ATP.
  - Type II (fast twitch) muscle fibers contain higher concentrations of CP than Type I (slow-twitch) fibers.
  - People with more Type II muscle fibers are able to replenish ATP faster during anaerobic, explosive exercise.
  - Another reaction to rapidly replenish ATP is adenylate kinase reaction.
    - 2ADP < -- > ATP + AMP. Enzyme: adenylate kinase
  - AMP is a powerful stimulant of glycolysis.
- Control of the phosphagen system
  - Reactions of the phosphagen system are controlled by the law of mass action.
  - *Law of mass action:* the concentrations of reactants or products in solution will drive the direction of the reaction.
  - As ATP is hydrolyzed to yield energy, there is an increase in ADP and P_i in the sarcolemma. This will increase the rate of creatine kinase and adenylate kinase reactions to replenish ATP supply.
  - This process will continue until the exercise ceases, or the intensity is low enough that it does not deplete CP stores.

- **Glycolysis**
  - Is the breakdown of carbohydrate to resynthesize ATP. Occurs in the sarcoplasm.
  - Does not produce ATP as fast as the phosphagen system does, but it produces more ATP because of the higher supply of glucose compared to CP stores.
  - Pyruvate is the end product of glycolysis. Pyruvate can proceed by being converted to lactate in the sarcoplasm or can be shuttled to the mitochondria.
  - *Anaerobic glycolysis:* pyruvate is converted to lactate. ATP resynthesis occurs at a faster rate because of the rapid regeneration of NAD^+, but is limited in duration due to the H^+ production and resulting decrease in cytosolic pH.
  - *Aerobic glycolysis:* Pyruvate is shuttled into the mitochondria to undergo the Krebs cycle. The ATP resynthesis rate is slower because of the many reactions, but can occur for a longer duration if the exercise intensity is low enough.
  - The fate of pyruvate is controlled by the energy demands in the cell.
  - *Both processes of glycolysis: figure 3.2 on pg 47.
  - Glycolysis and the formation of lactate:
    - Formation of lactate from pyruvate is catalyzed by lactate dehydrogenase. This is NOT lactic acid.
    - Proton (H^+) accumulation during fatigue reduces the intracellular pH, inhibits glycolytic reactions, and directly interferes with muscle's

excitation-contraction coupling-- possibly by inhibiting calcium binding to troponin or by interfering with crossbridge recycling. This process of exercise induced decrease in pH is referred to as metabolic *acidosis*, and may be responsible for much of the peripheral fatigue that occurs during exercise.

        - *peripheral fatigue is controversial with many possible reasons for it (pg 48).
        - Lactate is used as an energy substrate in, especially in Type I and cardiac muscle fibers.
        - Lactate is used in gluconeogenesis (formation of glucose from noncarbohydrate sources) during extended exercise and recovery.
        - There is a low lactate concentration in the blood and muscle. Lactate production increases with exercise intensity and depends on muscle fiber type. More in Type II than in Type I.
        - Blood lactate concentrations reflect the net balance of lactate production and clearance as a result of bicarbonate buffering.
        - *Cori cycle:* Lactate can be transported in the blood to the liver, where it is converted to glucose. Figure 3.3 on pg. 48
        - Blood lactate concentrations normally return to pre exercise values within an hour after activity. Light activity during the postexercise period has been shown to increase lactate clearance rates.
        - Peak blood lactate concentrations occur roughly 5 minutes after exercise, a delay frequently attributed to the time required to buffer and transport lactate from tissue to the blood.
        - Blood lactate accumulation is greater after high-intensity interval training than in low-intensity continuous exercise.
        - Trained people experience lower blood lactate concentrations than untrained people during the same workload.
        - Glucose + $2P_i$ + 2ADP → 2 Lactate + 2ATP + H_2O
    - Glycolysis Leading To The Krebs Cycle
        - If oxygen is present in sufficient quantities in the mitochondria, pyruvate is transported into the mitochondria.
        - When pyruvate enters the mitochondria, it is converted to acetyl-CoA by the pyruvate dehydrogenase complex, resulting in the loss of carbon as CO_2. Acetyl-CoA can enter the Krebs cycle for further ATP-resynthesis. The NADH molecules enter the ETC.
        - Glucose + $2P_i$ + 2ADP + $2NAD^+$ → 2pyruvate + 2ATP + 2NADH + $2H_2O$
    - Energy Yield of Glycolysis
        - Two ways to resynthesize ATP during metabolism
            - Substrate-level phosphorylation
            - Oxidative phosphorylation
        - *Phosphorylation:* process of adding an inorganic phosphate to another molecule
        - *Oxidative phosphorylation:* resynthesis of ATP in the ETC.

        - *Substrate-level phosphorylation:* direct resynthesis of ATP from ADP during a single reaction in the metabolic pathways.
            - 1,3-bisphosphoglycerate + ADP + P_i → 3-phosphoglycerate + ATP. Enzyme: phosphoglycerate kinase
            - Phosphoenolpyruvate + ADP + P_i → Pyruvate + ATP. Enzyme: pyruvate kinase
        - When glycolysis begins with one molecules of blood glucose, two ATP molecules are used and four ATP are resynthesized
        - When glycolysis begins from muscle glycogen, only one ATP is used and four ATP are resynthesized.
    - Control of Glycolysis
        - Rate of glycolysis will increase if during intense muscle actions by high concentrations of ADP, P_i, ammonia, and by a slight decrease in pH and AMP.
        - Rate of glycolysis will decrease by lower pH, ATP, CP, citrate, and free fatty acids.
        - Glycolysis is also regulation through three enzymes
            - Hexokinase
            - Phosphofructokinase (PFK)
            - Pyruvate kinase
        - All of these have important allosteric binding sites (other sites)
        - *End product regulations:* occurs when the end product of a reaction feeds back to regulate the turnover rate of key enzymes in the metabolic pathways.
        - *Allosteric inhibition:* occurs when end product binds to the regulatory enzyme and decreases its turnover rate and slows product formation
        - *Allosteric activation:* occurs when an activator binds with the enzyme and increases its turnover rate.
        - Hexokinase
            - Catalyzes the phosphorylation of glucose to glucose-6-phosphate, is allosterically inhibited by the concentration of glucose-6-phosphate in the sarcoplasm.
        - PFK
            - Commits the cell to metabolizing glucose rather than storing it as glycogen
            - The most important regulator of glycolysis
            - ATP is an allosteric inhibitor
            - AMP is an allosteric activator
        - Pyruvate kinase
            - Catalyzes the conversion of phosphoenolpyruvate to pyruvate.
            - ATP and acetyl-CoA are an allosteric inhibitor
            - High concentrations of AMP and fructose-1,6-biphosphate are an allosteric activator
    - Lactate Threshold and Onset of Blood Lactate Accumulation
        - There are specific breakpoints in lactate accumulation

        - *Lactate threshold:* exercise intensity at which blood lactate begins an abrupt increase above the baseline concentration
            - Represents a significant reliance on anaerobic mechanisms for energy production to meet demand
            - Usually begins at 50%-60% of maximal oxygen uptake in untrained and at 70%-80% in aerobically trained.
        - *Onset of blood lactate accumulation (OBLA):* second increase in the rate of lactate accumulation
            - Occurs when concentration of blood lactate reaches 4 mmol/L
- **The Oxidative (Aerobic) System**
    - Primary source of ATP during rest and during low-intensity activities. Uses carbohydrates and fats as substrates
    - At rest, 70% of ATP produced is derived from fats and 30% from carbohydrates. During exercise there is a shift in preference from fats to carbohydrates.
    - During prolonged, submaximal, steady work, there is a gradual shift from carbohydrates back to fats.
    - Proteins DO NOT provide energy.
    - Glucose and Glycogen Oxidation
        - Pyruvate (from glycolysis) → Acetyl-CoA → Krebs cycle
        - The Krebs cycle continues the oxidation of the substrate from glycolysis and produces two ATP indirectly from GTP via substrate-level phosphorylation.
        - Pyruvate also produces six NADH and two $FADH_2$. These molecules transport hydrogen ions to the ETC to produce ATP from ADP.
        - Hydrogen atoms are passed down the chain (electron carriers known as cytochromes) to form a proton concentration gradient, which provides the energy for ATP production, with oxygen serving as the final electron acceptor.
        - One molecule of NADH can produce three molecules of ATP. One molecules of $FADH_2$ can produce two molecules of ATP
        - Production of ATP during this process is *oxidative phosphorylation*
        - Results in a production of about 38 ATP from one molecule of glucose.
        - If the initiation of glycolysis is muscle glycogen, the net ATP is 39 because the hexokinase reaction is not necessary with muscle glycogenolysis
        - *Total energy yield table pg. 53
        - *Krebs cycle diagram (also beta and protein oxidation) pg. 52
    - Fat oxidation
        - Fats can be used by the oxidative energy system.
        - Triglycerides in the fat cells can be broken down to produce free fatty acids and glycerol. This is then released into the blood where it can enter muscle fibers and undergo oxidation.
        - There are also some triglycerides stored in the muscle to produce a source of free fatty acids.

        - Free fatty acids enter the mitochondria where they undergo beta oxidation (reactions where free fatty acids are broken down and form acetyl-CoA (Krebs cycle) and hydrogen protons (ETC)
        - One triglyceride molecule can produce up to 300 ATP.
    - Protein Oxidation
        - Most amino acids can be converted into glucose, pyruvate, or various Krebs cycle intermediates.
        - This process may only contribute 3%-18% of the energy requirements during prolonged activity.
        - Major amino acids oxidized in skeletal muscle are branched-chain amino acids (leucine, isoleucine, valine, alanine, aspartate, and glutamate).
        - Nitrogenous waste products from amino acids are eliminated by urea and small amounts of ammonia. Elimination of these are important because ammonia is toxic and is associated with fatigue.
    - Control of the Oxidative (Aerobic) System
        - Reactions that produce NADH and $FADH_2$ influence the regulation of the Krebs cycle.
        - If NAD^+ and FAD^{2+} are not available to accept hydrogen, the rate of the Krebs cycle is reduced
    - *Metabolism of fat, carbohydrates, and proteins diagram: pg. 54
- **Energy Production and Capacity**
    - Exercise intensity is defined as a level of muscular activity that can be quantified in terms of power output.
    - Activities such as resistance training require a rapid rate of energy supply and rely almost entirely on the energy from the phosphagen system. Also some fast (anaerobic) glycolysis.
    - Activities that are long and at low intensity rely on the oxidative energy system. Also some slow (aerobic) glycolysis
    - There is never a single system only working. The systems that contribute to the ATP depends on the intensity of muscular activity and secondarily on the duration.
    - *Effect of event duration and intensity on primarily energy system used pg. 54
    - *Rate and capacity of ATP production pg. 54

<u>Substrate Depletion & Repletion</u> (55)

-
    - *Energy Substrates:* molecules that provide starting materials for bioenergetic reactions
        - Can be selectively depleted during the performance of activities of various intensities and durations
    - Fatigue experienced during exercise is mainly associated with the depletion of phosphagens and glycogen
- **Phosphagens**
    - Phosphagen concentrations in muscle are more rapidly depleted as a result of high-intensity anaerobic exercise compared to aerobic exercise.
    - Creatine phosphate can decrease up to 70% during the first stage of high intensity exercise and short duration.

- Dynamic muscle actions that produce external work use more metabolic energy and typically deplete phosphagens to a greater extent than isometric muscle actions.
- Postexercise phosphagen repletion can occur quickly. Resynthesis of ATP occurs within 3-5 minutes, and complete CP resynthesis can occur within 8 minutes.

- **Glycogen**
    - 300g-400g of glycogen are stored in the body's total muscle and about 70g-80g in the liver
    - Both anaerobic and aerobic training can increase resting muscle glycogen concentration with an appropriate diet.
    - During high-moderate intensity exercise, the glycogen from the muscle is a more important source of energy.
    - During low intensity exercise, glycogen from the liver is a more important source of energy
    - For intensities above 60% maximal oxygen uptake, glycogen becomes a very important energy substrate.
    - A decline in blood glucose to around 2.5-3.0 mmol/L results from reduced liver carbohydrate stores and causes decreased carbohydrate oxidation and eventual exhaustion.
    - Muscle glycogen may become a limiting factor for resistance training with many total sets and larger amounts of work. This could cause selective muscle fiber glycogen depletion (more in Type II), which can limit performance.
    - Repletion of muscle glycogen comes from ingesting carbohydrates after exercise. Repletion is optimal if 0.7g-3.0g of carbohydrate per kg of body weight is ingested every two hours following exercise. This will maximize muscle glycogen repletion per hour during the first 4-6 hours. After 24 hours, muscle glycogen should be replenished.

<u>Bioenergetic Limiting Factors in Exercise Performance</u> (56)

- Table 3.4 ranking of bioenergetic limiting factors pg. 57

<u>Oxygen Uptake and the Aerobic and Anaerobic contributions to Exercise</u> (57)

- *Oxygen Uptake:* measure of a person's ability to take in oxygen via the respiratory system and deliver it to the working tissues via the cardiovascular system, and the ability of working tissues to use oxygen.
- At the start of exercise some energy must be supplied through anaerobic mechanisms because the aerobic system responds slowly to the initial increase in demand for energy.
- *Oxygen deficit:* anaerobic contribution to the total energy cost of exercise
- *Oxygen debt (EPOC):* postexercise oxygen uptake, recovery O_2. Oxygen uptake above resting values used to restore the body to the pre-exercise condition.
- *Figures 3.9 and 3.10 are good for showing oxygen deficit and EPOC pg. 57-58
- *Table 3.5 contributions of anaerobic and aerobic mechanisms to maximal sustained efforts in bicycle ergometry pg. 59
- Aerobic exercise and EPOC
    - Greatest EPOC values are found when exercise intensity and duration are high

        - Brief intermittent bouts of supramaximal exercise may induce greatest EPOC with lower total work
    - Resistance exercise and EPOC
        - Heavy resistance exercise produces greater EPOC than circuit weight training
    - Factors responsible for EPOC
        - Replenishment of oxygen in blood and muscle
        - ATP/CP resynthesis
        - Increase body temperature, circulation, and ventilation
        - Increased rate of fatty acid cycling
        - Increased protein turnover
        - Changes in energy efficiency during recovery

Metabolic Specificity of Training (59)

- Most sports produce metabolic profiles that are very similar to those of a series of high intensity, constant effort exercise bouts interspersed with rest periods.

- **Interval Training**
    - Emphasizes bioenergetic adaptations for a more efficient energy transfer within the metabolic pathways by using predetermined intervals of exercise and rest periods.
    - Much more training can be accomplished at higher intensities with interval training
    - *Table 36 on work-to-rest ratios
- **High-Intensity Interval Training**
    - Involves brief repeated bouts of high intensity exercise with intermittent recovery periods. High intensity work phase followed by lower intensity recovery phase.
    - Intensities and durations of the active and recovery portions of each duty cycle are the most important factors to consider
    - HIIT is designed to repeatedly elicit a very high percentage of VO_2max which is the result of the concurrent recruitment of large motor units and near maximal cardiac output. Provides a stimulus for oxidative muscle fiber adaptation and myocardial hypertrophy.
- **Combination Training**
    - This suggests that aerobic endurance training should be added to the training of anaerobic athletes to enhance recovery because recovery relies primarily on aerobic mechanisms.
    - Recovery in power output is related to endurance fitness
    - However, combined anaerobic and aerobic endurance training can reduce gain in muscle girth, maximum strength, and speed and power related performance
    - Strength can be hindered through combination training by: decreasing rapid voluntary activation, chronically lower muscle glycogen levels that can limit intracellular signaling responses during resistance training, and fiber type transition to slow-twitch fibers.
    - On the other hand, studies have shown that anaerobic training (strength training) can improve low and high intensity endurance.
- **Study Questions:** b, a, a, c, d

Chapter 4: Endocrine Responses to Resistance Exercise

- **Learning Objectives**
  - Understand basic concepts of endocrinology, including what hormones are and how they interact with each other and target tissues.
  - Explain physiological roles of anabolic hormones
  - Describe hormonal responses to resistance exercise
  - Develop training programs that demonstrate and understanding of human endocrine responses
- **Introduction**
  - The endocrine system supports the normal homeostatic function of the body and helps it respond to external stimuli
  - Endocrine system relates to strength and conditioning through the development of periodization of training.
- *General Adaptation Syndrome:* refers to how the adrenal gland responds to a stressor
  - Starts with an initial alarm reaction that reduces function and is followed by an increase in resistance to the stress above the previous baseline function.
- *Adaptation:* increase in resistance to the stress
- For beneficial adaptation, you need to have a timely removal of the stress so the function can recover, and then reapplication of an increased stress.

<u>Synthesis, Storage, and Secretion of Hormones</u> (66)

  - *Adrenal Glands and Selected Hormones Table 4.1 pg. 67
  - *Hormones:* are chemical messengers that are synthesized, stored, and released into the blood by endocrine glands
  - *Neurons:* synthesize, store, and secrete neurotransmitters which may have hormonal functions.
  - Endocrine glands are stimulated to release hormones by a chemical signal received by receptors on the gland or by direct neural stimulation
  - Following stimulation, endocrine glands release hormones into the blood, which carries the hormones to hormone-specific receptors located on the surface or in the cytosol of the target tissue cells.
  - Hormones can be secreted to function via intracrine, autocrine, and paracrine
    - Intracrine and autocrine
      - Cell releases the hormone to act upon the cell itself, via binding to intracellular and membrane receptors.
      - May be stimulated by an external stimulus, but the secreted hormone never enters blood circulation
    - Paracrine
      - Release of a hormone to interact with adjacent cells, without moving into the blood circulation
  - Binding proteins that carry hormones are found in the blood (peptide and steroid). They act as storage sites within the circulation, help to fight degradation of the hormone, and extend its half life. Most hormones are not active unless they are separated from binding protein.

<u>Muscle as the Target for Hormone Interactions</u> (69)

- Muscle remodeling involves the disruption and damage of muscle fibers, an inflammatory response, degradation of damaged proteins, hormonal and other signal interactions, and ultimately the synthesis of new proteins and their orderly incorporation into existing or new sarcomeres.
- *Anabolic hormones:* hormones that promote tissue building (insulin, insulin-like growth factors, testosterone, and growth hormone)
  - Also block the negative effects on protein metabolism of catabolic hormones.
- *Catabolic hormones:* degrade cell proteins (cortisol and progesterone)

Role of Receptor in Mediating Hormonal Changes (69)

- A signal from a hormone is related only to cells that express the receptor for that specific hormone
- *Allosteric binding sites:* substances other than hormones can enhance or reduce the cellular response to the primary hormone
- When an adaptation is no longer possible or overstimulated by a hormone has occurred, receptors can become less responsive or even nonresponsive to a specific hormone, preventing it from stimulating further actions in the cell
- *Downregulation:* inability of a hormone to interact with a receptor
- *Lock and key theory diagram pg 70

Categories of Hormones (70)

- **Steroid Hormone Interactions**
  - These hormones come from the adrenal cortex and the gonads
  - They are fat soluble and passively diffuse across the cell membrane
  - After diffusing across the sarcolemma, the hormone binds with its receptors to form a hormone-receptor complex (H-RC), which activates it.
  - The H-RC then binds to another H-RC and moves to the nucleus where it arrives at the DNA
  - The H-RC opens the DNA to expose the transcriptional units that code for the synthesis of specific proteins.
  - DNA is transcribed and mRNA moves into the sarcoplasm of the cell, where it is translated by the ribosome into the specific protein promoted by the steroid hormone.
  - *This process is described in Figure 4.3 pg. 71
- **Polypeptide Hormone Interactions**
  - Made up of chains of amino acids
  - Are not fat soluble which means they cannot cross the cell membrane; secondary messengers inside the cell are activated
  - Membrane receptors transmit the hormonal signal to the inside of the cell.
  - *This process is described in Figure 4.4 pg.71

Heavy Resistance Exercise and Hormonal Increases (72)

- Long term, consistent heavy resistance exercise brings about significant adaptive responses that result in enhanced size, strength, and power
- Hormones are secreted before, during, and after the resistance exercise bout due to the physiological stress of resistance exercise

- Acute hormonal secretions provide information to the body regarding such things as the amount and type of physiological stress, the metabolic demands of exercise, and thus the need for subsequent changes in resting metabolism.
- Hormonal increases in response to resistance exercise takes place in a physiological environment that is unique to this type of exercise stress
- Among many different responses to a large production stress (lifting heavy) are alterations in the sarcolemma's ability to import nutrients and in the sensitivity and number of hormone receptors in the muscle cells.
- As few as one or two heavy lifting sessions can increase the number of androgen receptors, the receptor for testosterone, in the muscle.
- Also, local inflammatory processes related to tissue damage and repair mechanisms are activated by stress and run their time course with recovery.
- All of these things combined results in muscle growth
- After a resistance exercise session, remodeling of the muscle tissue takes place in the environment of hormonal secretions and other molecular signaling mechanisms that provide for anabolic reactions
- If the stress is too great, catabolic actions may exceed anabolic reactions.

<u>Mechanisms of Hormonal Interactions</u> (72)

- When exercise acutely increases blood concentrations of hormones, the probability of interaction with receptors might be greater.
- If the physiological function to be affected is already close to its genetic maximum, the receptor is not as sensitive to the increased hormonal exposure.
- Usually adaptations to heavy resistance exercise are anabolic, which increases the size of muscles
- Errors in exercise prescription can result in a greater catabolic effect or a lack of an anabolic effect.

<u>Hormonal Changes in Peripheral Blood</u> (73)

- We can monitor hormone concentrations during exercise through the blood.
- Peripheral concentrations of hormones in the blood does not indicate the status of the various receptor populations or the effects of a hormone within a cell.
- Large increases in hormone concentration indicate higher probabilities for interactions with receptors
- An increase in hormonal concentrations in the blood is not a prerequisite site for seeing gains in muscle size or strength but does represent an increased activation for hormonal release of the endocrine gland involved

<u>Adaptations in the Endocrine System</u> (73)

- When one trains muscles, endocrine glands are also being trained
- The involvement of any endocrine gland is dependent on how much support is needed by the gland's secretions to support the activated motor units
- Adaptations are related to changes in the target organs and the toleration of exercise stress
- Different hormonal adaptations:
    - Amount of synthesis and storage of hormones
    - Transport of hormones via binding proteins
    - Time needed for the clearance of hormones through liver and other tissues

        - Amount of hormonal degradation that takes place over a given period of time
        - How much blood-to-tissue fluid shift occurs with exercise stress
        - How tightly the hormone binds to its receptor; this is an uncommon response to exercise training
        - How many receptors are in the tissue
        - The change in the content and in some cases the size of the secretory cells in the glands
        - The magnitude of the signal sent to the cell nucleus by the H-RC and secondary messenger
        - The degree of interactions with the cell nucleus
    - Hormones are secreted in response to a need for homeostatic control in the body, the endocrine system is part of an overall strategy to bring physiological functions back to normal range

Primary Anabolic Hormones (74)

- **Testosterone**
    - Primarily androgen that interacts with skeletal muscle tissue
    - The binding of testosterone to its receptor is the key to stimulating anabolic functions
    - Circulating testosterone is a physiological marker for evaluating anabolic status of the body
    - Can promote growth hormone release from the pituitary, which can influence protein synthesis in muscle
    - Testosterone influence the nervous system: it can interact with receptors on neurons, increase the amount of neurotransmitters, and influence structural protein changes
    - These interactions can enhance force production and mass of innervated muscle
    - After secretion of testosterone in the blood, it is transported to target tissues by a binding protein.
    - Once it arrives at the target tissue it crosses the cell membrane and binds to an intracellular androgen receptor
    - This allows for calcium release to occur
    - Receptor interactions may be quite different under different exercise conditions due to the differential force on the membrane
    - High intensity aerobic endurance exercise can cause a dramatic catabolic response, and increases in testosterone may be related to the need for protein synthesis to keep up with protein loss. Despite increased testosterone, muscle hypertrophy does not take place in aerobic endurance training
    - Oxidative stress will promote a decrease in muscle fiber size in order to optimize oxygen transport into the cell.
    - Free testosterone and sex hormone--binding globulin
        - *Free testosterone:* testosterone not bound to a binding protein
        - Free testosterone only accounts for 0.5% to 2% of total testosterone
        - Heavy resistance exercise can acutely increase free testosterone

        - Free hormone hypothesis states that it is only the free hormone that interacts with target tissues
        - The bound hormone could significantly influence the rate of hormone delivery to a target tissue, and this may be an advantage that younger men have over older men after a workout.
        - Testosterone is a major player in the anabolic responses to resistance training
    - Testosterone Responses in Women
        - Women have 15-20 fold lower concentrations of testosterone than men do.
    - Training Adaptations of Testosterone
        - One has to realize that testosterone increases in response to the demands of an exercise protocol; then the receptors either increase binding to use the elevated testosterone or they do not due to lack of need for the signal to increase muscle-related metabolism.
        - Training time and experience may be very important factors in altering the resting and exercise-induced concentrations of this hormone
        - Research on this topic is limited.
- **Growth Hormone**
    - GH is very complex and little is known about the complexity of it.
    - *Figure 4.6 shows the GH and its interactions
    - GH is important for the development of a child, but it also appears to play a vital role in adapting to the stress of resistance training
    - Physiological roles of GH
        - Decrease glucose utilization
        - Decrease glycogen synthesis
        - Increases amino acid transport across cell membranes
        - Increases protein synthesis
        - Increases utilization of fatty acids
        - Increases lipolysis
        - Increases availability of glucose and amino acids
        - Increases collagen synthesis
        - Stimulates cartilage growth
        - Increases retention of nitrogen, sodium, potassium, and phosphorus
        - Increases renal plasma flow and filtration
        - Promotes compensatory renal hypertrophy
        - Enhances immune cell function
    - GH interacts directly with target tissues
    - The 22 kDa GH form both stimulates the release of insulin-like growth factors (IGF) at the autocrine level of the cell, contributing to the overall changes in the IGF in the body, and increases the availability of amino acids for protein synthesis. This results in conditions that promote tissue repair in general and perhaps in recovery following resistance exercise.
    - GH acts by binding to plasma membrane-bound receptors on the target cells
    - Growth hormone responses to stress

        - Pituitary hormones (POMC, GH, prolactin) respond to a variety of exercise stressors, including resistance exercise.
        - A substantial stimulus for GH (22 kDa) release is increased hydrogen ions (drop in pH) and lactate concentrations
        - Depending on the load, rest, exercise volume, and exercise selection different 22 kDa GH responses occur
    - Growth Hormone Responses in Women
        - Women have higher blood concentrations of 22 kDa GH because of their menstrual cycle
    - Training Adaptations of Growth Hormone
        - GH concentrations need to be measured over longer periods of time (2-24 hours) to show whether changes occur with resistance training.
        - Limited research and needs more to validate claims
- **Insulin-Like Growth Factors**
    - Some of the effects of 22 kDa are mediated through small polypeptides called IGF.
    - The liver secretes IGF after 22 kDa GH stimulates the liver to synthesize IGF
    - Thyroid hormone and testosterone are also involved in the regulation of IGF
    - IGF travel in the blood bound to binding proteins; in the target tissue, IGF disassociate from the binding protein and interact with the receptors
    - Binding proteins are important in the transport and physiological mechanism of IGF
    - Binding proteins act as a reservoir of IGF, and the release from the binding protein is signaled by the availability of a receptor on the cell. This allows IGF to be viable for a longer period of time and could reduce the amount of degradation of IGF
    - Exercise Responses of Insulin-Like Growth Factors
        - IGF I has been the main IGF studied because of its role in protein anabolism
        - It takes 8-24 hours for IGF to be produced and released from the liver following stimulation by GH
        - Higher resting concentrations can make acute exercise-induced increases less probable
        - Free forms of IGF may be effective elements that influence target tissues, especially in skeletal muscle
        - At rest, fat cells contain high concentrations of IGF, and skeletal muscle very little. However, mechanical stimulation, overload, and stretch of muscle cells, cause them to substantially increase their production of IGF-I
    - Training Adaptations of IGF
        - The intake of food or the level of caloric restriction influences the resting and exercise-induced concentrations in the blood

Adrenal Hormones (82)

- Adrenal gland plays a crucial role in the fight-or-flight response phenomenon and has two major divisions: medulla and cortex

- Adrenal medulla is stimulated directly by the nervous system and thus provides a fast and almost immediate response
- The adrenal cortex is stimulated by ACTH released from the anterior pituitary

- **Cortisol**
  - Have been viewed as catabolic hormones in the skeletal muscle
  - Cortisol is a primary signal hormone for carbohydrate metabolism and is related to the glycogen stores in the muscle
  - Role of cortisol
    - Cortisol exerts its major catabolic effects by stimulating the conversion of amino acids to carbohydrates, increasing the level of proteolytic enzymes (enzymes that break down proteins), inhibiting protein synthesis, and suppressing many glucose-dependent processes such as glycogenesis and immune cell function
    - Has greater catabolic effects of Type II fibers because they have more protein than in Type I
    - Type I fibers rely more on reducing degradation to develop hypertrophy, in contrast to dramatic increases in synthesis used by Type II fibers to develop hypertrophy
    - In situations of disease, joint immobilization, or injury, an elevation of cortisol mediates a nitrogen-wasting effect with a net loss of contractile proteins. This results in muscle atrophy
    - Cortisol is catabolic, testosterone and insulin are anabolic. If anabolic hormones attach to more receptors than catabolic, protein is conserved and enhanced. If the opposite happens, protein is degraded and lost. This directly influences strength
  - Resistance Exercise Responses of Cortisol
    - Cortisol increases with resistance exercise, most dramatically when rest periods are short or the total volume of work is high.
    - Muscle must be disrupted to a certain extent to remodel itself and enlarge; acute elevations in cortisol would help in this remodeling process by helping to remove damaged proteins
    - Cortisol levels need to be more than 800 mmol/L to indicate overtraining problems
    - Cortisol's role in overtraining, detraining, or injury may be critical when muscle tissue atrophy and decreases in force production is observed
    - Cortisol's role in suppressing function of cells of the immune system has a direct impact on the recovery and remodeling of skeletal muscle tissue
- **Catecholamines**
  - Are secreted by the adrenal medulla and are important or the acute expression of strength and power because the hormones act as central motor stimulators and peripheral vascular dilators and enhance enzyme systems and calcium release in muscle
  - Consist of epinephrine, norepinephrine, and dopamine
  - Role of Catecholamines
    - Physiological functions of epinephrine and norepinephrine

            - Increase force production via central mechanisms and increased metabolic enzyme activity
            - Increase muscle contraction rate
            - Increase blood pressure
            - Increase energy availability
            - Increase muscle blood flow
            - Augment secretion rates of other hormones, such as testosterone
        - If training is not varied, continued stress keeps the adrenal gland engaged, and recovery is delayed due to the secondary responses of cortisol and its negative effects on immune system cells and protein structures. Long-term continued high stress can even lead to adrenal exhaustion, at which point the ability of the adrenal medulla to release catecholamines is diminished
    - Training Adaptations of Catecholamines
        - Heavy resistance training has been shown to increase the ability of an athlete to secrete greater amounts of epinephrine during maximal exercise
- **How can athletes manipulate the Endocrine system with resistance training?**
    - The more muscle fibers recruited for an exercise, the greater the extent of potential remodeling process in the whole muscle
    - Only muscle fibers activated by resistance training are subject to adaptation, including hormonal adaptations to stress
    - To increase serum testosterone concentrations
        - Large muscle group exercises (deadlift, power clean, etc)
        - Heavy resistance (85%-95% of 1RM
        - Moderate to high volume of exercise, achieved with multiple sets of multiple exercises
        - Short rest intervals (30-60 sec)
    - To increase 22 kDa GH concentrations
        - Use high intensity with three sets of each exercise (high total work) and short rest periods
        - Supplement diet with carbs and protein before and after workouts
- **Study Questions:** d, a, b, b, a

Chapter 5: Adaptations To Anaerobic Training Programs

- **Learning Objectives**
    - Differentiate between aerobic training adaptations and anatomical, physiological, and performance adaptations following anaerobic training
    - Discuss the central and peripheral neural adaptations to anaerobic training
    - Understand how manipulating the acute training variables of periodized program can alter bone, muscle, and connective tissue
    - Explain the acute and chronic effects of anaerobic training on the endocrine system
    - Elucidate the acute chronic effects of anaerobic training on the cardiovascular system
    - Recognize the causes, signs, symptoms, and effects of anaerobic overtraining and detraining

- Discuss how anaerobic training programs have the potential to enhance muscular strength, muscular endurance, power, flexibility, and motor performance.

- **Introduction**
  - *Anaerobic training:* high-intensity, intermittent bouts of exercise that requires ATP to be regenerated faster than the aerobic energy system is capable of.
    - Differences in energy requirements between the systems are filled in from the anaerobic alactic system (CP) and the anaerobic lactic system (glycolytic).
  - Sprints and plyometric drills stress the phosphagen system which are less than 10 seconds and allow complete recovery afterward.
  - Long-durations interval-type anaerobic training uses the glycolytic system
  - High intensity exercises with short rest periods are important for anaerobic training. Athletes are often required to exert maximal effort when fatigued during their sporting event.

<u>**Neural Adaptations**</u> **(88)**

- Anaerobic training modalities emphasize the expression of muscular speed and power and depend greatly on optimal neural recruitment for maximal performance
- Neural adaptations are fundamental to optimizing athletic performance and increased neural drive is critical to maximizing the expression of muscular strength and power.
- Augmented neural drive is thought to occur via increased agonist muscle recruitment, improved neuronal firing rates, and greater synchronization in the timing of neural discharge during high intensity muscular contractions.

- **Central Adaptations**
  - Increased motor unit activation begins in the higher brain centers, where the intent to produce maximal levels of muscular force and power causes motor cortex activity to increase.
  - Adaptations to anaerobic training are reflected by substantial neural changes in the spinal cord, particularly along the descending corticospinal tracts.
  - The recruitment of fast-twitch motor units is elevated to support heightened levels of force expression
  - Research shows that only 71% of muscle tissue is activated during maximal efforts in untrained individuals
  - *Figure 5.1 neural adaptation diagram pg. 90
- **Adaptations of Motor Units**
  - When maximal force is desired, all of the available motor units must be activated within a muscle.
  - Change in firing rate of frequency of motor units also affects the ability to generate force
  - With increased firing rates, the muscle fibers are continually activated by subsequent action potentials before they have time to completely relax following a prior action potential
  - These firing rates represent and adaptive mechanism shown to improve following heavy resistance training

- Gain in maximal strength and power of agonist muscles are associated with an increase in recruitment, an increase in firing rate, and greater synchronization of neural discharge, which acts to coordinate the activity of multiple muscles in synergy
- *Size principle:* represents the relationship between motor unit twitch force and recruitment threshold.
  - Recruitment and decruitment of motor units are governed by this
  - *Figure 5.2 on pg. 91 illustrates this
- With heavy resistance training, all muscle fibers get larger because they are all recruited to some extent in order to produce higher levels of force required to lift progressively heavier loads.
- Once a motor unit is recruited, less activation is needed for it to be recruited
- Exceptions to the size principle do exist, an athlete can inhibit the lower-threshold motor units and activate higher threshold motor units instead when force production is required at very high speeds. This is called selective recruitment.
- Rapid changes in the direction of force productions and ballistic muscular contractions (Olympic weightlifting, plyometrics, speed, power, and agility training) have been shown to lead to preferential recruitment of fast-twitch motor units
- Selective recruitment is a beneficial intrinsic neural mechanism favoring explosive exercise
- *Table 5.2 physiological adaptations to resistance training pg. 90
- As a muscle size increases it does not require as much neural activation to lift a given load.
- There is a positive relationship between the magnitude of force produced and the rate of motor unit firing
- The increase in firing rate is dependent on muscle size. Larger muscles depend more on recruitment and smaller muscles depend on increased firing rate

- **Neuromuscular Junction (NMJ)**
  - The interface between the nerve and skeletal muscle fibers
  - Anaerobic training appears to induce beneficial morphological changes in the NMJ that are conducive to enhanced neural transmission capabilities
- **Neuromuscular Reflex Potentiation**
  - Anaerobic training causes positive changes in the reflex response of the neuromuscular system and enhances the magnitude and rate of force development via this reflex
  - This myotatic reflex harnesses the involuntary elastic properties of the muscle and connective tissue and acts to positively increase force production without any additional energy requirements.
- **Anaerobic Training and Electromyography Studies**
  - EMG is a common research tool used to examine the magnitude of neural activation within skeletal muscle. Two kinds: surface and intramuscular.
  - Surface EMG is good from superficial muscles. Not able to read past action potentials
  - Intramuscular EMG records localized motor unit action potentials

- An increase in EMG signal indicates greater neuromuscular activity
- Neural adaptations dominate in the early stages of training (6-10 weeks) but decrease once hypertrophy occurs (>10 weeks) which contribute to strength and power gains
- Eventually muscle hypertrophy plateaus as accommodations to the training load occurs.
- If the athlete incorporates a new variation or progressive load into the training plan, neural adaptations will once again contribute to the performance improvements by acting to tolerate the new physical insult from training
- *Cross-education:* exercising muscle undergoing unilateral resistance training produces increased strength and neural activity in the contralateral resting muscle.
  - The increase in strength of the untrained limb suggests that a central neural adaptation accounts for the majority of strength gains
- *Bilateral deficit:* the force produced when both limbs contract together is lower than the sum of the forces they produce when contracting unilaterally. The EMG activity is lower in bilateral contractions
- Cocontractions of antagonist muscles serves as a protective mechanism to increase joint stability and reduce the risk of injury

<u>Muscular Adaptations</u> (93)

- **Muscular Growth**
  - *Hypertrophy:* enlargement of muscle fiber cross-sectional area following training
  - The process of hypertrophy involves an increase in net accretion (increase in synthesis, reduction in degradation, or both) of the contractile proteins actin and myosin within the myofibril, as well as an increase in the number of myofibrils within a muscle fiber
  - Other structural proteins such as titin and nebulin are synthesized proportionally to the myofilament changes which result in an increase in diameter.
  - When muscle fiber contract, Akt.mTOR signaling increases dramatically, and this response is critical for increasing muscle protein synthesis.
  - The process of hypertrophy involves both an increase in the synthesis of contractile proteins and an increase in the number of myofibrils within the muscle fiber itself. The new myofilaments are added to the external layers of the myofibril, resulting in an increase in its diameter.
  - Exercise-induced muscle damage (EIMD) from anaerobic training has an effect on muscle growth. This is because structural changes from EIMD influence gene expression in an effort to strengthen the muscle tissue and protect it from further damage
  - The inflammatory responses and increased protein turnover ultimately contribute to long-term hypertrophic adaptations
  - In order to optimize muscle growth, appropriate training periodization is essential for maximizing the combination of mechanical and metabolic stimuli
  - Mechanical factors (heavy loads, eccentric action, etc) result in optimal recruitment of muscle fibers, growth factor expression, and potential disruption to the sarcomeres, all of which increase muscle size.

- The metabolic factors stress the glycolytic energy system and result in increased metabolites that may be involved in muscle growth.
- *Hyperplasia:* increase in the number of muscle fibers via longitudinal fiber splitting in response to high-intensity resistance training

- **Fiber Size Changes**
  - The magnitude of muscle hypertrophy is associated with muscle fiber type. The fibers within the high-threshold motor units governed by size principle must be activated in order to promote significant hypertrophy.
  - According to the size principle, only following hierarchical activation do Type I or Type II fibers receive a signaling mechanism that initiates a cascade of regulatory processes promoting protein synthesis.
  - Typically, Type II fibers manifest greater increases in size than Type I fibers
  - Athletes who genetically possess a large proportion of fast-twitch fibers may have a greater potential for increasing muscle mass than individuals possessing slow-twitch fibers.
- **Fiber Type Transitions**
  - Muscle fibers are positioned on a continuum from lease oxidative to the most oxidative: IIx, IIax, IIa, IIac, IIc, Ic, and I
  - Proportional of Type I and Ix fibers are genetically determined, changes within each subtype can occur following anaerobic training.
  - Training and activation of the high-threshold motor units causes a transition from Type IIx to IIa.
  - Any change in the muscle fiber type continuum occurs in the early stages of a resistance training program
  - Detraining results in an increase if Type IIx fibers and decrease in Type IIa fiber
- **Structural and Architectural Changes**
  - Pennation angle affects the force production capabilities as well as the range of motion of a muscle
  - Resistance training has shown to increase the angle of pennation and fascicle length
- **Other Muscular Adaptations**
  - Resistance training has been shown to increase myofibrillar volume, cytoplasmic density, sarcoplasmic reticulum and T-tubule density, and sodium-potassium ATPase activity
  - Sprint training has been shown to enhance calcium release, which assists in increasing speed and power production by promoting actin and myosin crossbridge formation
  - Heavy resistance training has been known to reduce mitochondrial density.
  - Anaerobic exercise results in substantial reductions in muscle and blood pH
  - With adaptations to consistent acute changes in pH during training, buffering capacity can improve. This increased capacity then allows the athlete to better tolerate the accumulation of H^+ within the working muscle, resulting in delayed fatigue and greater muscular endurance

- When ATP and CP concentrations are repeatedly exhausted following bouts of intermittent high-intensity muscular contraction, the storage capacity of these high-energy compounds is increased via a "supercompensation" effect.

<u>Connective Tissue Adaptations</u> (97)

- *Osteoblasts:* migrate to bone surface and begin bone modeling.
  - Manufacture and secrete proteins that are deposited in the spaces between bone cells to increase strength
- These proteins form the bone matrix and eventually become mineralized as calcium phosphate crystals (hydroxyapatite)
- *Figure 5.4 illustrates the bone modeling process on pg. 97

- **General Bone Physiology**
  - Trabecular bone is less dense and has a greater surface area-to-mass ratio which makes it able to respond more rapidly to stimuli than cortical bone as it is softer, weaker, and more flexible and therefore more inclined to adaptive change
  - *Minimal essential strain (MES):* the threshold stimulus that initiates new bone formation.
  - Consistently exceeding the MES signals osteoblasts to go to that area and form new bone. Under the MES results in no bone remodeling
  - The MES is thought to be 1/10 of the force required to fracture the bone
  - Increasing the diameter of the bone allows force to be distributed over a larger surface area which decreases the mechanical stress
- **Anaerobic Training and Bone Growth**
  - As muscular strength and hypertrophy increase, the forces generated by the increased muscle contractions also increase the mechanical stress on bone, and the bone itself must increase in mass and strength to provide an adequate support structure
  - *Bone mineral density (BMD):* quantity of mineral deposited in a given area of bone.
  - Inactivity or immobilization decreases bone matrix and BMD
  - Exercise that stimulates muscle hypertrophy and strength gains also appears to stimulate bone growth
  - Time course for bone adaptations is 6 months or longer
- **Principles of Training to Increase Bone Strength**
  - Anaerobic training programs that have the objective to stimulate bone growth need to incorporate specificity of loading, speed and direction of loading, sufficient volume, appropriate exercise selection, progressive overload, and variation
  - *Specificity of loading:* demands the use of exercises that directly load the particular region of interest of the skeleton
  - *Osteoporosis:* a disease in which BMD and bone mass become reduced to critically low levels
  - Exercise selection is critical when trying to elicit maximal osteogenic stimuli. These exercises should involve multiple joints, should direct the force vectors primarily through the spine and hip, and should apply external loads heavier than those with single joint assistance exercises

- Exercises for increasing bone strength: back squat, power clean, deadlift, snatch, push jerk, shoulder press, etc. Do NOT use machines because they only focus on single muscle growth and not bone growth.
- *Progressive overload:* progressively placing greater than normal demands on the exercising musculature
- The adaptive response of bone ensures that forces do not exceed a critical level that increases the risk of stress fractures
- *Stress fractures:* microfractures in bone due to structural fatigue
- Training variation is good for stimulating new bone formation because the skeleton compensates for new strain patterns experienced by the bone. Therefore changing the direction of force vectors provides a unique stimulus for new bone formation within a given region.
- Also, collagen formation in various directions will increase bone strength in various directions
- Components of mechanical load that stimulates bone growth are the magnitude of the load (intensity), rate of loading (speed), direction of the forces, and the volume of loading (reps)

- **How Can Athletes Stimulate Bone Formation?**
  - Do multi-joint exercises. Avoid isolated, single joint movements
  - Select exercises that direct axial force vectors through spine and hip and apply heavier loads
  - Use progressive overload
  - Use both heavy-load exercises and ballistic or high-impact exercises to expose the bone to different intensities of force
  - Varying exercise selection
- **Adaptations of Tendons, Ligaments, and Fascia to Anaerobic Training**
  - *Collagen fiber:* primary structural component of all connective tissue
    - Type I: bone, tendon, and ligaments
    - Type II: cartilage
    - *Figure 5.5 is a diagram of the collagen fiber on pg. 100
  - *Procollagen:* parent protein, is synthesized and secreted by fibroblasts, and act as stem cells in the synthesis of extracellular matrix, as well playing a critical role in wound healing
    - Consist of a triple helix
    - Leaves the cells with protective extensions on the ends to prevent premature collagen formation
    - Cleavage of the extensions results in the formation of active collagen that aligns with other collagen molecules to form a long filament
  - *Microfibril:* parallel arrangement of filaments
  - As bone grows, microfibrils become arranged into fibers, and the fibers into larger bundles.
  - Strength of collagen comes from the strong chemical bonds that form between adjacent collagen molecules throughout the collagen bundles
  - Collagen bundles are bunched together longitudinally to form tendons or ligaments

- There is a small number of metabolically active cells in tendons and ligaments that makes requirements for oxygen and nutrients low
- *Fascia:* fibrous connective tissue that surround and separate the different organizational levels within skeletal muscle
- Tendon metabolism is much slower due to poorer vascularity and circulation which is the reason why it takes so long to heal after injury
- The primary stimulus for growth of tendons, ligaments, and fascia is the insult from mechanical forces during high-intensity exercise. Degree of tissue adaptations appears to be proportional to the intensity of exercise
- Connective tissues increase their function capabilities in response to increase muscle strength and hypertrophy.
- Sites where connective tissues increase strength
  - Junctions between the tendon and bone surface
  - Within the body of a tendon or ligament
  - In the network of fascia within skeletal muscle
- Changes within a tendon that contribute to its increase in size and strength
  - Increase in collagen fibrils. diameter
  - Greater number of covalent cross-links within the hypertrophied fiber
  - Increase in the number of collagen fibrils
  - Increase in the packing density of collagen fibrils

- **How Can Athletes Stimulate Connective Tissue Adaptations?**
  - Tendons, ligaments, fascia
    - Progressive high-intensity loading patterns using external resistances
    - High-intensity loads
    - Forces should be exerted throughout the full range of motion of a joint. Multi-joint exercises should be used
  - Cartilage
    - Moderate-intensity anaerobic exercise
    - Adopting varying of exercises and that load is applied throughout the range of motion
- **Adaptations of Cartilage of Anaerobic Training**
  - Dense connective tissue capable of withstanding considerable force without damage to its structure
  - Functions
    - Provide a smooth joint articulating surface
    - Acts as a shock absorber for forces directed through the joint
    - Aid in the attachment of connective tissue to the skeleton
  - Lacks blood supply so it depends on diffusion of oxygen and nutrients from synovial fluid
  - *Hyaline cartilage:* found on the articulating surfaces of bones
  - *Fibrous cartilage:* very tough form of cartilage found in the intervertebral disks of the spine and at the junctions where tendons attach to bone
  - Human cartilage undergoes atrophy when external loading is removed

Endocrine Responses and Adaptations to Anaerobic Training (102)

- **Acute Anabolic Hormone Responses**

    - Following anaerobic exercise, there are elevated levels of testosterone, growth hormone, and cortisol up to 30 minutes after exercise in men.
    - The magnitude of these are the greatest during large muscle mass exercises are performed and during workouts with moderate to high intensity and volume combines with shorter rest intervals
    - IGF-I is a primary mediator of growth hormone; it acts as a hormonal messenger that stimulates growth-promoting effects in almost every cell of the body
- **Chronic Changes in the Acute Hormonal Responses**
    - When following a resistance training program for a long time muscular force increased and acute endocrine responses will mirror these improvements
    - Chronic adaptations in acute hormonal response patterns potentially augment the ability to better tolerate and sustain prolonged higher exercise intensities
- **Chronic Changes in Resting Hormonal Concentrations**
    - Chronic changes in resting hormonal concentrations following anaerobic exercise are unlikely
- **Hormone Receptor Changes**
    - Resistance training has been shown to upregulate Androgen receptors within 48-72 hours after the workout

<u>Cardiovascular and Respiratory Responses to Anaerobic Exercise</u> (103)

- **Acute Cardiovascular Responses to Anaerobic Exercise**
    - Heart rate, cardiac output, and blood pressure all increase significantly during resistance exercise.
    - Blood pressure usually increases higher in during the concentric phase compared to the eccentric phase
    - Stroke volume and cardiac output increase mostly during the eccentric phase
    - The degree to which blood flow is increased in the working muscles during anaerobic training is dependent on a number of factors including the intensity of resistance, the length of time of the effort, and the size of the muscle mass activated
- **Chronic Cardiovascular Adaptations at Rest**
    - Short-term resistance training has been shown to decrease resting heart rate by 5%-12%
    - Both systolic and diastolic blood pressure decreased by 2%-4% as an adaptation to resistance training
    - Stroke volume will increase as lean tissue mass increased during long-term resistance training
- **Chronic Adaptations of the Acute Cardiovascular Response to Anaerobic Exercise**
    - Chronic resistance training reduced the cardiovascular response to an acute bout of resistance exercise
- **Ventilatory Response to Anaerobic Exercise**
    - Training adaptations include increased tidal volume and breathing frequency with maximal exercise

<u>Compatibility of Aerobic and Anaerobic Modes of Training</u> (105)

    - Combines resistance training and aerobic training my interfere with strength and power gains

- A study showed that simultaneous sprint and aerobic endurance training decreased sprint speed and jump power. This may be due to the adverse neural changes and alteration of muscle proteins in muscle fibers
- On the contrary, resistance training may help aerobic endurance and power
- Resistance training recruits more of the Type IIx fibers than high-intensity aerobic endurance interval training
- Power development is more negatively affected than strength during concurrent high-intensity resistance and aerobic endurance training

- **What Performance Improvements Occur Following Anaerobic Exercise**
  - Muscular strength
  - Power
  - Local Muscular Endurance
  - Body Composition
  - Flexibility
  - Aerobic Capacity
  - Motor performance
  - *detailed explanations on pg. 106

<u>Overtraining</u> (107)

- The goal of training is to provide incremental overload on the body so that physiological adaptations can subsequently contribute to improved performance.
- Successful training must avoid excessive overload with inadequate recovery
- Overtraining can lead to fatigue, illness, and injury. Restoration to performance can take weeks or months
- *Functional overreaching (FOR):* when an athlete undertakes excessive training that leads to short-term decrements in performance
- It has been shown that short-term FORM followed by an appropriate tapering period can result in beneficial strength and power gains
- *Nonfunctional reaching (NFOR):* intensification of a training stimulus continues without adequate recovery and regeneration
  - This leads to stagnation and a decrease in performance for several weeks or months
- *Overtraining syndrome (OTS):* prolonged maladaptation of several biological, neurochemical, and hormonal regulation mechanisms
  - Sympathetic: increased sympathetic activity at rest
  - Parasympathetic: increased parasympathetic activity at rest and exercise
  - Sympathetic develops before parasympathetic and predominates in younger athletes who train for speed and power
- *Figure 5.6 the overtraining continuum pg 108
- *Table 5.3 the theoretical development of anaerobic overtraining pg. 108
- *What are the Markers of Anaerobic Overtraining? Pg. 109

- **Mistakes That Can Lead to Anaerobic Overtraining**
  - A mistake in the prescription of any acute program variable could lead to OTS. This can often occur in highly motivated athletes who work out a lot and take limited rest
  - Training periodization should consist of careful planning to avoid overtraining

- **Hormonal Markers of Anaerobic Overtraining**
  - It has been hypothesized that endocrine factors mediate the central dysfunction that occurs during the pathogenesis of OTS
  - Volume related overtraining has been shown to increase cortisol and decrease resting luteinizing hormone and total and free testosterone concentrations
  - Intensity relation overtraining does not appear to alter resting concentrations of hormones

<u>Detraining</u> (110)

  - *Detraining:* decrement in performance and loss of the accumulated physiological adaptations following the cessation of anaerobic training
  - Training-induced-adaptations can disappear when the training load or insufficient or completely removed
  - Strength performance is readily maintained for up to four weeks of inactivity; but in highly trained athletes, eccentric force and sport-specific power may decline significantly faster
  - The strength loss is coupled with decreased average maximal bilateral and unilateral intramuscular EMG
  - Strength reductions appear related to neural mechanisms initially, with atrophy predominating as the detraining period extends
- **Study Questions:** d, a, c, b, c, d

Chapter 6: Adaptations to Aerobic Endurance Training Programs

- **Learning Objectives**
  - Identify and describe the acute responses of the cardiovascular and respiratory systems to aerobic exercise
  - Identify and describe the impact of chronic aerobic endurance training on the physiological characteristics of cardiovascular, respiratory, nervous, muscular, bone and connective tissue, and endocrine systems
  - Recognize the interaction between aerobic endurance training and optimizing physiological responses of all body systems
  - Identify and describe external factors that influence adaptations to acute and chronic aerobic exercise including altitude, sex, blood doping, and detraining
  - Recognize the causes, signs, symptoms, and effects of overtraining

<u>Acute Responses to Aerobic Exercise</u> (116)

- **Cardiovascular Responses**
  - The primary function of the cardiovascular system during aerobic exercises are to deliver oxygen and other nutrients to the working muscles and remove metabolites and waste products
  - Cardiac Output
    - Is the amount of blood pumped by the heart in liters per minute.
    - Q = Stroke volume x Heart rate
    - In the progression from rest of aerobic exercise, cardiac output initially increases rapidly and then plateaus
    - Stroke volume continues to rise until oxygen consumption is at 40%-50% of maximal oxygen uptake

- Stroke Volume
  - There are two mechanisms responsible for the regulation of stroke volume
  - First: *End-diastolic volume:* the volume of blood available to be pumped by the left ventricle at the end of the filling phase
  - Second, is due to the action of catecholamines (epinephrine and norepinephrine) that produce a more forceful ventricular contraction and greater systolic emptying of the heart
  - With aerobic exercise, the amount of blood returning to the heart is increased due to venoconstriction, skeletal muscle pump, and the respiratory pump.
  - *Frank-Starling Mechanism:* when there is an increase in venous return, the end-diastolic volume is significantly increased. With the increased volume, the myocardial fibers become more stretched than at rest, resulting in more forceful contraction and an increase in force of systolic ejection and greater cardiac emptying
- Heart Rate
  - Just before the beginning of an exercise session, a reflex stimulation of the sympathetic nervous system results in an increased heart rate.
  - Heart rate increases linearly with increases in intensity during aerobic exercises
  - You can estimate maximal heart rate by subtracting one's age from 220. The number +/- 10 to 12 variance is a good estimate range of maximal heart rate.

- **Oxygen Uptake**
  - The amount of oxygen consumed by the body's tissues
  - The oxygen demand of working muscles increased during an acute bout of aerobic exercise and is directly related to the mass of exercising muscle, metabolic efficiency, and exercise intensity.
  - *Maximal Oxygen Uptake:* is the greatest amount of oxygen that can be used at the cellular level for the entire body. Correlates well with the degree of physical fitness
  - *Metabolic equivalent (MET)*: resting oxygen uptake is estimated at 3.5 ml of oxygen per kg of body weight per minute
  - Maximal oxygen uptake values in normal, healthy individuals are 25-80 kg x min
  - VO_2 = Q x a-vO_2 difference or VO_2 = heart rate x stroke volume x a-vO_2 difference
    - Q is cardiac output
    - a-vO_2 is arteriovenous oxygen difference (difference in the oxygen content between arterial and venous blood)
- **Blood Pressure**
  - *Systolic blood pressure:* estimates the pressure exerted against the arterial walls as blood is forcefully ejected during ventricular contraction and, when combined with heart rate, can be used to describe the myocardial oxygen consumption of the heart
  - Rate-pressure product = heart rate x systolic blood pressure

- *Diastolic blood pressure:* estimates the pressure exerted against the arterial walls when no blood is being forcefully ejected through the vessels
- *Mean arterial pressure:* the average blood pressure throughout the cardiac cycle
  - Mean arterial blood pressure = [(Systolic blood pressure - Diastolic blood pressure) / 3] + diastolic blood pressure
- Normal resting blood pressure is usually between 110-139 mmHg systolic and between 60-89 mmHg diastolic

- **Control of Local Circulation**
  - During aerobic exercises, blood flow to active muscles is considerably increased by the dilation of local arterioles; at the same time, blood flow to other organ systems is reduced by constriction of arterioles
  - At rest, 15%-20% of cardiac output is distributed to skeletal muscle, whereas vigorous exercise may increase it to 90%
- **Respiratory Responses**
  - Aerobic exercise provides for the greatest impact on both oxygen uptake and carbon dioxide production as compared to other types of exercise
  - Significant increases in oxygen delivered to the tissue, carbon dioxide returned to the lungs, and minute ventilation provide for appropriate levels of alveolar gas concentrations during aerobic exercise
  - *Tidal volume:* amount of air inhaled and exhaled with each breath
  - *Ventilatory equivalent:* ratio of minute ventilation to oxygen uptake
  - *Alveoli:* functional unit of the pulmonary system where gas exchange occurs
  - With inspiration air enters the alveoli. Air can only get there by passing through the anatomical dead space (nose, mouth, throat, bronchi, etc.
  - Increasing tidal volume (deeper breathing) provides for a more efficient ventilation than increasing frequency of breathing alone
  - *Physiological dead space:* alveoli in which poor blood flow, poor ventilation, or other problems with the alveolar surface impair gas exchange
  - During aerobic exercise, large amounts of oxygen diffuse from the capillaries into the tissues; increased levels of carbon dioxide move from the blood into the alveoli; and minute ventilation increases to maintain appropriate alveolar concentration of these gases
- **Gas Reponses**
  - At rest the partial pressure of oxygen in the interstitial fluid rapidly drops from 100 mmHg in arterial blood to as low as 40 mmHg, while the partial pressure of carbon dioxide is elevated above that of arterial blood to about 46 mmHg.
  - During high-intensity aerobic exercises, the partial pressures of these gases are approximately 3 mmHg for oxygen and 90 mmHg for carbon dioxide
  - *Pressure gradients for gas transfer in the boy pg.119
- **Blood Transport of Gases and Metabolic By-Products**
  - Oxygen is carried in blood by being dissolved in the plasma or combined with hemoglobin
  - Only 3mL of oxygen can be carried per liter in plasma
  - People have around 14g-16g of hemoglobin per 100 ml of blood. One gram of hemoglobin can carry about 1.34 ml of oxygen in the blood

- After carbon dioxide is formed in the cells, it diffuses across the cell membrane and is transported to the lungs
- Lactic acid is another metabolic by-product of exercise.
- During low-moderate exercise, sufficient oxygen is available to working muscles and lactic acid does not accumulate.
- During high-intensity, aerobic metabolism cannot keep up with lactic acid production, then the lactic acid level in the blood will rise.

<u>**Chronic Adaptations to Aerobic Exercise**</u> **(120)**

- *Physiological Adaptations of Aerobic Endurance Training pg.121
- **Cardiovascular Adaptations**
    - Aerobic endurance training results in several changes in cardiovascular function, including increased maximal cardiac output, increased stroke volume, and reduced heart rate at rest and during submaximal exercises
    - Muscle fiber capillary density increases as a result of aerobic endurance training, supporting the delivery of oxygen and removal of carbon dioxide
    - Aerobic endurance training can increase the heart's ability to pump blood per contraction at rest and thus may account for a slower heart rate
    - Increased muscle fiber capillary density has been observed in response to the increased density of muscle associated with aerobic endurance training and is a function of volume and intensity of training. The increase in capillary density decreased the diffusion distance for oxygen and metabolic substrates
- **Respiratory Adaptations**
    - There are rarely any respiratory adaptations to aerobic training
- **Neural Adaptations**
    - Efficiency is increased and fatigue of the contractile mechanisms is delayed.
    - Improved aerobic performance may result in a rotation of neural activity among synergists and among motor units within a muscle
- **Muscular Adaptations**
    - The most frequent adaptation of aerobic exercise is an increase in aerobic capacity of the trained musculature. This allows the athletes to perform a given absolute intensity of exercise with greater ease.
    - An athlete can exercise at a greater relative intensity of a now-higher maximal aerobic power. This occurs as a result of glycogen sparing and increased fat utilization within the muscle, which prolongs performance at the same intensity.
    - Muscles involved in aerobic endurance training involve submaximal contractions over a large number of reps.
    - Type I fibers have a higher preexisting initial aerobic capacity, to which the increase in aerobic potential from training is added. Type I fibers posses an oxidative capacity greater than that of Type II fibers both before and after training
    - Type II fibers, under higher aerobic intensity, aerobic capacity increases with training, but chronic aerobic endurance training reduces the concentration of glycolytic enzymes and can reduce the overall muscle mass of these fibers
    - Muscular adaptations to aerobic exercise include an increase in size and number of mitochondria and increased myoglobin content
    - *Myoglobin:* protein that transports oxygen within the cell

  - *Mitochondria:* produce ATP via oxidation of glycogen and free fatty acids
- **Bone and Connective Tissue Adaptations**
  - New bone formation can happen as a result of aerobic training by having the activity significantly more intense than the daily activities the person normally engages in, this exceeds the minimum threshold intensity, as well as at a cyclical strain to exceed the minimum and strain frequency for bone growth
  - Exercise intensity that consistently exceeds the strain placed on the connective tissues during normal daily activities is needed to create connective tissue changes
  - Complete movement through a full range of motion during weight bearing is likely essential to maintain tissue viability
- **Endocrine Adaptations**
  - Testosterone, insulin, IGF-I, and growth hormone affect the integrity of muscle, bone, and connective tissue as well as assist in maintaining metabolism within a normal range
  - The greater hormonal response patterns to maximal exercise appear to augment the athlete's ability to tolerate and sustain prolonged high aerobic exercise intensities
  - Aerobic training is often associated with an increase in net protein breakdown from the muscle, brought about in part by stress-induced secretion that the body attempts to offset by increasing hormonal anabolic responses in testosterone and IGF-I. However, recent evidence suggests that net protein synthesis in skeletal muscle of endurance-trained athletes does not occur and may lead to muscle hypertrophy, bust most likely is due to mitochondrial rather than contractile proteins

<u>Adaptations to Aerobic Endurance Training</u> (124)

  - Aerobic metabolism plays a key role in recovery
  - Many sports involve continuous movements mixed with bursts of sprint and power activities. Proper conditioning of the aerobic system is vital to the ability of the player to sustain such activity and adequately recover within and between exercise sessions
  - Interval training is a good way to do aerobic fitness
  - One of the most common measuring adaptations to aerobic endurance training is an increase in maximal oxygen uptake associated with an increase in maximal cardiac output
  - Aerobic endurance training can improve an athlete's aerobic power by 5%-30%
  - Metabolic changes include increased respiratory capacity, lower blood lactate concentrations, increased mitochondrial and capillary densities, and improves enzyme activity
  - The intensity of training is one of the most important factors in improving and maintaining aerobic power
  - High-intensity sprints with short rest intervals will increase aerobic power. High-intensity sprints with long rest intervals will improve sprint speed by not change aerobic power
  - Aerobic endurance training results in reduced body fat, increased maximal oxygen uptake, increased running economy, increased respiratory capacity, lower

blood lactate concentrations at submaximal exercise, increased mitochondrial and capillary densities, and improved enzyme activity
    - *Physiological variable in aerobic endurance training pg 125

<u>External and Individual Factors Influencing Adaptations to Aerobic Endurance Training</u> (124)

- **Altitude**
    - At elevations greater than 3,900 ft, acute physiological adjustments begin to occur to compensate for the reduced partial pressure of oxygen in the atmosphere
    - There is an increase in pulmonary ventilation and an increase in cardiac output at rest due to increases in heart rate
    - Within 10-14 days at a given altitude, heart rate and cardiac output begin to return to normal values because of the longer-term acclimatization responses of increased RBC production
    - Chronic adjustments that occur during prolonged altitude exposure are:
        - Increased formation of hemoglobin and RBC
        - Increased diffusing capacity of oxygen through the pulmonary membranes
        - Maintenance of the acid-base balance of body fluids by renal excretion of HCO_3^- and through hyperventilation
        - Increased capillarization
    - *Adjustments to Altitude Hypoxia pg. 127
- **What are the improvements in performance from aerobic exercise?**
    - Respiratory system
        - Decreased submaximal respiration rate
    - Cardiovascular system
        - Decreased heart rate for submaximal loads and increased stroke volume and cardiac output
    - Musculoskeletal system
        - Increased arterial-venous O_2 difference, increased capillarization in muscle, increased oxidative enzyme concentrations, and increased mitochondrial size and density
    - Aerobic Power
        - Increase in VO_2 max.
        - High VO_2 max coupled with increased lactate threshold allows for enhanced performance
    - Lactate Threshold
        - Increases the absolute lactate threshold, allowing the highly trained individual to work at both a higher relative absolute percentage of their VO_2 max than an individual less well trained
    - Effective Utilization of Substrate
        - Aerobic exercise utilizes fat as a substrate with a relative sparing for carbohydrates. With a sparing of carbohydrates, an endurance-trained individual can maintain higher-intensity exercises for longer periods of time
    - Muscle Fiber Adaptations

        - Elite distance runners have a higher percentage of Type I fibers and the available Type I fibers are very efficient for aerobic metabolism
        - Aerobic training causes an increase in the oxidative capacity of Type I fibers
    - Exercise efficiency
        - Athletes with the more efficient exercise (proper form) are able to sustain the same power output for longer periods of time
- **Hyperoxic Breathing**
    - Breathing enriched mixtures during rest periods has been proposed to positively affect some aspects of exercise performance
    - Hyperoxic breathing may increase the amount of oxygen carried by the blood and therefore increase the supply of oxygen to working muscles
- **Blood Doping**
    - Practice of artificially increasing RBC mass as a means to improve athletic performance
    - Increasing RBC mass increases the blood's ability to carry oxygen and thus increase oxygen availability to working muscles
- **Genetic Potential**
    - Each biological system adaptation has an upper limit, and as closer the athlete gets to that upper limit, the smaller and smaller the gains are
- **Age and Sex**
    - Maximal aerobic power decreases with age in adults

<u>Overtraining: Definition, Prevalence, Diagnosis, and Potential Markers</u> (129)

- **Cardiovascular Responses**
    - Heart rate can either be increased or decreased with OTS
- **Biochemical Responses**
    - Increases levels of creatine kinase, indicating muscle damage.
    - Muscle glycogen decreases with prolonged periods of overtraining which can contribute to the lowered lactate responses
- **Endocrine Responses**
    - The anabolic-catabolic state of an athlete may be quantified by the testosterone-to-cortisol ratio, with decreases or stays the same with the greater training volumes. A decrease of 30% or more in this ratio may indicate OTS
    - Decreased pituitary secretion of growth hormone occurs with overtraining
    - Catecholamines appear to be very responsive to an overtraining stimulus
- **Strategies for Prevention of Overtraining Syndrome**
    - Make sure the athlete is following a good nutritional guideline as well as getting enough sleep and recovery times
    - Programs should provide variety in intensity and volume
- ***What are the Markers of Aerobic Overtraining? Pg. 131**
- **Detraining**
    - The partial or complete loss of training-induced adaptations in response to an insufficient training stimulus
    - *Tapering*: planned reduction of volume of training that occurs before an athletic competition or a planned recovery cycle

- **Study Questions:** d, d, d, a, c

Chapter 7: Age and Sex Related Differences and Their Implications For Resistance Exercise

- **Learning Objectives**
  - Evaluate the evidence regarding the safety, effectiveness, and importance of resistance exercise for children
  - Discuss sex-related differences in muscular function and their implications for females
  - Describe the effects of aging on musculoskeletal health and comment on the trainability of older adults
  - Explain why adaptations to resistance exercise can vary greatly among these three distinct populations

Children (136)

- **The Growing Child**
  - Chronological Age Versus Biological Age
    - *Peak height velocity:* the age at maximum rate of growth during the pubertal growth spurt
  - Muscle and Bone Growth
    - At birth about 25% of a child's body weight is muscle mass, at adulthood this percentage is 40%
    - The increase in muscle mass is due to hypertrophy and not hyperplasia
    - The majority of bone formation occurs in the diaphysis, which is the central shaft of a long bone, and in the growth cartilage (epiphyseal plate, joint surface, and apophyseal insertions of muscle-tendon units
    - Damage to the growth cartilage may impair the growth and development of the affected bone
  - Developmental Changes in Muscular Strength
    - As muscle mass increases in adolescence, so does muscular strength.
    - Peak gains occur about 1.2 years after peak height velocity and 0.8 years after peak weight velocity
    - During periods of rapid growth, muscle first increases in mass and then in higher levels of force
    - If myelination of nerve fibers is absent or incomplete, fast reactions and skilled movements cannot be successfully performed, and high levels of strength and power are impossible
    - *Mesomorphic:* muscular and broader shoulders
    - *Endomorphic:* rounder and broader hips
    - *Ectomorphic:* slender and tall
- **Youth Resistance Training**
  - Resistance exercise can be a safe and effective method of conditioning for children
  - Responsiveness to resistance training in children
    - Studies have shown that boys and girls can increase muscular strength from resistance training if the volume and intensity are adequate

        - Strength gains of about 30%-40% have been observed in preadolescent children following a short term resistance training programs
        - Preadolescents appear have more potential for an increase in strength owing to neural factors, such as increases in motor unit activation and synchronization, as well as enhanced motor unit recruitment and firing frequency
        - *factors that contribute to the development of muscular strength pg.141
    - Potential benefits
        - Resistance exercise in the youth may favorably alter selected anatomic and psychosocial parameters, reduce injuries in sport and recreational activities, and improve motor skills and sport performance
        - It has been reported that resistance training can result in a decrease in body fat, improvements in insulin sensitivity, and enhanced cardiac function among obses children and adolescence
        - Any participation of exercise that include resistance training and weight-bearing physical activity has been shown to enhance bone mineral density in children and adults
        - Regular participation in a preseason conditioning program that includes resistance training may increase a young athlete's resistance to injury
        - Youth who specialize in a specific sport or position are at an increased risk of developing muscle imbalances, overuse injuries, overtraining, and potential burnout.
        - Late specialization and involvement in a variety of sports and activities during the younger years may be better related to sporting success at a later age
    - Potential Risks and Concerns
        - It is very important to head safety guidelines when dealing with resistance training for younger people
- **Program Design Considerations for Children**
    - Children should have emotional maturity to follow directions and be focused to complete workouts
    - Two important areas of concern in youth resistance training is quality of instruction and rate of progression. It is important to focus on proper form and technique before getting gains
- **Youth Resistance Training Guidelines**
    - Dynamic warm-up exercises should be performed before resistance training
    - Static stretching should be performed after resistance training
    - Carefully monitor each child
    - Start with light loads and work up as form gets better
    - Focus on doing 3 sets of 6-15 in the exercises
    - Workouts should be 2-3 times a week

<u>Female Athletes</u> (144)

- **Sex Differences**
    - Body size and composition
        - During puberty, the production of estrogen also stimulates bone growth

        - Ove average women tend to have more body fat, less muscle, and lower mineral bone density
        - Women have broader hips
    - Strength and power output
        - Women generally have ⅔ the strength of men
        - The lower body strength is similar to men, but the upper body is much less
        - Eccentric strength may be more similar between men and women than concentric strength when compared relative to fat-free mass.
        - Muscle quality is generally the same and not sex specific
- **Resistance Training for Female Athletes**
    - Responsiveness to Resistance Training in Women
        - In a resistance training program, women can increase their strength at the same rate as men
        - Strength gains are often greater in men because baseline neuromuscular levels are lower on average in females
    - Female athlete triad
        - The riad refers to the interrelationships between energy availability, menstrual function, and mineral bone density, is a health risk for female athletes who train for prolonged periods of time with insufficient caloric intake to meet the high energy expenditure of training and adaptations
        - Trainers must ensure that nutritional intake supports the training prescription
- **Program Design Considerations**
    - There should be no differences in program design for men and women
    - Upper Body Strength Development
        - Two areas of concern regarding program prescription in women are upper body strength and prevention of sport-related injuries, specifically the knee
        - The addition of upper body is good for women who struggle to perform multi-joint lifts
    - ACL Injury in Females
        - Females are 6x likely to have an ACL tear than men
        - It is possible that joint laxity, limb alignment, notch dimensions, ligament size, body movement, shoe-surface interaction, skill level, hormonal changes, use of ankle braces, and training deficiencies
        - The most significant factor is believed to be a neuromuscular deficiency, which leads to abnormal biomechanics
        - To prevent ACL tears, females should take part in a well balanced training program, and is designed to enhance the strength of supporting structures and increase neuromuscular control of the knee joint
- **How Can Female Athletes Reduce Their Risk of ACL Injury?**
    - Identify risk factors and recommend a preparticipation screening
    - Encourage athletes to participate in a year long conditioning program that includes resistance, plyometric, speed and agility, and flexibility
    - Learn correct movement mechanics

    - Do a dynamic warmup before every workout session
    - Encourage females to participate in injury prevention programs

<u>**Older Adults**</u> **(148)**

- **Age-Related Changes in Musculoskeletal Health**
    - Loss of bone and muscle with age with age increase the risk of falls, fractures, and long-term disability
    - *Osteopenia:* bone mineral density between -1 and -2.5 SD of the young adult mean
    - *Sarcopenia:* loss of muscle mass and strength
    - Power recedes at a faster rate than muscle strength with aging
    - Factors that contribute to age-related decline in muscle strength and power include reductions in muscle mass, nervous system changes, hormonal changes, poor nutrition, and physical inactivity
    - *Tabel 7.1 Summary of the effects of aging and resistance training pg.149
- **Age-Related Changes in Neuromuscular Function**
    - Intrinsic factors that lead to increased risk of falls in seniors include decrements in muscle strength and power, reaction time, and imparie balance and postural stability
    - Increased preactivation helps increase stiffness of the limb using fast stretch reflexes to better prepare the limb for ground contact
    - Cocontraction is a motor control strategy that dynamically stabilizes the joint; however, due to the simultaneous activation of both the agonist and antagonist muscle groups crossing at the same joint, net joint movements and agonistic force outputs are reduced
- **Resistance Training for Older Adults**
    - Responsiveness to resistance training in older adults
        - Though aging is associated with a number of undesirable changes in body composition, older people maintain their ability to make significant improvements in strength and functional ability.
        - Aerobic, resistance, and balance exercises are beneficial for older adults, but only resistance training can increase muscular strength, muscular power, and muscle mass
- **Study Questions:** d, a, c, d, b

Chapter 8: Psychology of Athletic Preparation and Performance

- **Learning Objectives**
    - Understand the psychological constructs of arousal, motivation, focus, and confidence and be able to ascertain their impact on physical performance
    - Comprehend terms relevant to psychological areas of concern, such as anxiety. Attention, the ideal performance state, self-efficacy, imagery, and goal setting
    - Understand varying ways to manipulate practice schedules including whole part, random, and variable practice, and how to use these schedules to facilitate skill acquisition and learning
    - Understand different types of instructions and feedback and their application in practice and performance setting

Role of Sport Psychology (156)

- Sports psychology has three goals
    - Measuring psychological phenomena
    - Investigating the relationships between psychological variables and performance
    - Applying theoretical knowledge to improve athletic performance

Ideal Performance State (156)

- Ideal performance state
    - No fear of failure
    - No thinking about analysis or performance
    - A narrow focus of attention concentrated on the activity itself
    - A sense of effortlessness - an involuntary experience
    - A sense of personal control
    - A distortion of time and space, in which time seems to slow

Energy Management: Arousal, Anxiety, and Stress (157)

- Athletes who deplete energy through worry, anger, frustration, anxiety experience a greater likelihood of distraction and decreased self-confidence, and they have less physical energy for when they really need to perform
- *Emotions:* temporary feeling states that occur in response to events that have both physiological and psychological components
- *Figure 8.1 on the interrelationships of anxiety pg. 159

- **Arousal**
    - *Arousal:* simply a blend of physiological and psychological activation in an individual and refers to the intensity of motivation at any given moment
- **Anxiety**
    - *Anxiety:* subcategory of arousal in that it is a negatively perceived emotional state characterized by nervousness, worry, apprehension, or fear and is associated with a physiological activation of the body
    - Anxiety creates cognitive anxiety (negative thoughts) and somatic anxiety ("butterflies")
    - *State Anxiety:* subjective experience of apprehension and uncertainty accompanied by elevated autonomic and voluntary neural outflow and increased endocrine activity
    - *Trait anxiety:* personality variable relating to the probability that one will perceive and environment as threatening
    - Trait anxiety is a primer for the athlete to experience state anxiety
    - The athlete with low trait anxiety can handle higher levels of pressure because of the decreased probability of engaging in such a personal catastrophizing
    - Arousal is too high during periods of ineffective state anxiety. The lack of physical and psychological efficiency is typically initiated by uncertainty about a present or anticipated event. These factors include
        - A high degree of ego involvement, in which the athlete may perceive a threat to self-esteem
        - A perceived discrepancy between one's ability and the demands for athletic success

        - A fear of the consequences of failure
- **Stress**
    - Substantial imbalance between demand and response capability, under conditions in which failure to meet that demand has important consequences
    - *Stressor:* an environmental or cognitive event that precipitates stress.
        - Distress: negative
        - Eustress: positive

<u>Influence of Arousal and Anxiety on Performance</u> (158)

- **Drive Theory**
    - As an individual's arousal or state anxiety increases, so too does performance
    - When people perform well-learned or simple skills, a higher level of arousal can benefit performance. However, the more complex a given skill becomes, or less experience, the more arousal can produce catastrophic performance outcomes
    - Skill Level
        - The more skill an athlete has, the better they can perform during states of less-than or greater-than-optimal arousal
        - The optimal arousal point is lower for less-skilled players than for more advanced players
    - Task Complexity
        - Simple or well-trained skills are less affected by a high degree of arousal because they have few task-relevant cues to monitor
- **Inverted-U Theory**
    - Arousal facilitates performance up to an optimal level, beyond which further increases in arousal are associated with reduced performance.
    - *Figure 8.2 inverted-U theory and its modifications pg. 160
- **Individual Zones of Optimal Functioning Theory**
    - Different people, in different types of performances, perform best with very different levels of arousal
    - Ideal performance does not seem to always occur at the midpoint of the arousal continuum
    - This best performance can occur within a small range of arousal level
    - Any emotion can be positively perceived by one athlete and negatively perceived by another
- **Catastrophe Theory**
    - When the physiological arousal occur in the presence of cognitive anxiety, a sudden drop in performance occurs; instead of the gradual decline
- **Reversal Theory**
    - The way in which arousal and anxiety affect performance depends on the individual's interpretation of that arousal
    - Athletes have within their own power the ability to reverse their perception and interpret arousal as reflecting excitement and anticipation

<u>Motivation</u> (161)

    - Intensity and direction of effort
- **Intrinsic and Extrinsic Motivation**
    - *Intrinsic:* a desire to be competent and self-determining.

        - Athletes are driven because of their love for the game
        - This motivation comes from within
    - *Extrinsic:* motivation that comes from some external as opposed to internal source
    - An athlete needs both intrinsic and extrinsic motivation
- **Achievement Motivation**
    - Person's efforts to master a task, achieve excellence, overcome obstacles, and engage in competition or social comparison
    - *Motive to Achieve Success (MAS):* capacity to experience pride in one's accomplishments and is characterized by a desire to challenge oneself and evaluate one's abilities
    - *Motive to avoid failure (MAF):* desire to protect one's ego and self-esteem
    - MAS athletes have 50% success in situations that are challenging
    - MAF athletes are comfortable in situations where it is easy to achieve success
- **Motivational Aspects of Skill Learning**
    - Self-controlled practice involves the athlete in decisions related to the practice structure, including when to receive feedback; it also involves simply asking athletes how they believe they are doing
    - This promotes a more active involvement in the practice session and can enhance feelings of competence and autonomy
- **Positive and Negative Reinforcement in Coaching**
    - *Positive reinforcement:* the act of increasing the probability of occurrence of a given behavior by following it with a positive action.
    - *Negative reinforcement:* also increases the probability of occurrence of a given operant, but it is accomplished through the removal of an act.
    - *Positive punishment:* presentation of an act that could decrease the behavior's occurrence (punishment push ups)
    - *Negative punishment:* removal of something valued

<u>Attention and Focus</u> (163)

    - *Attention:* processing of both environmental and internal cues that come to awareness
    - *Selective attention:* ability to inhibit awareness of some stimuli in order to process others; it suppresses task-irrelevant cues
    - The ability to focus attention on task-relevant cues and to control distraction is a skill that can be learned and that improves with increased experience
    - Athlete passes through three stages when learning a new motor skill:
        - Cognitive stage: effortful and conscious regulation of movement
        - Associative stage: must focus on the task but is less concerned with the details of the movement
        - Automaticity stage: mind is relaxed and the skill is executed automatically without thinking
- **Attention Styles**
    - *figure 8.3 four quadrants of attentional focus pg.164

<u>Psychological Techniques for Improved Performance</u> (164)

- **Relaxation techniques to Control Elevated Arousal and Anxiety**
    - Designed to reduce physiological arousal and increase task-relevant focus

- Diaphragmatic breathing
  - Form of breathing is a basic stress management technique and precursor to virtually all other mental training techniques
  - In any mental training exercise, an athlete should engage in a deep, rhythmic breathing in a relaxed, natural manner
  - The deep inspiration, followed by a controlled expiration alters ANS balance so that increased vagal tone can occur
  - Rhythmic breathing can decrease neural stimulation of both the skeletal muscles, resulting in a sense of deep relaxation
- Progressive Muscular Relaxation
  - Technique by which psychological and physical arousal are self-regulated through the control of skeletal muscle tension
  - This relaxes the mind and muscles
- Autogenic Training
  - Series of exercises designed to produce physical sensations in the body; generally warmth and heaviness
  - Eliminates the need for uncomfortable levels of muscle tension in the contraction-relaxation cycle
- Systematic desensitization
  - Its goal is to confront and reduce fear
  - Combines mental and physical techniques that allow an athlete to replace a fear response to various cues with a relaxation response.
  - This adaptive, learned replacement is called counterconditioning
  - To practice this the athlete should be good at mental imagery and PMR

- **Imagery**
  - Cognitive skill in which the athlete creates or recreates an experience in his or her mind
  - Mental imagery allows the athlete to get used to this uncertain environment over longer periods of time despite minimal real-world competitive opportunity
- **Self-Efficacy**
  - Self confidence or self-efficacy is a better predictor of task execution than arousal and anxiety
  - *Self-confidence:* belief that one can successfully perform a desired behavior
  - *Self-efficacy:* situationally specific form of self-confidence, is the perception of one's ability to perform a given task in a specific situation
  - Self-efficacy derives from:
    - Performance accomplishments
    - Vicarious experiences
    - Verbal persuasion
    - Imaginal experience
    - Physiological states
    - Emotional states
  - Self-efficacy influences people's choice of activity, their level of effort in that activity, and how much persistence they will have in the face of challenging obstacles

- **Self-Talk**
  - Inner dialogue we have with ourselves
  - Self-talk can be positive, negative, or instructional and can influence our behaviors and moods
  - Positive and instructional self-talk can improve performance
  - Negative self-talk is associated with poor performance, as it directs one's focus to inappropriate cues, can trigger negative emotional energy, and can decrease confidence
- **Goal Setting**
  - Those with higher confidence and efficacy generally envision, create, and strive to accomplish more challenging goals
  - *Goal setting:* process whereby progressively challenging standards of performance are pursued with a defined criterion of task performance that increases the likelihood of perceived success
  - Why goal setting affects performance
    - Direct an athlete's attention by prioritizing efforts
    - Increases effort because of the contingency of success on goal attainment
    - Increase positive reinforcement through the feedback given to athletes
  - Process goals
    - Achievement is under the complete control of the athlete
    - Focuses on the actions and behaviors of the athlete to perform the skill well.
    - Success is strongly contingent on effort
  - Outcome goals
    - Goals in which the athlete has little control. Winning attitude
    - Athletes should have a combination of process and outcome goals
  - Short-term goals
    - Increase the likelihood of success because they are relatively close to the athlete's present ability level.
    - They also increase confidence, self-efficacy, and motivation
  - Long-term goals
    - The attachment of short-term goals should lead to the achievement of a long term goal
    - Provide a sense of meaningfulness and direction for pursuing short-term goals

<u>Enhancing Motor Skill Acquisition and Learning</u> (169)

- **Learning-Performance Distinction**
  - Learning is a process that results in a relatively permanent change in the capability for a motor skill
  - Performance is the execution of the skill in the current environment
  - Performance can be affected by many factors so it does not directly reflect the skill capabilities of an individual
- **Practice Schedule**
  - Challenging practice enables motor skill acquisition
  - Whole versus part practice

        - Whole practice addresses the skill in its entirety
        - Part practice separates the skill into a series of subcomponents
        - Tasks that are challenging by having low interrelatedness of the subcomponents are learned better with part practice
        - Segmentation breaks down the task into a series of subcomponents that have clear breaks between them
        - Fractionalization breaks the tasks into subcomponents that occur simultaneously
        - Simplification adjusts the difficulty of the tasks by changing task characteristics such as execution speed or equipment used
        - Pure-part training has the athlete practice each subcomponent of the skill multiple times independently
        - Progressive-part training has the athlete practice the first two parts in isolation before practicing these parts together
        - Repetitive part training has the athlete practice only the first part in isolation; then each subsequent part is added until the whole task is reintegrated
    - Random practice
        - Multiple skills are practiced in random order during a given practice session
    - Variable practice
        - Includes variations of the same skill within a single practice session as opposed to specific practice in which specific skill is repeated multiple times
        - A combination of specific and variable practice allows the athlete to develop sport-specific skills while also providing the athlete with the flexibility to perform in unfamiliar contentexts
    - Observational learning
        - Practice through observation of the task or skill to be performed has important implications for motor skill learning
- **Instructions**
    - *Explicit instructions:* include prescriptive information that gives the athlete the rules for effectively executing the given task
    - *Guided discovery:* provides the athlete with instructions about the overall movement goal and important prompts for task accomplishment without explicitly telling the athlete how to accomplish the task
    - *Discovery:* instructs the athlete on the overarching goal of the task and the athlete receives little to no direction
- **Feedback**
    - *Intrinsic feedback:* feedback provided to the athlete by the athlete from the senses
    - *Augmented feedback:* feedback provided to the athlete by the observer
- **Study Questions:** a, d, b, b, c

Chapter 9: Basic Nutrition Factors in Health

- **Learning Objectives**

- Know when to refer an athlete to the appropriate resource, a medical doctor or sports dietitian
- Identify protein, carbohydrate,and fat recommendations for athletes
- List the dietary recommendations for disease prevention and overall health
- List hydration and electrolyte guidelines for different age groups and scenarios and help athletes develop an individualized hydration plan

<u>Standard Nutrition Guidelines</u> (178)

- **MyPlate**
  - www.choosemyplate.gov
  - This is a good starting point to evaluate your diet
  - *Food Group Recommendations from MyPlate pg. 179
  - *MyPlate Vegetable Subgroup Recommendations pg.180
- **Dietary Reference Intakes**
  - Complete set of nutrient intakes for use when evaluating and planning diets for healthy individuals
  - *Recommended Dietary Allowance:* average daily nutrient requirment adequate for meeting the needs of most healthy people within each life stage and sex
  - *Adequate Intake:* Average daily nutrient intake when RDA cannot be established
  - *Tolerable Upper Intake Level:* maximum average daily nutrient level
  - *Estimated Average Requirement:* average daily nutrient intake level considered sufficient to meet the needs of half of the healthy population
- **More Information of Nutrition**
  - Interactive DRI for healthcare professionals:
    - http://fnic.nal.usda.gov/fnic/interactiveDRI
  - USDA's National agricultural library, dietary supplements
    - http://fnic.nal.usda.gov/dietary-supplements
  - Collegiate and Professional Sports Dietitians Association
    - www.sportsrd.org
  - International Society of sports nutrition
    - www.sportsnutritionsociety.org
  - Sports, cardiovascular, and wellness nutritionists
    - www.scandpg.org

<u>Macronutrients</u> (181)

- **Protein**
  - Primary structural and functional component of every cell in the body
  - Used for growth and development and to build and repair cells; they also serve as enzymes, transport carriers, and hormones
  - *Table 9.3 essential and non-essential amino acids pg.182
  - Protein quality and dietary recommendations
    - Proteins quality is determined by amino acid content and protein digestibility
    - Higher quality proteins are very digestible and contain all of the essential amino acids
    - High quality proteins include
      - Eggs, dairy foods, meat, fish, poultry, soy

        - *Protein digestibility corrected amino acid score (PDCAAS):* measure of protein quality
        - Vegetarians and vegans can eat a combination of legumes, vegetables, seeds, nuts, rice, and whole grains that provide different essential amino acids
        - During the constant breakdown and regeneration of cells, the body's free amino acid pool is the immediate and largest supplier of amino acids. The amino acids are replenished for our diet
        - RDA for protein in adults is 0.80g per kg of body weight
    - Concerns about the RDA for Protein
        - Some scientists suggest that adults should eat more protein than the RDA says for bone health, weight management, and building and repairing muscle
        - Proteins contributed to 50% of bone volume and 33% of bone mass
        - Individuals consuming 0.7-2.1g of protein per kg bodyweight, both urinary calcium excretion and intestinal calcium absorption increase
        - Greater amounts of protein allow to you become full quicker
        - More calories are burned in the digestion of proteins instead of carbohydrates or fat
        - Aerobic endurance athletes: 1-1.6g per kg bw
        - Strength athletes: 1.4-1.7g per kg bw
        - Combination: 1.4-1.7 g per kg bw
        - After exercise, both muscle protein synthesis and breakdown are increased. Protein consumed after exercise increases these two things up to 48 hours. The sooner the better. 20-48g of protein seem to be the best
        - *Table 9.4 Protein Content of Common foods pg. 185
- **Carbohydrate**
    - Serves as a source of energy but is not an essential nutrient because the body can break down the carbon skeletons of certain amino acids and convert them into glucose
    - *Monosaccharides:* single-sugar molecules. Glucose, fructose, and galactose
        - Glucose is used as the primary energy substrate for cells
        - Fructose causes less insulin secretion than other sugars
        - Galactose combines with glucose to for lactose
    - *Disaccharides:* two simple sugar units joined together. Sucrose, lactose, and maltose
        - Sucrose: glucose + fructose
        - Lactose: glucose + galactose
        - Maltose: glucose x2
    - *Polysaccharides:* complex carbohydrates. Starch, fiber, glycogen
        - Starch: storage form of glucose in plants. Must be broken down into glucose components before it can be used
        - Fiber: induce feelings of fullness, reduce constipation, and decrease the absorption of cholesterol.

        - Glycogen: is glucose is not metabolized for energy it can be synthesized to form glycogen
    - Glycemic index and glycemic load
        - *Glycemic index (GI):* ranks carbohydrates according to how quickly they are digested and absorbed
        - Low GI foods are digested and absorbed slowly, resulting in a smaller rise in blood glucose and subsequent insulin release from the pancreas
        - *Glycemic load (GL):* takes the amount of carbohydrate in grams in portion of food in account
        - Food with a higher GL are expected to lead to greater increases in blood sugar and subsequent insulin release
        - *Table 9.5 glycemic index of various foods pg.186
        - *Table 9.6 glycemic index and glycemic load pg. 187
    - Fiber
        - DRI 21-29g/day for women and 30-38g/day for men
        - Fruits, vegetables, nuts, seeds, legumes, and whole-grain products (bread, oatmeal, popcorn)
    - Carbohydrate requirements for athletes
        - Carbohydrates can improve time to exhaustion during aerobic endurance performance as well as work output and performance in high-intensity sports.
        - Aerobic endurance athletes should aim for 8-10g per kg bw
        - Anaerobic athletes should aim for 5-6g per kg bw
        - Within 30 minutes of aerobic endurance training, about 1.5 g of higher glycemic carbohydrate per kg bw should be consumed to stimulate glycogen resynthesis
        - People who do not train every day can restore glycogen over 24 hours if eating in a proper diet
        - Athletes adapt to dietary changes in carbohydrate intake. Though athletes who regularly consume carbohydrates use them as a primary source of energy during aerobic exercise, consistent intake of a law-carbohydrate diet leads to greater reliance on fat as a source of fuel
- **Fat**
    - Fats provide 9 kcal/g and carbohydrates provide 4 kcal/g
    - The body makes saturated fatty acids so there is no need for it in our diet
    - Two polyunsaturated fatty acids are essential because our body cannot make them: omega-6 and omega-3 fatty acids
    - These two fatty acids are important for the formation of healthy cell membranes, proper development, and functioning of the brain and nervous system, and hormone production
    - Omega-6 is found in soybean, corn and safflower oil
    - Omega-3 is found in fish, flaxseeds, walnuts, soybean oil, or canola oil
    - Relationship with cholesterol
        - *Cholesterol:* a waxy, fat-like substance that is an important structural and functional component of all cell membranes

            - Cholesterol is also used for the production of bile salts, vitamin D, and several hormones
            - High levels of total cholesterol, LDL and triglycerides increase the risk of heart disease
            - HDL are protective against heart disease
            - *Table 9.7 Classification of LDL, total, and HDL cholesterol pg. 189
        - Fat and performance
            - Both intramuscular and circulating fatty acids are potential energy sources during exercise
- ***Macronutrient Guidelines pg. 190**

<u>Vitamins</u> (190)

- Organic substances needed in very small amounts to perform specific metabolic function
- *Table 9.8 Vitamins pg.191-192

<u>Minerals</u> (193)

- Contribute to the structure of bone, teeth, and nails; are a component of enzymes; and perform a wide variety of metabolic functions
- For the athlete, minerals are important for bone health, oxygen-carrying capacity, and fluid and electrolyte balance
- *Table 9.9 Minerals pg.193-194

- **Iron**
    - Is essential for both the functioning and synthesis of hemoglobin, a protein that transfers oxygen throughout the body
    - Iron plays an important role in growth development, cell functioning, and the synthesis and functioning of some hormones
    - Iron deficiency is the most prevalent nutritional deficiency, and can negatively impact performance greatly
- **Calcium**
    - Calcium helps bones grow in length and density during adolescence, with up to 90% of peak bone mineral density occurring during late adolescence
    - In adults, calcium helps maintain bone density
    - Calcium also keeps teeth strong, helps regulate muscle contraction, and plays a role in nerve functioning, blood vessel expansion and contraction, and hormone and enzyme secretion

<u>Fluid and Electrolytes</u> (196)

- In the body, water acts as a lubricant, shock absorber, building material, and solvent
- Also, water is essential for body temperature regulation, nutrient transport, and waste product removal, and maintaining fluid balance and therefore normal blood pressure
- Mild dehydration (2-3% weight loss) can increase core body temperature and affect performance by increasing fatigue and decreasing motivation, neuromuscular control, accuracy, power, strength, muscular endurance, and overall performance

- **Fluid Balance**

  - AI for water is 2.7 L to 3.7 L per day
- **Preventing Dehydration**
  - Athletes should try to prevent water weight losses exceeding 2% of body weight while restoring electrolytes lost through sweat
  - You can estimate hydration status by weighing yourself before and after a workout
  - *Table 9.10 Biomarkers of Hydration Status pg.197
- **Electrolytes**
  - Major electrolytes lost in sweat include sodium, chloride, potassium, magnesium, and calcium
  - Therefore, if an individual works out a lot, that person will need to salt their food, and drink electrolyte drinks, not just water
- **Fluid Intake Guidelines**
  - *Fluid Intake Guidelines at a Glance pg. 198
  - Before activity
    - If necessary, prehydrate several hours before exercise to allow for fluid absorption and urine output
  - During Activity
    - Drink to stay hydrated
  - After activity
    - Replace fluid and electrolyte losses
- **Study Questions:** a, b, b, d, c

Chapter 10: Nutrition Strategies for Maximizing Performance

- **Learning Objectives**
  - List pre, during, and post competition nutrition recommendations for different sports
  - Provide guidelines for weight gain and weight loss
  - Recognize signs and symptoms of eating disorders
  - Understand the importance of having an intervention and referral system in place for athletes suspected of having an eating disorder
  - Recognize the prevalence and etiologies of obesity
  - Assist in the assessment process for obese individuals

<u>Pre Competition, During-Event, and Postcompetition Nutrition</u> (202)

- **Pre Competition Nutrition**
  - Pre game meal helps provide fluid to maintain adequate hydration and carbohydrate to maximize blood glucose and stored glycogen levels
  - Glycogen is the main form of energy used during high-intensity exercise; once they have been deleted, muscle fatigue sets in
  - Pre game foods should avoid fat and fiber so the food can digest quickly
  - Aerobic Endurance Sports
    - Pre game meal is most important for aerobic endurance athletes
    - High-carbohydrate meal 3 or more hours before competition can significantly improve aerobic endurance running capacity

        - Endurance athletes who do not adapted to a low-carbohydrate diet will start exercise with depleted glycogen stores which will break down muscle to use protein for energy and may acutely suppress immune and central nervous system functioning
        - *Table 10.1 pre competition food and fluid recommendations for aerobic endurance athletes pg. 204
    - Carbohydrate loading
        - This includes high carbohydrate intake in the days leading up to an event to maximize glycogen stores and therefore carbohydrate availability in the later stages of the event
        - Athletes must consume 8-10 g of carbohydrate per kg bw per day during the loading period to notice any benefit from carbohydrate loading
        - *Table 10.2 Carbohydrate Loading Regimens and sample daily meal plans for aerobic endurance athletes pg.207
- **During Event Nutrition**
    - Athletes should hydrate themselves several hours before exercise to allow for fluid absorption and urine output before competing
    - Aerobic endurance sports
        - Consuming carbohydrates during prolonged aerobic endurance exercise can improve performance while also reducing exercise-induced stress and suppression of immune system functioning
        - Athletes who train intensely may burn 600 to 1,200 calories per hour
        - Carbohydrate ranging from 28-144g per hour during aerobic endurance activity can decrease reliance on limited glycogen stores, extending time to exhaustion, and improve performance by providing a steady stream of carbohydrate that can be used for energy
        - Glucose, sucrose, maltose, maltodextrins, and amylopectin are oxidized quickly.
        - Fructose, galactose, and amylose are oxidized 25%-50% slower
    - Intermittent high-intensity sports
        - Provision of both fluids and carbohydrates is essential to performance during prolonged intermittent sports
        - The effects of carbohydrate on performance may depend not only on the amount consumed during intermittent activities but also on whether the athlete is competing in a fed or fasted and glycogen-depleted state
    - Strength and power sports
        - During resistance training, a significant amount of muscle glycogen is used
        - Strength and power athletes need to maintain their glycogen stores, this may decrease muscular fatigue in slow-twitch fibers and possibly lead to better performance, but supplementing with carbohydrates before and during competition
- **Post Competition Nutrition**
    - Post game meal serves to rehydrate, replenish glycogen stores, and repair muscle tissue

- Normal meals and water will help with replenishing the bodies substances
- Aerobic endurance events
  - After prolonged aerobic endurance events, it is important to replenish carbohydrate stores before the next training session or competition and consume enough protein to build and repair muscle
  - Athletes who train two or three times a day or have less than 24 hours to recover may want to consider eating or drinking a high-carbohydrate meal immediately after finishing their event and at regular intervals thereafter to quickly replenish glycogen stores
  - Protein should be included in the meal as well
- High-intensity intermittent sports
  - Fully replacing muscle glycogen before a subsequent bout of exercise may prolong time until fatigue and improve performance
- Strength and Power sports
  - Athletes in strength and power sports rely on both blood glucose and glycogen for energy during competition
  - Because a single bout of resistance training can lead to significant reduction in glycogen and decreases in glycogen can impair force production and isometric strength while accentuating muscle weakness, it is imperative that these athletes restore glycogen levels before their next bout of exercise
  - Supplementing with protein after a muscle-damaging bout of exercise increases acute muscle protein synthesis
- Concurrent Training
  - Endurance exercise, when combined with strength training, blunts gains in strength compared to strength training along but results in improvements in endurance performance
  - Consumption of carbohydrates after endurance exercise and pre lift can help suppress skeletal muscle breakdown
- Protein at mealtime
  - In addition to consuming protein right after working out, adults should also focus on their protein intake at each main meal, especially since resistance training can increase muscle sensitivity to amino acids for 24-48 hours after exercise whereas the anabolic effect of a meal lasts approximately 3-5 hours
  - *Table 10.3 Sport-specific protein needs pg.213-214

- ***Nutrition for various performance goals pg. 215-216**

<u>Nutrition Strategies for Altering Body Composition</u> (216)

- The first step to altering body composition is to estimate your calorie needs
- Basal metabolic rate is by far the largest contributor to total energy expenditure, accounting for approximately 65-70% of daily energy expenditure. It is a measure of the calories required for maintaining normal body functions
- *Diet induced thermogenesis:* the thermic effect of food, and it the increase in energy expenditure above the resting metabolic rate that can be measured for several hours following a meal

- The thermic effect of food indicates the energy cost of digestion, absorption, metabolism, and storage of food in the body
- *Table 10.4 estimated daily calorie needs of male and female athletes by activity level pg. 217

- **Weight Gain**
  - Weight gain should be focused during the off-season
  - If athletes increase their calorie intake dramatically and consistently, they could gain more fat than they would like
  - The athlete should eat 500 extra calories a day
  - Athletes should also consider supplementing creatine phosphate
- **Weight Loss**
  - There is no one ideal diet. Instead, athletes need to choose a dietary approach based on whether it is safe for them, contains enough protein to meet their needs, and fits their lifestyle so that they can easily adhere to it.
  - Overweight and obesity
    - Obesity is defined as a BMI of 25-30 kg/m^2
    - Body mass index should not be used as a diagnostic tool but instead as an initial screening tool to identify potential weight issues in individuals and to track population-based rates of overweight and obesity
    - BMI = weight (kg) / Height (m^2)
- **Study Questions:** b, a, c, c, a

Chapter 11: Performance-Enhancing Substances and Methods

- **Learning Objective**
  - Provide reliable and up-to-date information to athletes on the risks and benefits of performance-enhancing substances, including anabolic steroids
  - Understand the efficacy and adverse effects of over-the-counter dietary supplements marketed to athletes for enhancing sport and exercise
  - Determine which performance-enhancing supplements are beneficial for strength/power performance, endurance performance, or both
  - Distinguish between those performance-enhancing supplements that mimic the effects of hormones in the body and those that improve performance through some other means

Types of Performance-Enhancing Substances (226)

- Two types of substances
  - Hormones and drugs
  - Dietary supplements
- *Ergogenic aid:* any substance, mechanical aid, or training method that improves sport performance

Hormones (229)

- **Anabolic Steroids**
  - Synthetic derivatives of the male sex hormone testosterone
  - Elevated testosterone stimulate protein synthesis, resulting in improvements in muscle size, body mass, and strength
  - Dosing

        - Athletes used anabolic steroids through a stacking method where they take several drugs at the same time
        - They do this because the potency of one anabolic agent may be enhanced when it is consumed simultaneously with another anabolic agent
    - Efficacy
        - Anabolic steroids increase muscle mass, strength, and athletic performance
    - Psychological effects
        - Associated with changes in aggression, arousal, and irritability
    - *Table 11.2 Signs and symptoms of ergogenic aid abuse pg. 232
- **Testosterone Precursors**
    - Prohormones are precursors to the synthesis of other hormones and are theorized to increase the body's ability to produce a given specific hormone
    - Do not produce many impactful effects
- **HCG (Human Chorionic Gonadotropin)**
    - Obtained from the placenta of a pregnant woman and is very closely related in structure and function to luteinizing hormone
    - HCG can increase testosterone in men
- **Insulin**
    - Facilitates the uptake of glucose and amino acids into the cell
- **Human Growth Hormone**
    - It is anabolic due to its stimulation of bone and skeletal muscle growth, but it also has important metabolic functions such as maintaining blood glucose levels, increasing uptake of glucose and amino acids into muscle cells, and stimulating the release of fatty acids from the fat cells
- **Erythropoietin**
    - Stimulates the production of new red blood cells
    - Really benefits aerobic endurance athletes
- **Beta-Adrenergic Agonists**
    - Regulate lipolysis (breakdown of fat) and thermogenesis (increased energy expenditure)
    - They help body composition, increase lean mass and decrease stored fat
- **Beta-Blockers**
    - Block beta-adrenergic receptors, preventing the catecholamines from binding
    - They reduce anxiety and tremors during performance

<u>Dietary Supplements</u> **(237)**

- **Essential Amino Acids, Branched-Chain Amino Acids**
    - Not produced in the body: histidine, isoleucine, leucine, valine, lysine, methionine, phenylalanine, threonine, and tryptophan
    - isoleucine, leucine, valine helps in stimulating muscle protein synthesis
    - *Figure 11.3 role of leucine in muscle protein synthesis pg.238
- **Arginine**
    - Required for the synthesis of protein and creatine, and its metabolism results in the production of nitric oxide
    - Do not take this orally

- **B-Hydroxy-B-Methylbutyrate**
  - Stimulates protein synthesis and decreases protein breakdown by inhibiting the ubiquitin-proteasome pathway
  - Is most effective when an adequate training stimulus is provided
- **Nutritional Muscle Buffers (MBC)**
  - *Muscle buffer capacity:* ability to regulate H^+ concentration in skeletal muscle during high-intensity exercise
  - B-Alanine
    - Rate-limiting substrate for carnosine synthesis. This will improve MBC and improve anaerobic performance
  - Sodium bicarbonate
    - Counteracts or neutralizes acid
    - Increases pH in the blood
    - Will improve MBC and high-intensity exercise performance
  - Sodium Citrate
    - Help regulate intramuscular pH during high-intensity exercise by the same mechanism as sodium bicarbonate
- **L-Carnitine**
  - Synthesized from the amino acids lysine and methionine and is responsible for the transport of fatty acids from the cytosol into the mitochondria to be oxidized for energy
  - Increases fat utilization and sparing muscle glycogen
- **Creatine**
  - Has been shown to increase maximal strength, power, and lean body mass in both trained and untrained populations
- **Study Questions:** b, d, b, c, a

Chapter 12: Principles of Test Selection and Administration

- **Learning Objectives**
  - Identify and explain the reasons for performing tests
  - Understand testing terminology to communicate clearly with athletes and colleagues
  - Evaluate a test's validity and reliability
  - Select appropriate tests
  - Administer test protocols properly and safely

Reasons For Testing (250)

- Testing can be used to assess athletic talent, identify physical abilities and areas in need of improvement, set goals, and evaluate progress

Testing Terminology (250)

- *Test:* procedure for assessing ability in a particular endeavor
- *Field Test:* assess ability that is performed away from the laboratory and does not require extensive training or equipment
- *Measurement:* collecting data
- *Evaluation:* analyzing test results for the purpose of making decision

- *Pretest:* test before the beginning of training to determine the athletes initial basic ability levels
- *Midtest:* test during a training period to assess progress
- *Formative Evaluation:* periodic reevaluation based on midtests administered during the training
- *Posttest:* test after training period to see progress made

Evaluation of Test Quality (250)

- **Validity**
  - Degree to which a test or test item measures what it is supposed to measure; this is one of the most important characteristics of testing
  - Construct validity
    - Ability of a test to represent the underlying construct
    - Refers to the overall validity
    - To be valid, physical performance tests should
      - measure abilities important in the sport,
      - produce repeatable results,
      - measure the performance of one athlete at a time,
      - appear meaningful,
      - be of suitable difficulty,
      - be able to differentiate between various levels of ability,
      - permit accurate scoring,
      - include a sufficient number of trials,
      - and withstand the test of statistical evaluation
  - Face validity
    - Appearance to the athlete and other casual observers that the test measures what it is supposed to measure
    - Informal and non-quantitative
  - Content Validity
    - Assessment by experts that the testing covers all relevant subtopics or component abilities in appropriate proportions
  - Criterion-referenced validity
    - Extent to which test scores are associated with some other measure of the same ability
    - Concurrent: extent to which test scores are associated with those of other accepted tests that measure the same ability
    - Convergent: evidenced by high positive correlation between the results of the test being assessed and those of the recognized measure of the construct
    - Predictive: extent to which the test score corresponds with future behavior or performance
    - Discriminant: ability of a test to distinguish between two different constructs and is evidenced by a low correlation between the results of the test and those of tests of a different construct
- **Reliability**
  - Measure of the degree of consistency or repeatability of a test

- A test must be reliable to be valid
- Intrasubject variability is a lack of consistent performance by the person being tested
- Interrater reliability is the degree to which different raters agree in their test results over time. Measure of consistency
- Inter Rater variability is the lack of consistent scores by a given tester.

Test Selection (253)

- **Metabolic Energy System Specificity**
  - A valid test must emulate the energy requirements of the sport for which ability is being assessed. (Ex. Basketball is an anaerobic running sport)
- **Biochemical Movement Pattern**
  - The more similar the test is an important movement in the sport, the better
- **Experience and Training Status**
  - their training status and experience may determine which tests will be good
- **Environmental factors**
  - Aerobic endurance performance and intermittent sprint performance may be impaired when the temperature approaches 80F and exceeds 50% humidity
  - Altitude can impair performance on aerobic endurance tests, although not on tests of strength and power

Test Administration (254)

- **Health and Safety Considerations**
  - Be aware of testing conditions that can threaten the health of athletes and be observant of signs and symptoms of health problems that warrant exclusion from testing
  - *Table 12.1 Temperature limits on exercise pg. 255
- **Test Format**
  - If athletes are aware of the purpose and procedures of the testing, will enhance the reliability of test measures
- **Testing batteries and Multiple Testing Trials**
  - In a big group, a tester can administer up to two non fatiguing tests in sequence to an athlete as long as test reliability can be maintained
  - When multiple trials of a test (finding 1RM) are performed, allow complete recovery between trials. There should be 2 minutes of rest in between non 1RM and 3 minutes of rest is close to 1RM
  - Test battery should be separated by 5 minutes (pullup test right to a pushup test)
- **Sequence of Tests**
  - One test should not affect the performance of a subsequent test
  - Logical sequence to administer tests:
    - Non-fatiguing tests (height, weight, etc.)
    - Agility tests
    - Max power and strength tests (1RM)
    - Sprint Tests
    - Local muscular endurance test (pushups)
    - Fatiguing anaerobic capacity tests (300-yd shuttle)
    - Aerobic capacity tests (mile run test)

  - Make an effort to split up the anaerobic and aerobic tests by days
- **Study Questions:** a, c, b, d, b

Chapter 13: Administration, Scoring, and Interpretation of Selected Tests

- **Learning Objectives**
  - Discern the best ways to measure selected parameters related to athletic performance
  - Administer field tests appropriately
  - Evaluate and analyze test data and make normative comparisons
  - Understand appropriate statistics
  - Combine the results of selected tests to generate an athletic profile

Measuring Parameters of Athletic Performance (260)

- **Maximum Muscular Strength**
  - Involve low-speed muscular strength
  - Muscular strength is related to the force a muscle can exert in one maximal effort while maintaining proper form
  - In bench press of back squat, the maximal force that can be exerted isometrically as measured with a transducer, or maximum force that can be exerted at a particular isokinetic speed
- **Anaerobic of Maximum Muscular Power**
  - High-speed strength
  - The ability of muscle tissue to exert high force while contracting at a high speed
  - These include the 1RM of explosive exercises (power clean, snatch, push jerk, etc), vertical jump, and time to sprint up a staircase
- **Anaerobic Capacity**
  - Maximal rate of energy production by the combined phosphagen and anaerobic glycolytic energy systems for moderate-duration activities.
  - It is quantified by the maximal power output during muscular activity between 30-90 seconds
- **Local Muscular Endurance**
  - Ability of certain muscles of muscle groups to perform repeated contractions against submaximal resistance
  - Ex. pullup test, pushups, etc
- **Aerobic Capacity**
  - Maximum rate at which an athlete can produce energy through oxidation of energy sources
  - Can be estimated by performance in aerobic endurance activities
- **Agility**
  - Ability to start, stop, and change the direction of the whole body rapidly
- **Speed**
  - Time taken over a fixed distance
  - Measuring speed with a stopwatch can be a major source of error
  - Use electronic timing devices
- **Flexibility**
  - Range of motion about a body joint

    - Goniometers can measure flexibility
    - Ballistic stretching cannot be allowed during any flexibility testing
- **Balance and Stability**
    - *Balance:* ability to maintain static and dynamic equilibrium or the ability to maintain the body's center of gravity over its base of support
    - *Stability:* measure of the ability to return to a desired position following a disturbance to the system
    - Athletes with poor balance are at a greater risk of lower limb injuries
- **Body Composition**
    - Refers to the relative proportions by weight of fat and lean tissue
    - The skinfold is the most valid and reliable if good equipment is not available
- **Anthropometry**
    - Science of measurement applied to the human body, generally includes measurements of height, weight, and selected body girths
- **Maximum Muscular Strength Tests**
    - *1RM Bench Press pg. 265
    - *1RM Bench Pull pg. 265
    - *1RM Back Squat pg. 266
- **Maximum Muscular Power Tests**
    - *1RM Power Clean pg. 267
    - *Standing Long Jump pg. 267
    - *Vertical Jump pg. 268
    - *Static Vertical Jump pg. 270
    - *Reactive Strength Test pg. 271
    - *Margaria-Kalamen test pg. 272
- **Anaerobic Capacity**
    - *300 yd Shuttle pg. 273
- **Local Muscular Endurance**
    - *Partial Curl-up pg. 274
    - *Push-up pg. 275
- **Aerobic Capacity**
    - *Yo-yo intermittent recovery test pg.278
    - *Maximal Aerobic Speed test pg. 279
- **Agility**
    - *T-Test pg. 280
    - *Hexagon Test pg. 281
    - *Pro Agility Test pg. 282
    - *505 Agility test pg. 282
- **Speed**
    - *Straight-Line Sprint Tests pg.283
- **Balance and Stability**
    - *Balance Error Scoring System pg. 284
    - *Star Excursion Balance Test pg. 285
- **Flexibility**
    - *Sit-and-reach test pg. 286

- *Overhead Squat pg. 287
- **Body Composition**
    - *Skinfold Measurements pg. 288
- **Anthropometry**
    - *Girth Measurements pg. 290

Statistical Evaluation of Test Data (291)

- Once the proper tests have been chosen and administered you must:
    - Analyze the data for change in performance
    - Analysis of the individual or group's performance relative to that of similar individuals or groups tested in the past
    - Analysis of the relationship of each athlete's scores to those of the group
    - Comparison of individual scores to local, state, national, or international norms
- Effectiveness of training is tough to determine from the change in scores of pre and post program training.
    - Athletes to start the training with a higher training status will experience less improvements compared to untrained
    - Athletes will give minimal effort in pre program testing to inflate results for after training
- **Types of Statistics**
    - *Statistics:* the science of collecting, classifying, analyzing, and interpreting numerical data
    - Descriptive Statistics
        - Summarizes or describes a large group of data
    - Central Tendency
        - Values about which the data tend to cluster
        - *Mean:* average of the scores
        - *Median:* middlemost score.
        - *Mode:* score that occurs with the greatest frequency
    - Variability
        - degree of dispersion of scores within a group
        - *Standard deviation:* a measure of the variability of a set of scores about the mean. Small score indicates a set of scores closely clustered about the mean
        - *Range:* interval from the lowest to the highest score
        - *Z-Score:* used to express the distance of any individual score in standard deviation units from the mean
    - Percentile Rank
        - Percentage of test takers scoring below that individual
    - Inferential vs Magnitude Statistics
        - *Inferential:* allows one to draw general conclusions about a population from information collected in a population sample
        - *Magnitude:* allows for interpretation of the clinical significance of fitness testing

        - *Smallest worthwhile change:* ability of a test to detect the smallest practically important change in performance. Usually 0.2 of the between subjects SD
        - *Effect Size:* useful for calculating group performance following a training program or comparing between groups of athletes.
            - ES: (x posttest - and pretest) / SD pretest
            - 0.2=small, 0.6=moderate, 1.2=large
- **Developing an Athletic Profile**
    - When evaluating athletes you should follow these six steps
        - Select tests that will measure the specific parameters most closely related to the physical characteristics of the sport.
        - Choose valid and reliable tests to measure these parameters, and arrange the testing battery in an appropriate order with sufficient rest between sets
        - Administer the test battery with as any athletes as possible
        - Determine the smallest worthwhile change for the tests and compare to normative data
        - Conduct repeat testing
        - Use the results of the testing in a meaningful way
- *Values for different tests and sports pg. 295
- **Study Questions:** b, c, c, c, b

Chapter 14: Warm-up and Flexibility Training

- **Learning Objectives**
    - Identify the components and benefits of a pre-exercise warm-up
    - Structure effective warmups
    - Identify the factors that affect flexibility
    - Use flexibility exercises that take advantage of proprioceptive neuromuscular facilitation
    - Select and apply appropriate static and dynamic stretching methods

<u>Warm-Up</u> (318)

- A warm-up is meant to prepare the athlete physically and mentally for the competition or workout
- Temperature-related effects include an increase in muscle temperature, core temperature, enhanced neural function, and the disruption of transient connective tissue bonds.
- Non-temperature-related effects include increased blood flow to muscles, an elevation of baseline oxygen consumption, and postactivation potentiation
- Positive effects of warm-up on performance include:
    - Faster muscle contraction and relaxation of both agonist and antagonist muscles
    - Improvements in the rate of force development and reaction time
    - Improvements in muscle strength and power
    - Lowered viscous resistance in muscles and joints
    - Improved oxygen delivery
    - Increased blood flow to active muscle

        - Enhanced metabolic reactions
        - An increased psychological preparedness for performance
    - The structure of the warm-up influences potential improvements; such as, the warmup needs to be specific to the activity to be performed.
- **Components of a Warm-Up**
    - It is advised that a warm-up consists of a period of aerobic exercise, followed by stretching, and ending with a period of activity similar to the upcoming activity
    - *General Warm-up period:*
        - 5 minutes of slow aerobic activity such as jogging, skipping, or cycling
        - The aim is to increase heart rate, blood flow, deep muscle temperature, respiration rate, and perspiration and decrease viscosity of joint fluids
    - *Specific Warm-up*
        - Incorporates movements similar to the movements of the athletes sport
        - Warmup should be between 10 and 20 minutes (lean more on the shorter end)
- **Targeted and Structured Warm-Ups**
    - The warm-up is an integral part of the training session. You should plan warm-ups incorporating short-, medium-, and long-term considerations that will contribute to the overall development of the athlete
    - A structure that has been popular because it addresses all key aspects of a warm-up is the Raise, Activate and Mobilize, and Potentiate (RAMP).
        - The first phase involves activities that raise the level of key physiological parameters but also the level of skill of the athletes
            - Aims to elevate body temp, heart rate, respiration rate, blood flow, and joint fluid viscosity
        - Second phase, activating and mobilizing, is analogous to the stretching component of a typical warm-up
            - Key movement patterns used in competition should be used. (squat, lunge, etc.)
            - Athletes in sports that require greater ranges of motion may need to spend more time in this phase of warm-up than those with a low-range of motion required
            - The focus on warmups should shift to performance
            - Dynamic stretching provides a lot of key advantages in this phase
        - Third phase, potentiation, analogous to the specific warm-up but importantly also focuses on the intensity of activities
            - This phase deploys sport-specific activities that progress in intensity until the athlete is performing at the intensity required for the subsequent competition or training session
            - This is especially important for activities that require high levels of speed, strength, and power

<u>Flexibility</u> (320)

    - Flexibility is a measure of ROM and has static and dynamic components

- *Static Flexibility:* the range of possible movement about a joint and its surrounding muscles during a passive movement. Requires no voluntary muscular activity
- *Dynamic Flexibility:* available ROM during active movements and therefore requires voluntary muscular actions

- **Flexibility and Performance**
  - Optimizing flexibility in relation to the specific activity rather than simply maximizing flexibility is the main aim of training
  - You should look at the optimal ROM required of the athlete, but also at the force pattens required through this ROM, and should develop these in tandem with enhanced ROM to ensure that the athlete is optimally prepared for performance
  - Increased risk of injury can include: inflexibility, hyperflexibility, imbalance in flexibility
- **Factors Affecting Flexibility**
  - Joint structure
    - Ball-and-socket joints move in all anatomical planes and have the greatest ROM (hip and shoulder)
    - The wrist is an ellipsoidal joint and allows movement in the sagittal and frontal planes
    - The knee is a modified hinge joint that can only move in the sagittal plane. Least ROM
  - Age and Sex
    - Young people tend to be more flexible than older people
    - Females tend to be more flexible than males
  - Muscle and Connective Tissue
    - Factors such as muscle tissue, the musculotendinous unit, tendons, ligaments, fascial sheaths, joint capsules, and skin may limit ROM
  - Stretch Tolerance
    - Ability to tolerate discomfort of stretching
    - The higher the stretch tolerance, the better the flexibility
  - Neural Control
    - The control of an athlete's ROM is ultimately held at the level of the central and peripheral nervous system and less by structural elements
  - Resistance Training
    - Can increase flexibility and also assist in the development of force capacity through the enhanced ROM
    - Heavy resistance training with limited ROM during the exercises may decrease ROM.
    - To prevent this loss an athlete should develop both agonist and antagonist muscles and should exercise through the full available ROM of the involved joints
  - Muscle Bulk
    - An increase in muscle bulk may adversely affect ROM by impeding joint movement
  - Activity Level

        - An active person tends to be more flexible than an inactive one
- **Frequency, Duration, and Intensity of Stretching**
    - Both static and proprioceptive neuromuscular facilitation stretching have been shown to increase joint flexibility
    - Stretching twice per week for 5 weeks has been shown to significantly improve flexibility
    - For a static stretch, 15-30 secs is recommended
    - When performing static stretches, athletes should perform the stretch at mild discomfort
- **When Should an Athlete Stretch?**
    - Following practice and competition (within 5-10 minutes)
    - As a separate session
- **Proprioceptors and Stretching**
    - *Muscle Spindles:* located within intrafusal muscle fibers that run parallel to extrafusal muscle fibers, monitor changes in muscle length
    - *Stretch reflex:* during a rapid stretching movement, a sensory neuron from the muscle spindle innervates a motor neuron in the spine. The motor neuron than causes a muscle action of the previously stretched extrafusal muscle fibers
    - *Golgi tendon organs:* located near the musculotendinous junction, are sensitive to increases in muscular tension. When stimulated, the GTO causes a muscle to reflexively relax
    - *Autogenic inhibition:* relaxation that occurs in the same muscle that is experiencing increased tension
    - *Reciprocal inhibition:* relaxation that occurs in the muscle opposing the muscle experiencing the increased tension

<u>Type of Stretching</u> (323)

- *Active Stretch:* occurs when the person stretching supplies the force of the stretch
- *Passive Stretch:* occurs when a partner provides external force to cause or enhance a stretch

- **Static Stretch**
    - Is a slow and constant, with the end position held for 15-30 seconds
    - Has been shown to effectively improve ROM
- **Ballistic Stretch**
    - Involves active muscular effort and usesa bouncing-type movement in which the end position is not held
    - Not the greatest type of stretching method
- **Dynamic Stretch**
    - Type of functionally based stretching exercise that uses sport-generic and sport-specific movements to prepare the body for activity
    - More specific to the sport
- **Proprioceptive Neuromuscular Facilitation Stretch (PNF)**
    - Developed as part of the neuromuscular rehabilitation program designed to relax muscles with increased tone or activity
    - Involves both passive and active muscle contractions

- Three Types of techniques: Hold-relax, contract relax, hold-relax with agonist contraction
- Hold-Relax
  - Passive stretch that is held at the point of mild discomfort for 10 seconds
  - Isometric muscle action occurs and is held for 6 seconds
  - The athlete relaxes and them a passive stretch is performed and held for 30 seconds
- Contract-Relax
  - Begins with a passive stretch and held for 10 seconds
  - Hips are extended against resistance for concentric muscle contraction
  - The athlete relaxes and passive hip flexion stretches for 30 seconds.
- Hold-Relax with Agonist Contraction
  - Identical to hold-relax in the first two phases
  - During the third phase, a concentric action of the agonist is used in addition to the passive stretch to add to the stretch force
- *Figures 4.1-4.11 on PNF stretching pg. 325-327
- Common PNF Stretches with a partner
  - Calves and ankles
    - *Figure 4.12 pg. 327
  - Chest
    - *Figure 14.13 pg. 327
  - Groin
    - *Figure 14.14 pg.328
  - Hamstrings and hip extensors
  - Quadriceps and hip flexors
    - *Figure 14.15
  - Shoulders
    - *Figure 14.16

- **Static Stretching Techniques**
  - *Neck
    - Look right and left: sternocleidomastoid
    - Flexion and extension: sternocleidomastoid, suboccipitals, splenae
  - *Shoulders and Chest
    - Straight arms behind back: anterior deltoid, pectoralis major
    - Seated Lean-Back: deltoids, pectoralis major
  - *Posterior of Upper Arm
    - Behind-Neck Stretch: triceps brachii, latissimus dorsi
  - *Upper Back
    - Cross Arm in Front of Chest: posterior deltoid, rhomboids, middle trapezius
    - Arms Straight Up Above Head: Latissimus dorsi
  - *Lower Back
    - Spinal Twist: internal oblique, external oblique, piriformis, erector spinae
    - Semi-Leg Straddle: erector spinae
  - *Hips

        - Forward Lunge: iliopsoas, rectus femoris
        - Supine Knee Flex: Hip extensors (gluteus maximus and hamstrings)
    - *Torso
        - Side Bend With Straight Arms: external oblique, latissimus dorsi, serratus anterior
        - Side Bend With Bent Arm: external oblique, latissimus dorsi, serratus anterior, triceps brachii
    - *Anterior of Thigh and Hip Flexor
        - Side Quadriceps Stretch: quadriceps, iliopsoas
    - *Posterior of Thigh
        - Sitting Toe Touch: hamstrings, erector spinae, gastrocnemius
        - Semi Straddle: gastrocnemius, hamstrings, erector spinae
    - *Groin
        - Straddle: gastrocnemius, hamstrings, erector spinae, hip adductors, sartorius
        - Butterfly: Hip adductors, sartorius
    - *Calf
        - Wall Stretch:gastrocnemius, soleus, achilles tendon
        - Step Stretch: gastrocnemius, soleus, achilles tendon
    - Pgs. 329-340
- **Dynamic Stretching Techniques**
    - *Arm Swings:
        - latissimus dorsi, teres major, anterior and posterior deltoids, pectoralis major
    - *Inchworm:
        - erector spinae, gastrocnemius, gluteus maximus, hamstrings, soleus, anterior tibialis
    - *Lunge Walk:
        - Gluteus maximus, hamstrings, iliopsoas, quadriceps
    - *Lunge With Overhead Side Reach:
        - gluteus maximus, hamstrings, iliopsoas, latissimus dorsi, internal and external oblique, rectus femoris
    - *Walking Knee Lift:
        - gluteus maximus, hamstrings
    - *Forward Lunge With Elbow Instep:
        - biceps femoris, erector spinae, gastrocnemius, gluteus maximus, hamstrings, iliopsoas, latissimus dorsi, internal and external oblique, quadriceps, rectus femoris, soleus
    - *Heel-to-Toe Walk
        - Gastrocnemius, soleus, anterior tibialis
    - *Walking Over and Under
        - Hip abductors, hip adductors, gastrocnemius, gluteus maximus, hamstrings, iliopsoas, rectus femoris, soleus
    - *Inverted Hamstring Stretch
        - Gluteus maximus, hamstrings, hip abductors, hip adductors, erector spinae

- *Straight-Leg March
    - Gluteus maximus, hamstrings, iliopsoas, rectus femoris
- *Spiderman Crawl
    - Biceps femoris, erector spinae, gastrocnemius, gluteus maximus, hamstrings, iliopsoas, latissimus dorsi, internal and external oblique, quadriceps, rectus femoris, soleus
- Pg. 341-349

- **Study Questions:** c, d, c, c, a

Chapter 15: Exercise Technique for Weight and Machine Training

- **Learning Objectives:**
    - Understand the general techniques involved in properly performing resistance training exercises
    - Provide breathing techniques
    - Determine the appropriateness of wearing a weight belt
    - Provide recommendations for spotting free weight exercises
    - Teach proper resistance training exercise and spotting techniques

<u>Fundamentals of Exercise Technique </u>(352)

- **Hand Grips**
    - *Pronated (overhead):* palms down and knuckles up
    - *Supinated (underhand):* Palms up and knuckles down
    - *Alternated:* one hand is pronated and the other is supinated
    - *Hook grip:* similar to the pronated grip except the thumb is positioned under the index and middle fingers
    - *Closed grip:* when thumb is wrapped around the bar
    - *False grip:* when them is not wrapped around the bar
- **Stable Body and Limb Positioning**
    - Exercises performed standing require the feet be positioned slightly wider than hip-width with the heels and balls of the feet in contact with the floor
    - Supine exercises on a bench requires a five point body contact position
        - Head is placed firmly on the bench or back pad
        - Shoulder and upper back are placed firmly and evenly on the bench
        - Buttocks are placed evenly on the bench
        - Feet are flat on the floor
- **Range of Motion and Speed**
    - When the entire ROM is covered during an exercise, the value of the exercise is maximized and flexibility is maintained or improved
    - Reps performed in a slow, controlled manner increase the likelihood that full ROM can be reached
- **Breathing Considerations**
    - *Sticking point:* the most strenuous movement of a repetition (typically soon after the transition from the eccentric phase to the concentric phase
    - Athletes should exhale through the sticking point and inhale through the less stressful phases
- **Weight Belts**

- The use of a weight belt may help maintain intra-abdominal pressure during lifting
- Weight belt should be worn for exercises that place stress on the lower back and during sets that use near maximal loads
- Wearing the belt too much reduced opportunities for the abdominal muscle to be trained

Spotting Free Weight Exercises (354)

- **Types of Exercises Performed and Equipment Involved**
    - With the exception of power exercises, free weight exercises performed with a bar moving over the head, positioned on the back, racked on the front of the shoulders, or passing over the face typically require one or more spotters
    - Spotting overhead exercises and those with the bar on the back or front shoulder
        - These should be performed inside a power rack. Doing these outside a rack would be dangerous
    - Spotting over-the-face exercises
        - It is important for the spotter to grasp the bar with an alternated grip, usually narrower than the athletes grip
        - *Figure 15.2 on dumbbell spotting pg. 355
    - Do Not Spot Power Exercises
- **Number of Spotters**
    - Heavier loads and less experience require more spotters
- ***Guidelines for Spotting pg 356**
- **Resistance Training Exercises**
    - *Abdomen pg 359-361
        - Bent Knee Sit up: rectus abdominis
        - Abdominal Crunch: rectus abdominis
    - *Backpage. 362-366
        - Bent Over Row: latissimus dorsi, teres major, middle trapezius, rhomboids, posterior deltoids
        - One-Arm DB Row: latissimus dorsi, teres major, middle trapezius, rhomboids, posterior deltoids
        - Lat Pulldown: latissimus dorsi, teres major, middle trapezius, rhomboids, posterior deltoids
        - Seated Row: latissimus dorsi, teres major, middle trapezius, rhomboids, posterior deltoids
        - Low-Pulley Seated Row: latissimus dorsi, teres major, middle trapezius, rhomboids, posterior deltoids
    - *Biceps pg.367-368
        - BB Biceps Curl: biceps brachii, brachialis, brachioradialis
        - Hammer Curl: biceps brachii, brachialis, brachioradialis
    - *Calves pg.369-370
        - Standing Calf Raise: gastrocnemius, soleus
        - Standing Heel Raise: gastrocnemius, soleus
    - *Chest pg. 371-376
        - BB Bench Press: pectoralis major, anterior deltoids, triceps brachii

        - Incline DB Bench Press: pectoralis major, anterior deltoids, triceps brachii
        - Flat DB Fly: pectoralis major, anterior deltoids,
        - Vertical Chest Press:pectoralis major, anterior deltoids, triceps brachii
        - Pec Deck: pectoralis major, anterior deltoids, triceps brachii
    - *Forearms pg. 377-378
        - Wrist curl: flexor carpi ulnaris, flexor carpi radialis, palmaris longus
        - Wrist extension: extensor carpi ulnaris, extensor carpi radialis brevis
    - *Hip and Thigh pg. 379-393
        - Hip Sled: gluteus maximus, semimembranosus, semitendinosus, biceps femoris, vastus lateralis, vastus intermedius, vastus medialis, rectus femoris
        - Back Squat: gluteus maximus, semimembranosus, semitendinosus, biceps femoris, vastus lateralis, vastus intermedius, vastus medialis, rectus femoris
        - Front Squat: gluteus maximus, semimembranosus, semitendinosus, biceps femoris, vastus lateralis, vastus intermedius, vastus medialis, rectus femoris
        - Forward Step Lunge: gluteus maximus, semimembranosus, semitendinosus, biceps femoris, vastus lateralis, vastus intermedius, vastus medialis, rectus femoris, iliopsoas
        - Step-Up: gluteus maximus, semimembranosus, semitendinosus, biceps femoris, vastus lateralis, vastus intermedius, vastus medialis, rectus femoris
        - Good Morning: gluteus maximus, semimembranosus, semitendinosus, biceps femoris, erector spinae
        - Deadlift: gluteus maximus, semimembranosus, semitendinosus, biceps femoris, vastus lateralis, vastus intermedius, vastus medialis, rectus femoris
        - Stiff-Leg Deadlift: gluteus maximus, semimembranosus, semitendinosus, biceps femoris, erector spinae
        - RDL: gluteus maximus, semimembranosus, semitendinosus, biceps femoris, erector spinae
        - Leg Extension: vastus lateralis, vastus intermedius, vastus medialis, rectus femoris
        - Seated Leg curl: semimembranosus, semitendinosus, biceps femoris, vastus lateralis,
    - *Shoulders pg. 394-397
        - Shoulder press: anterior and medial deltoids, triceps brachii
        - Seated BB shoulder press: anterior and medial deltoids, triceps brachii
        - Upright row: deltoids, upper trapezius
        - Lateral shoulder raise: deltoids
    - *Triceps pg. 398-399
        - Lying BB triceps extension: triceps brachii
        - Triceps pushdown: triceps brachii
    - *Power Exercises pg. 400-406

        - Push Jerk: gluteus maximus, semimembranosus, semitendinosus, biceps femoris, vastus lateralis, vastus intermedius, vastus medialis, rectus femoris, soleus, gastrocnemius, deltoids trapezius
        - Push press: gluteus maximus, semimembranosus, semitendinosus, biceps femoris, vastus lateralis, vastus intermedius, vastus medialis, rectus femoris, soleus, gastrocnemius, deltoids trapezius
        - Power clean: gluteus maximus, semimembranosus, semitendinosus, biceps femoris, vastus lateralis, vastus intermedius, vastus medialis, rectus femoris, soleus, gastrocnemius, deltoids trapezius
        - Power snatch: gluteus maximus, semimembranosus, semitendinosus, biceps femoris, vastus lateralis, vastus intermedius, vastus medialis, rectus femoris, soleus, gastrocnemius, deltoids trapezius
- **Study Questions:** d, b, c, b, b

Chapter 16: Exercise Technique for Alternative Modes and Nontraditional Implement Training

- **Learning Objectives**
    - Understand the basic guidelines for performing resistance exercise with alternative modes and nontraditional implements
    - Describe the benefits and limitations of bodyweight training activities
    - Identify the benefits and limitations associated with core training
    - Identify the appropriate technique and key technical flaws associated with the alternative mode exercises
    - Appropriately determine how to apply resistance bands and chains to traditional ground-based free weight exercise
    - Determine the appropriate use of alternative methods and nontraditional implement exercises

General Guidelines (410)

    - Ensure proper body alignment
    - Is ground-based keep feet slightly wider than shoulder-width
    - Use appropriate grip
    - Use proper breathing

Bodyweight Training Methods (410)

    - Is specific to each individual's anthropometrics
    - Often includes closed chain-based exercises
    - Strengthens several muscle groups at once
    - Develops relative strength
    - Improves body control
    - Is a low-cost training alternative

Core Stability and Balance Training Methods (411)

- **Anatomical Focus**
    - *Anatomical core:* axial skeleton and all the soft tissues with proximal attachments that originate on the axial skeleton
    - Increasing an athlete's core stability will result in a better foundation for force production in the upper and lower extremities

- **Isolation Exercises**
  - Consist of dynamic or isometric muscle actions designed to isolate specific core musculature without the contribution of the lower and upper extremities
  - These types of exercises can increase muscle activation, which has been suggested to result in improvements in spinal stability and reduction of injuries
  - These do not improve sports performance.
  - Ground bases free weight activities appear to offer activation of the core musculature that is similar to, or in most cases greater than, that with traditional isolation exercises designed to engage the core
  - These are the best for injuries athletes that are going through rehab and are not able to load via ground-based free weights
- **Machines vs Free Weight Exercises**
  - Machine based training is only good for isolating muscles but is rarely used when applied to sport
  - Stabilizer muscles are activated greater in free weight exercises
  - Free weight ground-based exercises offer the ideal combination of specificity and instability
- **Instability Devices**
  - Exercises that are performed on unstable surfaces
  - These devices are used to promote postural disequilibrium or imbalance requiring a greater stabilizing function of the core musculature
  - Ground-based free weight exercises involve a degree of instability that allows for simultaneous development of all links of the kinetic chain, offering a much better training stimulus for the development of core stability and the enhancement of athletic performance than do instability device-based exercises
  - In the rehab setting, unstable devices has shown to reduce low back pain and improve the efficiency of the soft tissues that stabilize the knee and ankle joints
  - Can help prevent ACL injuries

Variable-Resistance Training Methods (413)

  - Resistance training practices include three methods for applying overload to the body: constant external, accommodating, and variable resistance
    - Constant external load: free weights, most common method. The external load stays constant
    - Accommodating: allows for the speed of movement or isokinetic resistance to be controlled throughout the ROM. Has poor external validity and unlikely to provide an adequate training stimulus
    - Variable resistance: attempt to alter the resistance so the muscle maximizes force application throughout the full ROM
- **Chain-Supplemented Exercises**
  - The use of chains in resistance training has evidence on both sides of the spectrum
- **Resistance Band Exercises**
  - Some research has suggested that using bands substitute 35% of the total load during a back squat and can acutely increase peak power by 13%
  - Use of bands may result in a postactivation potentiation effect with each repetition

Nontraditional Implement Training Methods (417)

- **Strongman Training**
    - These introduce a high-intensity stimulus resulting in an elevated blood lactate response
    - These exercises create a greater degree of instability that effectively challenges the athlete in different ways
    - Tire Flipping
        - The tire should not be taller than the athletes standing height
        - *Tire Flipping pg. 418
    - Log Lifting
        - Cleans, press, jerks, rows, squats, deadlift, and lunges can be performed with the log
    - Farmers Walk
        - This is useful because it involves unstable and awkward resistances that have both unilateral and bilateral motions
        - It is suggested that it develops total body anaerobic endurance, back endurance, and grip strength
- **Kettlebell Training**
    - This is a good tool for fitness and development
    - This is good an a preparation exercise but traditional training methods are the best for strength and power
- **Modes and Nontraditional Exercises**
    - *Bodyweight Exercises pg.423-424
        - Front Plank: rectus abdominis, internal obliques, external obliques, erector spinae
        - Side Plank: internal obliques, external obliques
    - *Core Stability and Balance Training Exercises pg. 425-427
        - Stability Ball Rollout: rectus abdominis, iliopsoas
        - Stability Ball Pike: rectus abdominis, iliopsoas
        - Stability Ball Jackknife: rectus abdominis, iliopsoas
    - *Strongman Exercises pg. 428-430
        - Tire Flip: gluteus maximus, semimembranosus, semitendinosus, biceps femoris, vastus lateralis, vastus intermedius, vastus medialis, rectus femoris, soleus, gastrocnemius, deltoids trapezius
        - Log Clean and Press: gluteus maximus, semimembranosus, semitendinosus, biceps femoris, vastus lateralis, vastus intermedius, vastus medialis, rectus femoris, soleus, gastrocnemius, deltoids trapezius
    - *Other Alternative Exercises pg. 432-436
        - Back Squat with Bands: gluteus maximus, semimembranosus, semitendinosus, biceps femoris, vastus lateralis, vastus intermedius, vastus medialis, rectus femoris,
        - Two-Arm Kettlebell Swing: gluteus maximus, semimembranosus, semitendinosus, biceps femoris, vastus lateralis, vastus intermedius, vastus medialis, rectus femoris

- Single-Leg Squat: gluteus maximus, semimembranosus, semitendinosus, biceps femoris, vastus lateralis, vastus intermedius, vastus medialis, rectus femoris
- Single-Leg RDL: gluteus maximus, semimembranosus, semitendinosus, biceps femoris,
- One-Arm DB Snatch: gluteus maximus, semimembranosus, semitendinosus, biceps femoris, vastus lateralis, vastus intermedius, vastus medialis, rectus femoris, soleus, gastrocnemius, deltoids trapezius

- **Study Questions:** b, a, b, a, c

Chapter 17: Program Design For Resistance Training

- **Learning Objectives**
  - Evaluate the requirements and characteristics of a sport and assess an athlete for the purpose of designing a resistance training program
  - Select exercises based on type, sport specificity, technique experience, equipment availability and time availability
  - Determine training frequency based on training status, sport season, load, exercise type, and other concurrent exercise
  - Arrange exercises in a training session according to their type
  - Determine 1RM, predicted 1RM from a multiple RM, and RM loads
  - Assign load and repetitions based on training goal
  - Know when and by how much an exercise load should be increased
  - Assign training volumes according to the athletes training status and the training goal
  - Determine rest period lengths based on the training goal

Principles of Anaerobic Exercise Prescription (440)

  - The type of demand placed on the body dictates the type of adaptation that will occur.
  - Athletes training for power in high-speed movements should attempt to activate or recruit the same motor units by their sport at the highest velocity possible.
  - *Overload:* assigning a workout or training regimen of greater intensity than the athlete is accustomed to
  - Without overload, the athlete's ability to make improvements greatly decreases
  - Is a training program is to continue producing higher levels of performance, the intensity of the training must become progressively greater

- **Resistance Training Program Design Variables**
  - Needs analysis
  - Exercise Selection
  - Training frequency
  - Exercise order
  - Training Load and repetitions
  - Volume
  - Rest Periods

Needs Analysis (441)

- Two-stage process that includes an evaluation of the requirements and characteristics of the sport and an assessment of the athlete
- **Evaluation of The Sport**
    - The first task is to determine the unique characteristics of the sport, which include the general physiological and biomechanical profile, common injury sites, and position-specific attributes
        - Body limb and movement patterns and muscular involvement
        - Strength, power, hypertrophy, and muscular endurance priorities
        - Common sites for joint and muscle injury and causative factors
- **Assessment of the Athlete**
    - The second task is to profile the athlete's needs and goals by evaluating training status, conducting a variety of tests, evaluating the results, and determining the primary goal of training
    - Training Status
        - Current condition or level of preparedness to begin a new or revised program is an important consideration in the design of training programs
        - Assessment of an athletes training background should include
            - Type of training program
            - Length of recent regular participation in previous training programs
            - Level of intensity involved in previous training programs
            - Degree of exercise technique experience
            - *Table 17.1 Example of Classifying Resistance Training Status pg. 442
        - Physical Testing and Evaluation
            - To yield pertinent and reliable data that can be used effectively to develop a resistance training program, the tests selected should be related to the athlete's sport, consistent with the athlete's level of sill, and realistically based on the equipment available
            - Major upper body exercises include bench press and shoulder press
            - Exercises mimicking jumping movements are power clean, squat, leg press
        - Primary Resistance Training Goal
            - The athlete's test results, the movement and physiological analysis of the sport, and the priorities of the athlete's sport season determine the primary goal or outcome for the training program
            - *Table 17.2 General Training Priorities by Sport Season pg. 444

<u>Exercise Selection</u> (443)

- **Exercise Type**
    - Core and Assistance Exercises
        - *Core Exercises:* recruit one or more large muscle areas, involve two or more primary joints, and receive priority when one is selecting exercises because of direct application to the sport

        - *Assistance Exercises:* usually recruit smaller muscle areas, involve only one primary joint, and are considered less important to improving sport performance
            - These are often exercises used for injury prevention and rehabilitation
        - Structural and power exercises
            - *Structural Exercise:* Loading the spine. Directly (back squat), indirectly (power clean). Involves muscular stabilization of posture during performance of the lifting movement
            - *Power Exercise:* structural exercise that is performed very quickly or explosively
- **Movement Analysis of The Sport**
    - The exercises selected for a resistance training program that focus on conditioning for a particular sport need to be relevant to the activities of that sport in their body and limb movement patterns, joint ranges of motion, and muscular involvement
    - The exercises should also creature muscular balance to reduce risk of injury from disproportionate training
    - Sport-specific exercises
        - *Table 17.3 Examples of Movement-Related Resistance Training Exercises pg. 445
    - Muscle Balance
        - Exercises selected for the specific demands of the sport should maintain a balance of muscular strength across joints and between opposing muscle groups (biceps and triceps)(hamstrings and quads)
        - Muscle balance does not always mean equal strength, just a proper ratio of strength, power, or muscular endurance of one muscle or muscle group relative to another muscle or muscle group
    - Exercises to Promote Recovery
        - *Recovery Exercise:* exercises that do not involve high muscular stress and high stress on the nervous system by promote movement and restoration
        - They can take the form of lightly loaded resistance exercises or low-intensity aerobic exercise to assist the body in returning to its pre-exercise state
        - These exercises assist in the removal of metabolic wastes and by-products and maintain some amount of blood flow to the exercised muscles so the repair processes can be optimized

<u>Training Frequency</u> (447)

- **Training Status**
    - Traditionally, three workouts per week are recommended for many athletes
    - The general guideline is to schedule training sessions so as to include at least one rest or recovery day (but not more than three) between sessions that stress the same muscle group
    - For split routines with three distinct training days, the rest days are not on the same day each week.
    - *Table 17.4 Resistance Training Frequency Based on Training Status pg. 447

- *Table 17.5 Examples of Common Split Routines pg. 448
- *Table 17.6 Resistance Training Frequency Based on the Sport Season pg. 448

- **Training Load and Exercise Type**
  - Athletes who train with maximal or near-maximal loads require more recovery time before their next training session
  - The ability to train more frequently may be enhanced by alternating lighter and heavier training days
- **Other Training**
  - If the athlete's program already includes aerobic or anaerobic training, sport skill practice, or any combination of these components, the frequency of resistance training may need to be reduced

Exercise Order (448)

- **Power, Other Core, Then Assistance Exercises**
  - Power exercises include: snatch, hang clean, power clean, and push jerk
  - This should be following by non-power core exercises and then assistance exercises
- **Upper and Lower Body Exercises (Advanced)**
  - This methods provides the opportunity for athletes to recover more fully between exercises is to alternate upper body and lower body exercises
  - If training time is limited, this methods of arranging exercises minimizes the length of the rest periods required between exercises and maximized the rest between body areas
  - If the exercises are performed with minimal rest periods (20-30sec), this methods is referred to as circuit training
- **Push and Pull Exercises (Alternated)**
  - Other methods of improving recovery and recruitment between exercises is to alternate pushing exercises with pulling exercises
  - This push-pull arrangement ensures that the same muscle group with not be used in two exercises in succession, thus reducing fatigue in the involved muscles
- **Supersets and Compound Sets**
  - *Superset:* involves two sequentially performed exercises that stress two opposing muscles or muscle areas (bicep curl right to tricep pushdown)
  - *Compound Set:* involves sequentially performing two different exercises for the same muscle group

Training Load and Repetitions (451)

- **Terminology Used to Quantify and Qualify Mechanical Work**
  - *Mechanical Work:* defined as the product of force and displacement
  - The amount of work done for a workout can be done by multiplying each weight lifted by the number of times it is lifted and summing all such values over a training session
  - *Volume-Load:* is the weight x reps x displacement
- **Relationship Between Load and Repetitions**
  - *Table 17.7 Percent of the 1RM and repetitions allowed pg.452
- **1RM and Multiple-RM Testing Options**

- To gather information needed to assign a training load:
  - Actual 1RM
  - Estimated 1RM from a multiple-RM test (10RM)
  - Multiple RM Based on the number of repetitions planned for that exercises
- Testing the 1RM
  - *1RM Testing Protocol pg 453
  - Individuals who are untrained, inexperienced, injured, or medically supervised may not be appropriate for 1RM
  - When selecting exercises for 1RM testing you should choose core exercises.
- Estimating a 1RM
  - When maximal strength testing is not warranted, testing with a 10RM load can be suitable secondary option
  - *Table 17.8 Estimating 1RM and Training Loads pg. 455
- Multiple-RM Testing Based on Goal Repetitions
  - Core and assistance exercises can be selected for multiple RM testing, but high rep testing sets can create significant fatigue and compromise the accuracy of the tested multiple RM

- **Assigning Load and Repetitions Based on The Training Goal**
  - During the needs analysis you are challenged to choose the primary goal of the resistance training program based on the athlete's testing results, the movement and physiological analysis of the sport, and the priorities of the athlete's sport season
  - *Summary of testing and assigning Training loads and reps pg. 457
  - Repetition Maximum Continuum
    - *Figure 17.3 shows how RM ranges are associated with training goals pg. 457
    - This illustrates that a certain RM emphasizes a specific outcome, but the training benefits are blended at any given RM
  - Percentage of the 1RM
    - *Table 17.9 Load and Reps assignments based on the training goal pg. 458
    - Assigning percentages for power training
      - The force-velocity curve illustrates that the greater the amount of concentric muscular force generates, the slower the muscle shortening and corresponding movement velocity
      - Max power is produced at intermediate velocities with the lifting of light or moderate, not maximal, loads
      - Non-weightlifting multi joint power exercise (jump squat, overhead press throw) and single-joint muscle actions data reveal that peak power is generally reached with the lifting of very light loads from bodyweight to 30& of 1RM.
      - The most effective and practical applications is to assign loads that are about 75% to 90% of the 1RM for resistance training exercises that can be heavily loaded

        - Power exercises cannot be maximally loaded at any repetition scheme because the quality of the movement technique will decline before momentary muscle fatigue defines a true multiple RM set
        - Lighter loads allow the athlete to complete reps with max speed to promote max power development
        - Power exercises are usually limited to 5 reps per set, but with loads up to and equal to a 10RM
- **Variation of The Training Load**
    - You cannot use every training session as a max load session. You can do heavy loads for the power and core exercises one day a week (designed for full rep maxes)
    - The loads for the other days should be reduced to provide recovery after the heavy day while still maintaining sufficient training frequency
    - For a light day, calculate 80% of the loads lifted in the power and other core exercises of the heavy day
    - For a medium day, calculate 90% loads lifted in power and other core exercises from the heavy day
- **Progression of The Training Load**
    - Timing Load Increases
        - *2-for-2 Rule:* if the athlete can perform two or more reps over his assigned rep goal for a given exercise in the last set in two consecutive workouts, weight should be added to that exercise for the next training session
    - Quantity of Load Increases
        - *Table 17.10 Examples of Load Increases pg. 460

<u>Volume</u> (462)

- *Volume:* relates to the total amount of weight lifted in a training session
- *Repetition-Volume:* is the total number of repetitions performed during a workout session
- *Volume-Load:* total number of sets multiplied by the number of repetitions per set, then multiplied by the weight lifted per repetition

- **Multiple vs Single Sets**
    - Single-set training may be appropriate for untrained individuals or during the first several months of training
    - Many studies indicate that higher volumes are necessary to promote further gains in strength, especially for intermediate and advanced resistance-trained athletes
    - Performing 3x10 without going to failure enhances better strength than 1x10 to failure
- **Training Status**
    - It is appropriate for an athlete to perform only one or two sets as a beginner and to add sets as he or she becomes better trained
- **Primary Resistance Training Goal**
    - *Table 17.11 Volume Assignments Based on The Training Goal pg. 463
    - Strength and Power

            - Maximal strength gains require 6 or less reps for core exercises. And a range of 2-5 sets or 3-6 sets
            - 1-3 sets will be good for assistance exercises
            - 3-5 sets for power exercises
        - Hypertrophy
            - Higher training volumes are associated with increases in muscular size
            - 6-12 reps per set
            - 3-6 sets per exercise
            - Performing 3 or more exercises per muscle group is the most effective strategy for increasing muscle size
        - Muscular Endurance
            - 12 or more reps per set
            - 2 or 3 sets per exercise

<u>Rest Periods</u> (465)

- The length of the rest period between sets and exercise is highly dependent on the goal of training, the relative load lifted, and the athlete's training status
- The amount of rest between sets is strongly related to load; the heavier the load lifted, the longer the rest periods
- *Table 17.12 Rest Period Length Assignments Based on The Training Goal pg. 465

- **Strength and Power**
    - Training may enhance an athlete's ability to exercises with less rest
    - Common rest guidelines are 2-5 minutes
- **Hypertrophy**
    - Gaining muscular size often uses short to moderate interset rest periods
    - Common rest guidelines are 30 sec to 1.5 min
- **Muscular Endurance**
    - Common rest guideline is less than 30 sec
    - These are common is circuit training programs in which it is common to alternate exercises and limit rest period lengths to 30 sec or less
- **Study Questions:** a, c, b, a, d

Chapter 18: Program Design and Technique For Plyometric Training

- **Learning Objectives**
    - Explain the physiology of plyometric exercise
    - Identify the phases of the stretch-shortening cycle
    - Identify the components of a plyometric training program
    - Design a safe and effective plyometric training program
    - Recommend a proper equipment for use during plyometric exercise
    - Teach correct execution of lower and upper body plyometric exercises
- **Introduction**
    - *Plyometric exercise:* refers to those activities that enable a muscle to reach maximal force in the shortest possible time

  - The purpose of a plyometric exercise is to increase the power of the subsequent movements by using both the natural elastic components of muscle and tendon and the stretch reflex

<u>**Plyometric Mechanics and Physiology**</u> **(472)**

- **Mechanical Model of Plyometric Exercise**
  - The elastic energy in the musculotendinous components is increased with a rapid stretch and then stored
  - When this movement is immediately followed by a concentric muscle action, the stored elastic energy is released, increasing the total force production
  - The series elastic component (SEC) that is the workhorse of plyometric exercise
    - The tendons constitute the majority of the SEC
    - When the musculotendinous unit is stretched, as in an eccentric muscle action, the SEC acts as a spring and is lengthened; as it lengthens elastic energy is stored.
    - If the muscle begins a concentric action immediately after the eccentric action, the stored energy is released, allowing the SEC to contribute to the total force production by naturally returning the muscles and tendons to their unstretched configuration
  - *Figure 18.1 Mechanical model of plyometric exercise pg. 472
- **Neurophysiological Model of Plyometric Exercise**
  - Involves the potentiation of the concentric muscle action by use of the stretch reflex
  - *Potentiation:* change in the force-velocity characteristics of the muscle's contractile components caused by stretch
  - *Stretch reflex:* body's involuntary response to an external stimulus that stretches the muscles
  - *Muscle Spindles:* proprioceptive organs that are sensitive to the rate and magnitude of a stretch; when a quick stretch is detected, muscular activity reflexively increases
  - During plyometric exercises, the muscle spindles are stimulated by a rapid stretch, causing a reflexive muscle action. This reflexive response potentiates or increased the activity in the agonist muscle, thereby increasing the force the muscle produces
  - *Figure 18.2 stretch reflex pg. 473
- **Stretch-Shortening Cycle**
  - This cycle employs the energy storage capabilities of the SEC and stimulation of the stretch reflex to facilitate a maximal increase in muscle recruitment over a minimal amount of time
  - Phase 1: eccentric phase
    - Preloading the agonist muscle groups
  - Phase II: Amortization
    - *Amortization:* Time between concentric and eccentric phases.
    - There is a delay between concentric and eccentric muscle actions during which Type Ia afferent nerves synapse with the alphas motor neurons in the ventral root of the spinal cord

        - The SSC in this phase is the most crucial in allowing greater power production; its duration must be kept short.
        - If this phase lasts too long, the energy stored during the eccentric phase dissipates as heat, and the stretch reflex will not increase muscle activity during the concentric phase
    - Phase III: concentric
        - The body's response to the eccentric amortization phases
        - The energy stored in the SEC is either used to increase the force of the movement or dissipated as heat
        - The stored elastic energy increases the force produced by the concentric phase movement beyond that of an isolated concentric muscle action
    - The rate of musculotendinous stretch is vital to plyometric exercise. A high stretch rate results in greater muscle recruitment and activity during the SSC concentric phase
    - Static squat jump, countermovement jump, and an approach jump with several steps
    - Approach jump > countermovement jump > static squat jump
    - *Table 18.1 stretch-shortening cycle pg. 473

Program Design (475)

- **Needs Analysis**
    - You need to understand training status, sport requirements, injury profile,
- **Mode**
    - Lower Body Plyometrics
        - Football, baseball, and sprinting require horizontal or lateral movement during competition
        - Volleyball is vertical
        - Basketball and soccer must make quick powerful movements in all planes
        - *Table 18.2 Lower Body Plyometric Drills pg. 476
    - Upper Body Plyometrics
        - Baseball, softball, tennis, golf, and throws in track & field are great for upper plyometrics
        - A baseball pitcher usually throws between 80-100 mph. To reach these velocities, the shoulder joint must move at more than 6000 degrees/sec. Plyometric training on the shoulder joint would increase pitching velocity; and it may also prevent injury to the shoulder and elbow joints
    - Trunk Plyometrics
        - These are tough to effectively perform
- **Intensity**
    - Plyometric intensity is the amount of stress placed on involved muscles, connective tissues, and joints
    - As intensity increases, volume should decrease
    - *Table 18.3 Factors Affecting the Intensity of Lower Body Plyos pg. 476
- **Frequency**
    - Number of plyometric training sessions per week and typically ranges from one to three

    - 48-72 hours is a typical recovery time guideline for prescribing plyometrics
    - During the season 1 session per week is good for football players, and 2-3 is good for track and field
- **Recovery**
    - Because plyometric drills involve maximal efforts to improve anaerobic power, complete and adequate recovery is required
    - Depth jumps may need 5 to 10 seconds between reps and 2-3 minutes between sets
    - These drills should not be thought of as cardiorespiratory conditioning, but as power training
    - Drills for a given body area should not be performed two days in succession
- **Volume**
    - Expressed as the number of reps and sets
    - Lower body plyometric volume is normally given as the number of foot contacts per workout
    - Upper body plyometric volume is typically expressed as the number of throws or catches per workout
    - *Table 18.4 Appropriate Plyometric Volumes pg. 477
- **Program Length**
    - Most programs ranges from 6-10 weeks
    - Vertical jump height can improve as quickly as 4 weeks after the start of plyometric training
- **Progression**
    - *Progressive overload:* systematic increase in training frequency, volume, and intensity in various combinations
- **Warm-Up**
    - Plyometric sessions must begin with a general warm-up, stretching, and a specific warm-up
    - The specific warm-up should consist of low-intensity, dynamic movements
    - *Table 18.5 Plyometric Warm-up Drills pg. 478
- **Steps for Implementing a Plyometric Training Program**
    - Evaluate the athlete, including the athlete's sport and training intensity
    - Establish sport, position, and athlete specific goals
    - Assign proper plyometric training program design variables, addressing intensity, frequency, recovery, volume, and program length
    - Teach the athlete proper jumping, landing, and throwing technique
    - Properly progress the plyometric training program

<u>Age Considerations</u> (478)

- **Adolescents**
    - Regular participation in a plyometric training program can better prepare young athletes for the demands of sport and competition by enhancing neuromuscular control and performance
    - Plyometric programs for children should be used to develop the neuromuscular control and the anaerobic skills that will carry over to participation

- Benefits of teaching proper landing technique as a method of reducing an athletes risk of lower extremity injury
- Excessive inward valgus movement of the knees dramatically increase an athlete's risk of knee injury
- It is extremely important that children progress from relatively simple to more complex drills to develop techniques that will be essential for more advanced exercises
- Minimum of 2-3 days between plyometric workouts should be considered essential
- *Figure 18.4 proper plyometric landing position

Plyometrics and Other Forms of Exercise (480)

- **Plyometric Exercise and Resistance Training**
  - Guidelines for developing this type of program
    - Combine lower body resistance training with upper body plyometrics, and upper body resistance training with lower body plyometrics
    - Do not perform heavy resistance training and plyometrics on the same day
    - Some athletes benefit from high-intensity resistance training followed by plyometrics
    - Traditional resistance training may be combined with plyometric movements to further enhance gains in muscular power
    - *Table 18.6 Sample Schedule for Integrating Resistance Training and Plyometrics pg. 480
- **Plyometric and Aerobic Exercise**
  - Since aerobic exercise may have a negative effect on power production, it is advisable to perform plyometric exercises before aerobic endurance training

Safety Considerations (481)

- **Pretraining Evaluation of The Athlete**
  - To reduce risk of injury, the athlete must understand proper plyometric technique and possess sufficient base of strength, speed, and balance
  - Technique
    - Proper landing technique is essential.
    - If the center of gravity is offset from the base of support, the performance is hindered and injury may occur
    - The shoulders should be over the knees and the knees directly over the toes during landing
    - Knee valgus significantly increases risk for knee injury
  - Strength
    - For lower body plyometrics, the athlete’s 1RM should be 1.5 times his or her bodyweight
    - Focus more on the technique though
  - Balance
    - Each balance position should be held for 30 seconds
    - *Table 18.7 Balance Tests pg. 481
  - Physical Characteristics

        - Athletes who weight more than 220lbs may be at an increased risk for injury when performing plyometrics
        - Athletes weighing over 220lbs should avoid high-volume, high intensity performance, and depth jumps from heights greater than 18 inches
- **Equipment and Facilities**
    - Landing Space
        - Must possess adequate shock-absorbing properties
        - Grass field, suspended floor, or rubber mat
        - Concrete, tile, and hardwood are not recommended
    - Training Area
        - Ceiling must be 3-4 m
    - Equipment
        - Boxes should be sturdy and non-slip top
    - Proper Footwear
        - Footwear should have good ankle and foot support, good lateral stability, and a wide, non-slip sole
    - Depth Jumping
        - Height of 48 inches would provide significant overload
        - Recommended height is 16-42 inches with 30-32 inches being the norm

<u>Plyometric Drills</u> (483)

- **Lower Body Plyometrics**
    - Jumps in Place (484-488)
        - 2-foot ankle hop: low
        - SL-ankle hop: medium
        - Squat Jump:
        - Jump and Reach:
        - Double-Leg Tuck Jump:
        - Split Squat Jump:
        - Cycled Split Squat Jump:
        - SL-Tuck Jump:
        - Pike Jump:
    - Standing Jumps (489-490)
        - Vertical jump:
        - SL Vertical Jump:
        - Jump Over Barrier:
        - Standing Long Jump:
    - Multiple Hops and Jumps (491-494)
        - Double Leg Hop
        - Double Leg Zig Zag Hop
        - SL Hop
        - Front Barrier Hop:
        - Lateral Barrier Hop:
        - 4-Hurdle Drill:
    - Bounds (496-501)
        - Skip:

        - Power Skip:
        - Backward Skip:
        - Side Skip:
        - SA Alternate-Leg Bound:
        - Double Arm Alternate Leg Bound:
    - Box Drills (502-506)
        - SL Push Off:
        - Alternate Leg Push-Off:
        - Lateral Push off:
        - Side to Side Push Off:
        - DL jump to box:
        - SL jump to box:
        - Squat Box Jump:
        - Lateral Box Jump:
        - Drop Freeze:
    - Depth Jumps (507-513)
        - Depth Jump:
        - Depth Jump to Second Box:
        - Squat Depth Jump:
        - Depth Jump with lateral movement:
        - Depth Jump with standing long jump:
        - Depth Jump to 180 turn:
        - SL depth jump:
- **Upper Body Plyometrics:**
    - Throws (514-517
        - Chest Pass:
        - Overhead Throw:
        - Side-to-side throw:
        - SA throw:
        - Power Drop:
    - Plyometric Pushups (518)
        - Depth Push-up:
- **Trunk Plyometrics**
    - 45 degree situp (519)
- **Study Questions:** d, b, c, c, a

Chapter 19: Program Design and Technique For Speed and Agility Training

- **Learning Objectives**
    - Describe the underlying biomechanical constructs of sprint, change of direction, and agility performance
    - Apply sound movement principles to the coaching of locomotion modes and techniques
    - Analyze the abilities and skills needed to perform specific movement tasks
    - Effectively monitor the development of sprint, change of direction, and agility abilities

- Apply sound means and methods for developing speed, change of direction, and agility
- Design and implement training programs to maximize athletic performance

- **Introduction**
  - The physical capacity to change direction may be a component of agility, but the perceptual-cognitive component influences the physical demands of agility.
  - An athlete's success in these explosive movements is the product of an athlete's strength capacity combined with the ability to use this strength within the constraints of the activity
  - Speed requires the ability to accelerate and reach maximal velocity, whereas agility performance requires the use of perceptual-cognitive ability in combination with the ability to decelerate and then reaccelerate in an intended direction

Speed and Agility Mechanics (522)

- *Rate of Force Development (RFD):* the development of maximal force in minimal time, typically used as an index of explosive strength. Change in force divided by change in time.
- *Impulse:* product of the generated force and the time required for its production, which is measured as the area under the force-time curve

- **Physics of Sprinting, Change of Direction, and Agility**
  - Force is described as a push or pull exerted on one object by another, which prevents both objects from occupying the same space. This movement of mass changes an object's velocity, causing acceleration
- **Rate of Force Development**
  - *Figure 19.1 force curve of untrained, heavy resistance trained, explosive-ballistic trained pg. 523
  - The ability to produce force rapidly is arguably a more desirable trait than maximal force production
  - The generation of maximal contraction force takes at least 300ms, while many sport activities consume 0-200 ms
  - RFD may be the best way to measure an athlete's explosive ability
- **Impulse**
  - Athlete's attempting to increase speeds through the production of force never apply forces instantaneously.
  - Force is applied to a running surface over a period of time in the stance phase or the plant phase of changing direction
  - *Ground contact time:* length of time athletes are in stance or plant phase
  - *Impulse:* product of the time the force is applied to the ground and the amount of force applied. Can be graphically represented as the areas under the force-time curve.
  - *Figure 19.2 sprint ground reaction force and impulse pg. 524
    - During maximal-velocity phases, there is an asymmetrical production of force and the RFD is very high, resulting in much shorter ground contact times in comparison to the acceleration phase

- *Momentum:* relationship between the mass of an object and the velocity of movement
- A change in impulse results in a change in momentum and is the cause of an object's movement
- Training should focus on impulse in addition to RFD

- **Practical Implications For Speed**
  - Within a short sprint, force is the effort needed to accelerate an athlete up to his or her highest achievable speeds, which are largely determined by physiological factors
  - These forces or efforts are produced rapidly, with time constraints that are often shorter than the time needed for maximal voluntary force production.
  - Rate of force production may be a more important factor for sprinting success. Impulse is also an important underlying factor
- **Practical Implications for Change of Direction and Agility**
  - The amount of impulse required to change momentum effectively and efficiently is a direct reflection of the physical requirements for change of direction.
  - As the angle of directional change required or the velocity of entry into the change of direction increases, so does the impulse required to change momentum
  - The time restraints placed on a performer due to the perceptual-cognitive aspects of agility can influence the physical demands by limiting the time available to produce the required force to successfully change direction in response to a stimulus

<u>Neurophysiological Basis For Speed</u> (525)

- **Nervous System**
  - Neuromuscular function is vital to sprint performance because the activity and the interaction of the central nervous system with the muscle ultimately influence the rate and strength of muscle contraction
  - Strength training enhances neural drive, the rate and amplitude of impulses being sent from the nervous system to the target muscles
  - Increases in neural drive are related to increases in both muscular force production and the rate of force production
  - Plyometric training increases the excitability of high-threshold motor neurons. Increased excitability ultimately enhances neural drive
- **Stretch-Shortening Cycle**
  - An eccentric-concentric coupling phenomenon in which muscle-tendon complexes are rapidly and forcibly lengthened, or stretch loaded, and immediately shortened in a reactive or elastic manner
  - SSC exploit two phenomena
    - Intrinsic muscle-tendon behavior and
    - force and length reflex feedback to the nervous system
  - Acutely, SSC action tends to increase mechanical efficiency and impulse via elastic energy recovery, whereas chronically, they upregulate muscle stiffness and enhance neuromuscular activation
  - Training activities aimed at improving SSC performance should fulfill two criteria

        - They should involve skillful, multi-joint movements that transmit forces through the kinetic chain and exploit elastic-reflexive mechanisms
        - In order to manage fatigue and emphasize work quality and technique, they should be structured around brief work bouts or clusters separated by frequent rest pauses
        - A combination of progressive plyometric and heavy resistance methods can accomplish these objectives
    - Complex training is good for this because it alternates SSC tasks with heavy resistance exercises within the same session enhances their working effect. This causes postactivation potentiation
- **Spring-Mass Model**
    - Exposure to strength and sprint training may be linked to a rise in the preactivation of the musculature used in sprinting
    - The onset of pre-tension may be related to an increase in the sensitivity of associated muscle spindles
    - The improvement in the time needed for feedback from muscle spindles results in greater muscle stiffness and tendon compliance
    - *Spring-mass model (SMM):* mathematical model that depicts sprinting as a type of human locomotion in which the displacement of a body mass is the aftereffect from energy produced and is delivered through the collective coiling and extension of spring-like actions within muscle architecture
    - During a complete running cycle, one spring compresses and propels the sprinter;s body forward. Simultaneously, the other spring swings forward in preparation for ground contact
    - SMM and and sprinting explained
        - Compression of the spring begins at foot strike, resulting in horizontal braking forces
        - This sudden and brief deceleration assists in propelling the swing leg forward in preparation for the subsequent step
        - As the center of mass moves ahead of the foot, the sprinter is in midstance
        - Within the SMM, the spring is compressed to the lowest point, which coincides with a lowered center of mass at midstance
        - Finally, the model describes the push-off segment of the stance phase as the return of energy through the extension of the coiled spring
        - This resultant energy and return of force projects the sprinter forward
    - Because sprinting requires an athlete to move at high speeds, you should emphasize the prescription of exercises that have been shown to increase neural drive while overloading musculature of the hip and knee regions involved in the SSC
    - *Figure 19.3 SMM Model pg. 526
- **Additional Neurophysiological Considerations for Change-of-Direction and Agility Development**
    - The length of ground contact time of either an agility or a change of direction movement exceeds the typical ground contact time of both the acceleration phase

of sprinting and the maximal-velocity phase of sprinting. Most change of direction requires longer SSC activities
- Neuromuscular development with respect to high-velocity and high-force eccentric contractions should be considered
  - The adaptations or motor unit recruitment pathways called upon during eccentric contraction are different than those called upon during concentric contractions
  - The adaptations to eccentric training appear to be specific to the velocity of eccentric loading

<u>Running Speed</u> (527)

- Sprint speed can be increased by an increase in stride length or an increase in stride frequency
- The amount of vertical force applied to the ground during the stance phase may be the most critical component to improving speed. In addition, these greater forces must be applied to the ground in the shortest period possible
- Although the time required for staging the subsequent ground contact is similar between elite and novice sprinters, elite sprinters are able to propel themselves farther down the track due to properly directed vertical forces
- These vertical forces are better directed toward the track due to an optimized knee height at maximal flexion of the recovering leg
- This higher knee position provides a greater time periods for force production and subsequent ground clearance
- Sprint speed is determined by an athlete's stride length and stride rate; more successful sprinters tend to have longer stride lengths as a result of properly directed forces into the ground while also demonstrating a more frequent stride rate. These finding suggest that RFD and proper biomechanics are two of the primary limiting factors influencing sprint performance
- *Figure 19.5-19.6 stride length and rate pg. 528

- **Sprinting Technique Guidelines**
  - The stance phase can be broken down into an eccentric braking period followed by a concentric propulsive period
  - The flight phase consists of the recovery and ground preparation segments of the swing leg
- **Training Goals**
  - The following objectives should be considered during the development of speed in practical settings
    - Emphasize brief ground support times as a means of achieving rapid stride rate.
      - This is develop to consistent exposure to speed training as well as properly designing strength training
    - Emphasize the further development of the SSC as a means to increase the amplitude of impulse each step of the sprint.
      - The complete weightlifting movements and their derivatives are key exercises for overloading the SSC with forces greater than those produced during an open sprint

- ***Sprinting Technique Checklist: Start Acceleration, and Maximum Velocity pg. 530**
- ***Fundamental Movements Occuring in Maximum-Velocity Sprinting pg. 531**
- ***Table 19.1 Common Sprinting Technique Errors, Causes, and Corrections pg. 531**

Agility Performance and Change-of-Direction Ability (533)

- **Factors Affecting Change of Direction and Perceptual-Cognitive Ability**
  - Ground contact time and ground reaction force during the plant phase of a movement provide valuable insight into the physical factors that affect change-of-direction performance
  - Change-of-direction and agility movements performed at shallow cutting angles (<75) and associated with shorter ground contact times (<250ms). Vice versa
  - Once should consider increasing emphasis on eccentric strength and maximal strength alongside the concentric explosiveness required during reacceleration
  - *Table 19.2 Aspects of Agility Tested or Trained in Various Drills and Tests pg. 534
  - Change-of-Direction agility
    - The positioning of the trunk will influence the performance of the change of direction
    - It is the combination of the ability to decelerate, reorient the body to face or partially face the direction of intended travel, and then explosively reaccelerate that truly determines change-of-direction ability
    - Change-of-direction ability has been shown to improve with increased hip extension velocity, low center of mass height, increased braking impulse and propulsive impulse, increased knee flexion entering change of direction, minimized trunk angular displacement entering change of direction, and increased lateral trunk tilt
    - A well rounded approach to strength development involving dynamic, isometric, and eccentric is needed for the development of better change-of-direction performances
    - Neuromuscular requirements for braking capacity must be specifically trained using high-velocity eccentric contractions such as those during drop landings
  - Perceptual-Cognitive Agility
    - These include
      - Visual scanning, anticipation, pattern recognition, knowledge of the situation, decision-making time and accuracy, and reaction time
- **Technical Guidelines and Coaching**
  - Visual focus
    - When change-of-direction the athlete should focus on the shoulders, trunk, and hip
    - Athlete should quickly redirect attention to a new area to help lead the transition of the body
  - Body Position During Braking and Reacceleration
    - Control the trunk leading into deceleration
    - Through the stance phase, reorient the trunk and hips toward the direction of intended travel

        - Enter and exit changes in direction with a lower center of mass
    - Leg Action
        - Ensure that the athlete can endure the eccentric braking loads and avoid a stiff-legged braking style
        - Emphasize pushing the ground away
    - Arm Action
        - Powerful arm actions should be used to facilitate leg drive
- **Training Goals**
    - Goals of agility performance should include
        - Enhanced perceptual-cognitive ability
        - Effective and rapid braking the one's momentum
        - And rapid reacceleration toward the new direction of travel

<u>Methods of Developing Speed</u> (536)

- **Sprinting**
    - An athlete's sprint prowess depends on the generation of high forces in short periods of time.
    - Neurological adaptations resulting from long-term training plans that emphasize maximal strength and movement velocity improve both RFD and impulse generation
    - Weightlifting movements and jump training are prescribed to develop RFD and impulse at varying loads, as these movements use the SSC
    - Chronic exposure to movements eliciting the SSC can increase muscle stiffness, which is a potential physiological advantage for sprint ability
    - Sprinting requires maximal muscle activation, which depends on high central nervous system activity
    - *Rate coding:* when signal frequency reaches a threshold, skeletal muscle may not completely relax between stimulation
    - Incomplete muscle relaxation results in more forceful contractions and a greater RFD in subsequent contractions
- **Strength**
    - Maximal strength training may be beneficial, training should emphasize agendas that merge maximal strength and speed-strength qualities.
    - Weightlifting movements such as clean, snatch, and midthigh pulls may enhances sprint performance
    - *Table 19.3 Assistance and Resistance Training for Speed Development pg. 537
- **Mobility**
    - People rely on stretching, chiropractic care, massage, and myofascial release is an attempt to achieve optimal mobility within the dynamic state
    - If a sprinters mobility is limited, the sprinting techniques may be limited

<u>Methods of Developing Agility</u> (538)

- **Strength**
    - For agility, you should emphasize relative strength and variety of speed-strength qualities along the force-velocity spectrum
    - Training exercises can include a spectrum of load-velocity profiles in the weight room as well as activities in the field, such as squat jumps, CMJ, and drop jumps

    - *Table 19.4 Comparison of Focus For Agility Development in Novice and Advanced Athletes
- **Change-of-Direction Ability**
    - *Table 19.5 COD and Agility Drill Progressions pg. 540
- **Perceptual-Cognitive Ability**
    - First start with drills beginning with a whistle but progress to reaction, and dodging things (sport specific stuff)

Program Design (539)

    - *Periodization:* strategic manipulation of an athlete's preparedness through the employment of sequenced training phases defined by cycles and stages of workload

Speed Developmental Strategies (541)

    - Display of movement on the track is a reflection of enhanced neuromuscular factors, namely maximal strength, RFD, and impulse.
    - *application of speed development strategies pg. 541-542
- **Monitoring Sprint Ability**
    - The most common sprint test is the 40 yard dash
    - *Table 19.6 Monitoring Speed Development pg. 543

Agility Development Strategies (545)

    - Development of agility is best achieved using a periodized programming method
    - Random programming of the development of agility such as side games has not been found to be effective
    - Agility development should begin with the use of change-of-direction drills and progress in difficulty through increases in physical demands; this is followed by the addition of drills involving perceptual-cognitive stress
    - *Application of Agility Development Strategies pg. 545
    - *Sample Program of Agility Development pg. 544
- **Monitoring Agility and Change-of-Direction Ability**
    - *Table 19.7 Monitoring Ability Development pg. 546

Speed and Agility Drills (548)

- **Speed Drills**
    - A-skip
    - Fast Feet
    - Sprint Resistance
- **Agility Drills**
    - Deceleration Drill
    - Z-Drill
    - Agility Drill
- **Study Questions:** d, c, a, c, b

Chapter 20: Program Design and Technique For Aerobic Endurance Training

- **Learning Objectives**
    - Discuss the factors related to aerobic endurance performance
    - Select the mode of aerobic endurance training

- Set aerobic endurance training frequency based on training status, sport season, and recovery requirements
- Assign aerobic endurance training duration and understand its interaction with training intensity
- Assign aerobic endurance exercise intensity and understand the various methods used to monitor intensity
- Describe the various types of aerobic endurance programs
- Apply the program design variables based on the sport season
- Address the issues of cross-training, detraining, tapering, supplemental resistance training, and altitude when designing an aerobic endurance training program

Factor Related to Aerobic Endurance Performance (560)

- **Maximal Aerobic Capacity**
  - There is a high correlation between VO_2 max and performance in aerobic endurance events
  - Other factors include: high lactate threshold, good exercise economy, high efficiency in using fat of a fuel source, and a high percentage of Type 1 muscle fibers
  - Improving VO_2 max is good up to a certain point. Then the ability to sustain higher velocities during competition and training may have a greater impact on performance than attempting to make marginal improvements in aerobic capacity
- **Lactate Threshold**
  - The speed of movement or percentage of VO_2 max at which a specific blood lactate concentration is observed or the point at which blood lactate concentration begins to increase above resting levels
  - *Maximal Lactate Steady State:* exercises intensity at which maximal lactate production is equal to maximal lactate steady state is considered to be a better indicator of aerobic performance
- **Exercise Economy**
  - A measure of the energy cost of activity at a given exercise velocity
  - Athletes with a high exercises economy expend less energy during exercise to maintain a given exercise velocity
  - Improvement in exercise economy can enhance maximal aerobic capacity and lactate threshold

Designing an Aerobic Endurance Program (561)

- **Step 1: Exercise Mode**
  - Mode refers to the specific activity performed by the athlete
  - Selecting the appropriate exercise mode during training ensured that the systems used in competition are challenged to improve
- **Step 2: Training Frequency**
  - Refers to the number of training sessions per day or per week
  - Studies have shown increased injury rates with training sessions more frequent than 5x per week
  - It is necessary to train more than 2x per week in order to increase VO_2 max
  - Recovery from individual training sessions is essential if the athlete is to derive maximum benefits from the subsequent training session

- **Step 3: Training Intensity**
    - High intensity aerobic exercise increases cardiovascular and respiratory function and allows for improved delivery to the working muscles
    - It also affects muscle fiber recruitment by greater recruitment of Type II muscle fibers
    - Heart Rate
        - *Heart Rate Reserve:* difference between an athlete's maximal heart rate and his or her resting heart rate
        - *Table 20.1 Relationship between VO_2 max, heart rate reserve, and percentage of maximal heart rate pg. 563
    - Rating of Perceived Exertion Scales
        - Regulate intensity during aerobic endurance training
        - *Target Heart rate Calculations pg. 564
        - *Table 20.2 RPE Scale pg. 564
    - Metabolic Equivalents
        - 3.5 ml/kg/min of oxygen consumption and is considered the amount of oxygen required by the body at rest
        - AN activity with a MET of 10 requires 10 times the oxygen uptake that is required by an individual at rest
        - *Table 20.3 MET for Physical Activities pg. 565
- **Step 4: Exercise Duration**
    - The duration of a training session is often influenced by the exercise intensity; the longer the exercise duration, the lower the exercise intensity
- **Step 5: Exercise Progression**
    - aerobic fitness does not decrease for up to 5 weeks when intensity of training is maintained and frequency decreases to as few as two times per week
    - Always include at least one recovery or active rest day in each week of training
    - Exercise frequency, intensity, or duration should not increase more than 10% each week
    - *Examples of Aerobic Exercise Progression pg. 567

<u>Types of Aerobic Endurance Training Programs</u> (567)

- ***Table 20.4 Types of Aerobic Endurance Training pg. 567**
- **Low, Slow Distance Training**
    - Training at intensities equivalent to approximately 70% of VO_2 max
    - Slow refers to a pace slower than typical race pace
    - Benefits include enhanced cardiovascular and thermoregulatory function, improved mitochondrial energy production and oxidative capacity of skeletal muscle, and increase utilization of fat as fuel
    - These changes are likely to improve the lactate threshold intensity by enhancing the body’s ability to clear lactate
    - *Sample training program pg. 569
- **Pace/Tempo Training**
    - An intensity at or slightly higher than race competition intensity
    - Two ways to conduct pace/tempo training: steady and intermittent
    - *sample training program pg. 569

- **Interval Training**
  - Intensities close to VO_2 max
  - Work intervals should last between 3-5 minutes
  - *Sample program pg. 569
- **High-Intensity Interval Training**
  - Uses repeated high-intensity exercise bouts interspersed with brief recovery periods
  - Optimal stimulus is to spend several minutes within the HIIT session above 90% VO_2 max
  - Good for improving running and speed economy
  - *Sample Program pg. 570
- **Fartlek Training**
  - Combination of several of the previously mentioned types of training
  - *Sample program pg 570

<u>Application of Program Design To Training Seasons</u> (570)

- **Off-Season (Base Training)**
  - The priority is to develop a base of cardiorespiratory fitness
  - Initially workouts should consist of long-duration and low-intensity workouts
  - Increase in training duration should be no more than 5-10% per week
  - Increasing the training duration too much can actually lead to decreases in aerobic endurance performance
- **Preseason**
  - Athlete should focus on increases intensity, maintaining or reducing duration, and incorporating all types of training into the program
- **In-Season (Competition)**
  - Low-intensity and short-duration training days should precede scheduled competitions so that the athlete is fully recovered and rested
- **Postseason (Active Rest)**
  - The main focus should be on recovering from the previous competitive season
  - Low duration and intensity are typical for this active rest phase, but enough overall exercise or activity should be performed to maintain sufficient level of cardiorespiratory fitness, muscular strength, and lean body mass
- ***Table 20.5 Sport Season Objectives and Program Design Assignments**

<u>Special Issues Related to Aerobic Endurance Training</u> (571)

- **Cross-Training**
  - Mode of training that can be used to maintain general conditioning in athletes during periods of reduced training due to injury or during recovery from a training cycle
- **Detraining**
  - When an athlete reduces the training duration or intensity or stops training altogether due to the break in the training program, injury, or illness\
- **Tapering**
  - Systematic reduction of training duration and intensity, combined with an increased emphasis on technique work and nutritional intervention
  - Typical period is 7-28 days

- Tapering before competition helps facilitate recovery and rehydration and promotes increases in muscle and liver glycogen stores
- **Resistance Training**
  - For aerobic athletes this can help with faster recovery from injuries, prevention of overuse injuries, and reduction of muscle imbalances
- **Aerobic Endurance Training Exercises**
  - Treadmill
  - Stationary Bike
  - Rowing Machine
  - Stair Stepper
  - Elliptical Trainer
  - Walking Gait
  - Running Gait
- **Study Questions:** c, a, b, c, d

Chapter 21: Periodization

- **Learning Objectives**
  - Understand the central concepts that underpin the periodization of training
  - Appreciate the value, role, and application of periodization in strength and conditioning programs
  - Describe the four periods of the traditional periodization model
  - Describe the two phases of preparatory period of the traditional periodization model
  - Relate the four sport seasons to the four periods of the traditional periodization model
  - Apply the program design variable to create a periodized strength training program
- **Introduction**
  - As athletes become more trained or have a greater training age, it becomes more difficult to stimulate performance gains
  - *Periodization:* a theoretical and practical construct that allows for the systematic, sequential, and mutually dependent periods of time in order to induce specific physiological adaptations that underpin performance outcomes
  - This overall schedule of training encompasses all aspects of the athlete's training program

<u>Central Concepts Related to Periodization</u> (584)

  - Peak performance can be optimized only for short periods of time, and the average time it can be maintained is inversely related to the average intensity of the training plan
- **General Adaptation Syndrome**
  - Three stage response to stress: alarm, resistance, and exhaustion
  - Alarm phase
    - Any time the body experiences new or more intense stress, which can lead to fatigue, soreness, or reduction in energy stores
  - Resistance phase
    - Adapts to the stimulus and returns to normal functional capacity

        - If training is appropriate, adaptive responses can result in biochemical, structural, and mechanical adjustments that further elevate the athlete's performance capacity
    - Exhaustion Phase
        - The athlete is demonstrating an inability to adapt to the imposed stressors and will present some of the same symptoms noted in the alarm phase
    - *Figure 21.1 General Adaptation Syndrome pg. 585
- **Stimulus-Fatigue-Recovery-Adaptation Theory**
    - The greater the overall magnitude of the workload encountered, the more fatigue accumulates and the longer the delay before complete recovery and adaptation can occur.
    - As the athlete recovers from and adapts to the training stimuli, fatigue will dissipate, and preparedness and performance increases
    - It is not necessary to reach a state of complete recovery before engaging in a new bout or session of training
    - *Figure 21.2 pg. 586
- **Fitness-Fatigue Paradigm**
    - Every training bout, session, or cycle creates a state of preparedness
    - Fatigue dissipates at a faster rate than fitness, thus allowing preparedness to become elevated if appropriate training strategies are used to retain fitness while reducing fatigue

Periodization Hierarchy (587)

- The multiyear training plan covers the most time but is the least detailed plan within a periodized training structure
- Multiyear training structure is then subdivided into more detailed individual annual training plans that are developed based on the athlete's progression through the various stages
- Macrocycles last several months up to a year
- Mesocycles last several weeks to months (2-6 weeks is normal)
- Microcycles last from several days to weeks (1 week is normal)
- *Table 21.1 Periodization cycles pg. 587

Periodization Periods (588)

- The volume and intensity receive the greatest attention
- Training plans systematically shift training foci from general nonspecific activities of high volume and low intensity toward activities of lower volume and higher intensities over a period of many weeks or months to help reduce the potential for overtraining while optimizing performance capacities
- *Figure 21.4 periodization model pg. 588
- *Table 21.2 Periodization Model For Resistance Training pg. 590
- **Preparatory Period**
    - Starting point
    - This period occurs when there are no competitions, and technical, tectical, or sport-specific work is limited
    - The goal of this is to develop a base level of conditioning in order to increase the athlete's ability to tolerate more intense training

- Conditioning activities would begin with relatively low intensities and high volumes: long, slow distance running or swimming; low-intensity plyometrics; and high-rep resistance training with light to moderate resistances
- *General Preparatory Phase:* occurs during the early part of the period and often targets development of a general base.
  - Include high-volumes, low training intensities, and later variety of training means that are structured to develop general motor abilities and skills
- *Specific Preparatory Phase:* occurs after completion of general preparatory phase and involves a shift in training focus.
  - This phase expands the athlete's training base through an increased emphasis on sport-specific training activities that prepare the athlete for the competitive period
- During this period, resistance training phases can be created in order to depict more refined differences in training intensity and volume. In this order: hypertrophy/strength endurance and basic strength phases
- Hypertrophy/Strength Endurance Phase
  - Occurs during the early portion of the preparatory period
  - During this phase the training intensity is low to moderate and the overall volume is high
  - The primary goals include to increase lean body mass, to develop an endurance base, or to do both
  - With strength/power athletes, the primary target might be to stimulate hypertrophic effects while increasing strength endurance
  - With endurance athletes, the primary goal would be to increase strength endurance without significantly increasing hypertrophy
  - Recovery weeks may be placed throughout this phase and most often at the end of the phase before the next phase of training begins
  - The hypertrophy/strength endurance phase involves low to moderate intensity (50-75% of 1RM) and high volumes (3-6 sets of 8-20 reps)
- Basic Strength Phase
  - The later portion of the preparatory period, the primary aim of basic strength is to increase strength of muscles that are essential to the primary sport movements
  - This phase involves higher intensity (80-95% of 1RM) and moderate to high volumes (2-6 sets of 2-6 reps)

- **First Transition Period**
  - Link between preparatory and competitive periods
  - Resistance training in this period focused on development of strength and power
  - There are variations in training intensity and workload at the microcycle level
  - The last week of the period is marked by reduced volume, intensity, or both in order to achieve recovery before the beginning of the competition period
  - Strength/Power Phase
    - In order to address both strength and power development, a mixed training approach is warranted in which heavy and low load training is used to optimize both attributes

        - This phase involves low to very high loads (30-95% of 1RM) and low volumes (2-5 sets for 2-5 reps)
    - **Competitive Period**
        - Target is to prepare the athlete for competition by increasing strength and power via additional increases in training intensity while decreasing volume
        - Peaking programs attempt to place the athlete in peak condition for about one to two weeks. Used for sprinters leading up to an event.
        - Team sports use a maintenance program
            - Because of the prolonged duration of the competitive period in this situation, the intensity and volume of training must be manipulated on a microcycle basis in order to maintain strength and power while managing fatigue associated with a frequent-competition schedule
        - Peaking performance
            - Use very high to low intensities (50% to >93% of 1RM) and very low volume (1-3 sets of 1-3 reps) for 1-2 weeks
        - Maintenance performance
            - Moderate and high intensities (85-93% of 1RM) with moderate volumes (2-5 sets of 3-6 reps)
    - **Second Transition Period (Active Rest)**
        - Lasts 1-4 weeks
        - If active rest is extended for a prolonged duration, athletes will require a much longer preparatory period in order to regain their performance capacities
        - Secondary use of active rest concept is to structure 1 week breaks between long phases (3 weeks) or periods of training.
        - This is to reduce overtraining potential.
        - This periods is when athletes can rehab injuries and refresh physically and mentally before beginning a new annual training

<u>Applying Sport Seasons To The Periodization Periods </u>(592)

- **Off-Season**
    - Should be considered the preparatory period
    - The general and specific preparatory cycles are broken down into mesocycles
- **In-Season**
    - Structure 3-4 week mesocycle blocks that unload the athlete in the last macrocycle in order to allow for fatigue reduction and performance supercompensation before critical contests
- **Post Season**
    - This is time for active rest
    - The longer the postseason, the greater chance for detraining, which results in an increased need for a longer general preparatory phase during the next off-season
- ***Figure 21.5 Periodization Periods pg. 592**

<u>Undulating Vs Linear Periodization Models</u> (593)

    - A central tenet of periodization is the removal of linearity from training

- *Daily Undulating Periodization (Nonlinear):* involves large daily fluctuations in the load and volume of assigned core resistance training exercises
    - For example:
        - Monday: 4 sets with 6RM load (strength)
        - Wednesday: 3 sets with 10RM load (hypertrophy)
        - Friday: 5 sets with 3RM load (power)
    - The absence of accumulated neural fatigue caused by extended, ever-increasing training intensities
    - Overall high volume-loads of training result in greater peripheral fatigue and increased risk of injury because of the high level of metabolic fatigue
    - Has the potential to decrease athlete preparedness because of accumulated fatigue that occurs with higher volume-load training sessions
- *Linear Periodization:* athlete performs the same number of sets and reps across training days and varies the training load
    - For Example:
        - Monday: 4x6 at 85% of 1RM
        - Wednesday: 75% of 1RM
        - Friday: 65% of 1RM

- ***Example of an Annual Training Plan pg. 593**
- ***Example Offseason Program pg. 598**
- **Study Questions:** b, c, c, b, a

Chapter 22: Rehabilitation and Reconditioning

- **Learning Objectives**
    - Identify the members of the sports medicine team and their responsibilities during the rehabilitation and reconditioning of injured athletes
    - Recognize the types of injuries athletes sustain
    - Comprehend the timing and events of tissue healing
    - Understand the goals of each tissue healing phase
    - Describe the role of the strength and conditioning profession during injury rehabilitation and reconditioning

<u>Sports Medicine Team</u> (606)

- **Communication**
    - *Indication:* form of treatment required by the rehabilitating athlete
    - *Contraindication:* activity or practice that is inadvisable or prohibited due to the given injury
- **Principles of Rehabilitation and Reconditioning**
    - Healing tissues must not be overstressed
    - The athlete must fulfill specific criteria to progress from one phase to another
    - The rehabilitation program must be based on current clinical and scientific research
    - The program must be adaptable to each individual and his or her specific requirements and goals

- Rehabilitation is a team-oriented process requiring all the members of the sports medicine team to work together toward a common goal of returning the athlete to unrestricted competition as quickly and safely as possible

Types of Injury (608)

- *Macrotrauma:* specific, sudden episode of overload injury to a given tissue, resulting in disrupted tissue integrity
- *Dislocation:* complete displacement of the joint surfaces
- *Subluxation:* partial displacement of the joint surfaces
- *Sprain:* ligament trauma
    - 1st degree: partial tear of ligament without increased joint instability
    - 2nd degree: partial tear with minor joint instability
    - 3rd degree: complete tear with full joint instability
- *Contusion:* musculotendinous trauma (direct). An area of excess accumulation of blood and fluid in the tissues surrounding the injured muscle
- *Strains:* tears of muscle fibers
    - 1st degree: partial tear of individual fibers, strong but painful activity
    - 2nd degree: partial tear with weak, painful muscle activity
    - 3rd degree: complete tear of muscle fibers, very weak painless muscle activity
- *Microtrauma:* overuse injury, results from repeated, abnormal stress applied to a tissue by continuous training or training with little recovery time
- *Tendinitis:* inflammation of tendon, and if cause of the inflammation is left uncorrected, chronic tendinitis or tendinopathy may develop.
- *Tendinopathy:* degenerative condition characterized by minimal inflammation and neovascularization

Tissue Healing (610)

- *Table 22.1 Tissue Healing pg. 610

- **Inflammatory Response Phase**
    - Inflammation is necessary in order for normal tissue healing to occur
    - The injured area becomes red and swollen due to changes in vascularity, blood flow, and capillary permeability
    - *Edema:* inhibits contractile tissues and can significantly limit function
    - Tissue debris and pathogens are removed from the injured area by increased blood flow and a process called phagocytosis
    - This phase lasts 2-3 days following an acute injury
- **Fibroblastic Repair Phase**
    - In this phase tissue repair begins
    - This is characterized by catabolism and replacement of tissues that are no longer viable following injury
    - New capillaries and connective tissue (scar tissue) form in the area
    - Type III collagen is randomly deposited along the injured structure and serves as a framework for tissue regeneration. This new tissue is weaker than the original tissue

- Collagen fibers are strongest when they are positioned longitudinally to the primary line of stress, yet many of the new fibers are positioned transversely, which limits their ability to efficiently transmit force
- This phase may begin as early as 2 days and last up to 2 months

- **Maturation-Remodeling Phase**
  - Weakened tissue strengthens in this phase
  - Production of collagen fibers has shifted to a stronger Type I collagen, allowing the newly formed tissue the opportunity to improve its structure, strength, and function
  - With increased loading, the collagen fibers of the newly formed scar tissue begin to hypertrophy and align themselves along the lines of stress
  - This phase can last from months to years after injury

Goals Of Rehabilitation and Reconditioning (611)

- Healing tissue must not be overstressed
- Controlled therapeutic stress is necessary to optimize collagen matrix formation, but too much stress can damage new structures and significantly slow the athlete's return to competition
- The athlete must meet specific objectives to progress from one phase of healing to the next
- *Figure 22.3 Tissue Healing pg. 613

- **Inflammatory Response Phase**
  - Treatment goal
    - Primary goal is to prevent disruption of new tissue
    - A healthy environment for new tissue regeneration and formation is essential for preventing prolonged inflammation and disruption of new blood vessels and collagen production, which can prolong injury
    - Ice, compression, elevation, and electrical stimulation are often primary treatment options to minimize tissue damage and decrease acute pain
    - It is also important to realize that a quick return to function relies on the health of other body tissues
    - Power, strength, and endurance of the musculoskeletal tissues and function of the cardiorespiratory system must be maintained
  - Exercise Strategies
    - Exercise directly involving or stressing the injured area is not recommended during this phase
- **Fibroblastic Repair Phase**
  - Treatment goal
    - Goal is to prevent muscular atrophy and joint deterioration of the injured area
    - Precarious balance must be maintained in which disruption of the newly formed collagen fibers is avoided but low-load stresses are gradually introduced to allow increased collagen synthesis and prevent loss of joint motion
    - Avoid active resistance involving the damaged tissue

- Too little activity can also have a deleterious effect, as newly formed fibers will not optimally align and may form adhesions, thereby preventing full motion
- Ultrasound, electrical stimulation, and ice are continued in order to support and hasten new tissue

- Exercise Strategies
  - Isometric exercise may be performed
  - This allows the athlete to maintain neuromuscular function and improve strength with movements performed at an intensity low enough that the newly formed collagen fibers are not disrupted
  - *Neuromuscular control:* ability of muscles to respond to afferent sensory information to maintain joint stability
  - *Proprioception:* afferent sensory information and occurs in response to stimulation of sensory receptors in skin, muscles, tendons, ligaments, and the joint capsule

- **Maturation-Remodeling Phase**
  - Treatment goal
    - The primary goal is to optimize tissue function while transitioning to return to play or activity
    - Athletes improve function by progressing in the exercises used in the repair phase
    - Progressive tissue loading allows improved collagen fiber alignment and fiber hypertrophy
    - Return to play decisions should be based on measures of motion and strength, functional testing, and patient-reported function
  - Exercise Strategies
    - Exercises must be functional and must mimic activity demands
    - Examples include: joint angle-specific strengthening, velocity-specific muscle activity, closed kinetic chain exercises, and exercises designed to further enhance neuromuscular control
    - Strengthening exercises performed during rehabilitation should also mimic sport speed requirements
    - *Closed Kinetic Chain:* the terminal joint meets with considerable resistance that prohibits or restrains its free motion. Distal joint segment is stationary
      - Increase joint stability and functional movement patterns,
      - Squat or pushup
    - *Open Kinetic Chain:* uses a combination of successively arranged joints in which the terminal joint is free to move. Allow for greater isolation on an isolated joint or muscle
      - Viewed as more functional
      - Knee extension
- ***Rehabilitation and Reconditioning Goals and Strategies pg. 616**

Program Design (616)

- **Resistance Training**

    - *Daily Adjustable Progressive Resistive Exercise (DAPRE):* requires and allows more manipulation of intensity and volume.
        - *Table 22.2 DAPRE protocol pg. 617
- **Aerobic and Anaerobic Training**
    - Program should mimic specific sport and metabolic demands as closely as possible
    - Exercises targeting the uninvolved limb can improve muscle strength in the involved limb
- ***Design Principles for Resistance Training Programs During Rehabilitation and Reconditioning From Patellofemoral Injury pg. 618**

Reducing Risk Of Injury and Reinjury (618)

    - Previous injury is one of the most substantial risk factors for future injury in active individuals
    - Risk factors for upper extremity injury include decreased glenohumeral range of motion, scapular dyskinesis, and decreased shoulder strength
        - Range of motion exercise and Throwers Ten are often used as a structured program to reduce upper extremity injury risk
    - Risk factors for lower extremity injury include decreased balance, decreased neuromuscular control during jump landing, and decreased lower extremity muscle strength
        - Programs to reduce injury should should eb sport specific and should focus on neuromuscular control during activities such as landing from a jump and cutting
        - Figure 22.8 pg 619
    - Structured programs designed to reduce injury risk are sportsmetrics and PEP (prevent injury and enhance performance)
    - Eccentric exercise has been shown to dramatically reduce risk of hamstring injury
    - Side-to-side differences in strength and functional performance less than 10% may be considered acceptable
- **Study Questions:** c, b, b, a, d

Chapter 23: Facility Design, Layout, and Organization

- **Learning Objectives**
    - Identify the aspects of new facility design, including the four phases
    - Identify the aspects of modification of an existing facility, along with the differences between design of a new facility and modification or renovation of an existing facility
    - Explain how to assess an athletic programs needs in order to design a facility that is well suited to these needs
    - Explain how to design specific facility features, including supervision location, access, ceiling height, flooring, environmental factors, electrical service, and mirrors
    - Explain how to arrange equipment in organized groups, creating better traffic flow throughout the facility

- Explain the maintenance and cleaning needs for the surfaces and equipment in a strength and conditioning facility
- **Study Questions:** d, a, c, d, c

Chapter 24: Facility Policies, Procedures, and Legal Issues

- **Learning Objectives**
    - Develop or clarify the goals and objectives of a strength and conditioning program
    - Understand the daily operational practices of a strength and conditioning program and facility that help to achieve the goals and objectives
    - Establish a standard practice that leads to safe and effective strength and conditioning program
    - Identifiy common areas of potential liability exposure and implement appropriate risk management strategies
    - Create policies and procedures manual for a strenth and conditioning program and facility
    - Properly schedule the strength and conditioning facility, along with formulating guidelines on seasonal planning and staff-to-athlete ratios
- **Study Questions:** c, c, d, c, a