McCance: Pathophysiology, 6th Edition

Chapter 41: Structure and Function of the Musculoskeletal System

Key Points – Print

SUMMARY REVIEW

Structure and Function of Bones

1. Bones provide support and protection for the body's tissues and organs and are important sources of minerals and blood cells.
2. Bone formation begins in utero with the differentiation of mesenchymal cells into either chondrocytes or osteoblasts. Bone minerals then either crystallize on a cartilage framework or become bone-forming cells without cartilage.
3. Bone tissue is continuously being resorbed and synthesized by bone-remodeling units of osteoclasts and osteoblasts.
4. RANKL induces osteoclast activation and bone resorption. OPG, a protein, binds to a protein called OPG ligand. This attachment serves as a decoy receptor for RANKL and blocks osteoclast activity, thus decreasing bone resorption. The balance between RANKL and OPG determines the quality of bone.
5. Bones in the body are made up of compact bone tissue and spongy bone tissue. Compact bone is highly organized into haversian systems that consist of concentric layers of crystallized matrix surrounding a central canal that contains blood vessels and nerves. Dispersed throughout the concentric layers of crystallized matrix are small spaces containing osteocytes. Smaller canals, called *canaliculi*, interconnect the osteocyte-containing spaces. The crystallized matrix in spongy bone is arranged in bars or plates. Spaces containing osteocytes are dispersed between the bars or plates and interconnected by canaliculi.
6. BMPs are part of the TGF-β superfamily and involved in nearly all aspects of bone formation.
7. There are 206 bones in the body, divided into the axial skeleton and the appendicular skeleton. Bones are classified by shape as long, short, flat, or irregular. Long bones have a broad end (epiphysis), broad neck (metaphysis), and narrow midportion (diaphysis) that contains the medullary cavity.
8. Bone injuries are repaired in stages. Hematoma formation provides the fibrin framework for formation and organization of granulation tissue. The granulation tissue provides a cartilage model for the formation and crystallization of bone matrix. Remodeling restores the original shape and size to the injured bone.

Structure and Function of Joints

1. A joint is where two or more bones attach. Joints provide stability and mobility to the skeleton.

2. Joints are classified as synarthroses, amphiarthroses, or diarthroses, depending on the degree of movement they allow. Joints are classified also by the type of connecting tissue holding them together. Fibrous joints are connected by dense fibrous tissue, ligaments, or membranes. Cartilaginous joints are connected by fibrocartilage or hyaline cartilage. Synovial joints are connected by a fibrous joint capsule. Within the capsule is a small fluid-filled space. The fluid in the space nourishes the articular cartilage that covers the ends of the bones meeting in the synovial joint.
3. Articular cartilage is a highly organized system of collagen fibers and proteoglycans. The fibers firmly anchor the cartilage to the bone, and the proteoglycans control the loss of fluid from the cartilage.
4. Joints help move bones and muscle.

Structure and Function of Skeletal Muscles

1. Skeletal muscle is the largest organ in the body and is made up of millions of individual fibers.
2. Whole muscles vary in size (2 to 60 cm) and shape (fusiform and pennate). They are encased in a three-part connective tissue framework. The fundamental concept of muscle function is the *motor unit,* defined as all muscle fibers innervated by a single motor nerve.
3. Muscle fibers contain bundles of myofibrils arranged in parallel along the longitudinal axis and include the muscle membrane, myofibrils, sarcotubular system, aqueous sarcoplasm, and mitochondria. There are two types of muscle fibers, type I and type II, determined by motor nerve innervation.
4. Myofibrils and myofilaments contain the major muscle proteins, actin and myosin, which interact to form cross-bridges during muscle contraction. The nonprotein muscle constituents provide an energy source for contraction and regulate protein synthesis, enzyme systems, and membrane stabilization.
5. Muscle contraction includes excitation, coupling, contraction, and relaxation.
6. Muscle strength is graded by the “all or nothing” phenomenon and recruitment. Speed of contraction is affected by several factors: muscle fiber type, temperature, stretch, and weight of the load.
7. The two types of muscle contraction are isometric and isotonic. Muscle shortening occurs during contraction but can be seen also during pathologic and physiologic contracture.
8. Actin and myosin filaments form cross-bridges that cause the sarcomere to shorten, a process now known as the *cross-bridge theory of muscle contraction.*
9. Skeletal muscle requires a constant supply of ATP and phosphocreatine to fuel muscle contraction and for growth and repair. ATP and phosphocreatine can be generated aerobically or anaerobically. Phosphocreatine concentration is an extremely sensitive indicator of muscle fiber activity.

10. Several factors determine how force is transmitted from the actin-myosin cross-bridges on individual muscle fibers to accomplish whole-muscle contraction. When a motor unit responds to a single nerve stimulus, it develops a phasic contraction. The central nervous system smoothly grades the force generated by "recruiting" additional motor units and varying the discharge frequency of each active motor unit.

Tests of Musculoskeletal Function

1. Various diagnostic procedures are used to evaluate bone function, including gait analysis, serum calcium and phosphorus, x-ray films, angiography, bone scanning, and MRI.
2. Procedures used to evaluate joint function include arthrography, arthroscopy, MRI, and synovial fluid analysis.
3. Tests of muscular function include physical examination, serum creatine kinase, myoglobin, electromyogram, muscle biopsy, myometers, and the forearm ischemic exercise test.
4. Genetic evaluation is useful in detecting, diagnosing, and developing specific treatment for certain inheritable muscle diseases such as muscular dystrophy.

Aging and the Musculoskeletal System

1. Muscle bulk and strength slowly decline with aging, although not to a pathologic degree. The bone remodeling cycle takes longer to complete, and the rate of mineralization slows down.
2. Exercise in older adults does little to increase bone mineral density, but exercise has been shown to improve balance, coordination, muscle strength, lean body mass, and mobility.
3. Age-related loss in skeletal muscle is referred to sarcopenia. Loss of satellite cells appears to play a major role in the development of sarcopenia.