The Skeletal System

- Functions of the bones:
  - Forming skeletal support
  - Act as levers for movement
  - Basis for muscle attachment
  - Protect vital organs
    - Cranial and thoracic cavity
  - Storage of nutrients + production of red blood cells

- Components of the skeletal system:
  - Skull
  - Vertebral column
  - Thorax
  - Pelvis
  - Upper and lower extremity bones

Vertebral Column and Thorax

- Vertebral column
  - Stack of vertebrae protecting the spinal cord
    - Cervical (C1-C7)
    - Thoracic (T1-T12)
    - Lumbar (L1-L5)
    - Sacral (S1-S5)

- Thorax
  - Sternum
  - Ribs
Abnormal Spine Curvatures

• **Scoliosis**
  – Lateral bending
  – May lead to compression of the spinal cord

• **Kyphosis** (hunchback)
  – Excessive curvature with backward convexity

• **Lordosis**
  – Anterior convexity, normally in lumbar area

Pelvis - Abnormal Positions

• Pelvis affects the posture of the rest of the body

• Abnormal pelvis positions:
  – **Anterior/posterior pelvic tilt**
    • Resulting in sacral sitting
  – **Pelvic obliquity**
  – **Pelvic rotation**
Common Pathologies of the Bone

• Fractures
• Amputations
  – E.g. of toes or foot due to diabetes
• Congenital/acquired deformities
• Osteoporis
  – Common in elderly and persons who do not weightbear regularly through joints (e.g. because bedridden)
• Heterotopic ossification
  – Most common in individuals who have an injury, such as spinal cord injury, that results in neurologic deficits

Articulatory System

• Joints (articulations)
  – Junction between two or more bones
  – Connected by fibrous tissue, cartilage, or synovial fluid
• Classification of joints:
  – If not moving (e.g., skull): synarthrosis
  – Limited movement (e.g., vertebrae): amphiarthrosis
  – Freely moving: diathrosis
Articulatory System

• Type of movements:
  – Flexion
    • E.g. bending the forearm towards the arm
  – Extension
    • The opposite of flexion
  – Abduction
    • Movement of a body part away from the body midline
  – Adduction
    • Movement of a body part towards the body midline
  – Rotation
  – Supination
    • Rotation of the forearm so that the palm faces up
  – Pronation
    • Rotation of the forearm so that the palm faces down
  – Circumduction
    • E.g. swinging the arm in a circle

Articulatory System

• Range of motion (ROM)
  – The range through which a joint can be moved, usually its range of flexion and extension
  – Passive
    • When movement provided by force outside the individual
  – Active
    • When the individual moves the joint on his/her own

• Clinicians use a goniometer to read angles and determine whether passive/active ROM are “within normal limits”
Articulatory System

- Common joint impairments/pathologies:
  - Swelling (edema), inflammation
  - Subluxation or dislocation (loss of alignment)
  - Joint replacement (*arthroplasty*)
  - Contractures (shortening of soft tissue)
    - E.g. due to burns or compression of nerves and blood vessels (*compartment syndrome*) giving ischemic contrapuration
  - Arthritis
    - Leading cause of disability in people above 55
    - Osteoarthritis (degenerative joint syndrome)
    - Reumathoid and psoriatic arthritis
      - Both autoimmune diseases
    - Septic arthritis
      - Caused by joint infection
    - Gouty arthritis

(Skeletal) Muscles

- Functions:
  - Perform voluntary movement
  - Contract or relax
  - Act on bone to create working lever
- Controlled motion contraction:
  - Brain sends message down spinal cord
  - Motor message travels on *afferent* nerve
  - Muscle contracts
    - Stimulates stretch receptors
  - Sensory message travels on *afferent* nerve
  - Message travels on spinal cord up to the brain
- Two types of contractions:
  - *Isometric* contraction (length does not change)
  - *Isotonic* contraction (joint motion, muscle contracts)
(Skeletal) Muscles

- Muscle at rest are never completely relaxed
  - At rest: **muscle tone**
    - High enough to resist gravity, low enough to move
- Abnormal muscle tone
  - **Hypotonia** (decreased muscle tone, flaccidity)
    - Due to damage in central nervous system
    - Atrophy
      - of denervation (when a nerve to a muscle is cut)
      - of disuse (due to immobility or inactivity of a body part)
  - **Hypertonicity** (Increased muscle tone)
    - Patterns of flexion or extension
      - Typical in stroke, cerebral palsy, spinal cord injury, traumatic brain injury, multiple sclerosis
  - **Rigidity**
    - Both agonist and antagonist muscles contract steadily
      - Typical in Parkinson’s, encephalitis, brain tumors, some degenerative diseases

Nervous System

- Anatomical subdivision:
  - Central nervous system (CNS)
  - Peripheral nervous system (PNS)
- Functional subdivision:
  - Somatic nervous system
    - Coordinates activities under conscious control or sensation
  - Autonomic nervous system
    - Activities without conscious control or sensation
- Nerves are responsible for:
  - Carrying sensory information from receptors to CNS
    - Sensory neurons
  - Carrying motor information from CNS to effectors
    - Motor neurons
Central Nervous System

- Composed of **brain** and **spinal cord**
- **Brain**
  - Consists of cerebrum, cerebellum, brain stem
  - If an area is damaged (e.g., traumatic brain injury) or the blood supply is interrupted (e.g., cerebral vascular accident or stroke), the related function is lost
    - Sometimes other brain areas can take over those functions
- **Spinal cord**
  - Column of nerves continuous with brain stem ending at upper border of second lumbar vertebrae
  - Spinal cord injury (SCI) causes partial or complete interruption in the transmission of nerve signals
    - Level of injury determines function and movements compromised

Peripheral Nervous System

- Nerves in the peripheral nervous systems are of two types: **cranial** and **spinal**
- **Cranial nerves** (attached to brain)
  - Do not use spinal cord for connection
    - Hence, unaffected by spinal cord injuries
  - Mostly serve motor and sensory system of head and neck regions
    - Except for X (**Vagus nerve**) and XI
    - These provide parasympathetic fibers to thoracic and abdominal viscera
Peripheral Nervous System

- **Spinal nerves** (attached to spinal cord)
  - Exit in between vertebrae
  - Branch out and become several nerves as they reach to the ends of the limbs
  - Carry two types of nerves:
    - Sensory nerves keep the body in touch with the outside world
    - Motor nerves control interaction with outside world

Spinal Cord Injuries

- 10,000 new cases each year in the US
  - Currently about 450,000 in the US
  - Most expensive condition among all causes for hospitalization
  - Due to:
    - Trauma
    - Tumor
    - Ischemia
    - Developmental/neurodegenerative diseases
- May be complete or incomplete
  - Complete: no function (sensation or voluntary movement) below the level of injury
  - Incomplete: some functioning remaining
Spinal Cord Injuries

• For complete spinal cord injuries:
  – Cervical injuries: quadriplegia
    • Above C4: requires ventilator for breathing
    • C5: Shoulder and biceps control (not wrist or hand)
    • C6: Wrist control but not fingers
    • C7 and T1: can straighten arm but dexterity problems
  – Thoracic: paraplegia
    • T1-T8: poor trunk control (no abdominal muscle control)
    • T9-T12: good trunk + abdominal muscle control, good sitting
    • Lumbar and sacral: decreasing control of hip flexors and legs

Autonomic Nervous System

• Also called visceral nervous system
• Branches of certain peripheral nerves (both cranial and spinal) that connect to:
  – Organs in thorax, abdomen, and pelvis
  – Most of blood vessels and glands
• Controls internal environment (maintaining homeostasis), mostly without conscious control or sensation
  – Controls breathing, heart rate, perspiring, temperature, salivation, diameter of pupil
• Divided into:
  – Sympathetic (responds to impending danger or stress)
    • E.g. increases heartbeat/blood pressure
  – Parasympathetic (when one is resting and relaxed)
    • E.g. constriction of pupil, slowing of heart
  – Enteric
    • Manages digestion
ANS and Spinal Cord Injury

- Part of the autonomic nervous system of a person with spinal cord injury may be compromised
- Consequences:
  - Poor regulation of temperature because vascular tone disturbed and perspiration weak or absent
    - Need to manually control the environment temperature
  - Bladder and colon may contract or relax
    - Causing retention or voiding
  - Autonomic dysreflexia (blood pressure rises w/o control)
    - Typically for injuries at T5 or above
    - Hyperactivity of autonomic system
      - Irritating stimulus in body below cord injury sends impulses to spinal cord which are blocked by injury and cannot make it to central nervous system activating reflex that increases activity of sympathetic autonomic nervous system
    - If not controlled, may lead to stroke

Abnormalities of Coordination

- **Ataxia**
  - Unsteadiness, incoordination, clumsiness of movement
    - Results in activity that is jerky, halting and imprecise rather than smoothly coordinated

- **Dysmetria**
  - Inability to estimate the range of movement needed to reach the target of movement
    - Overshooting or undershooting the intended position with hand, arm, leg, or eye

- **Tremor** (Involuntary shaking)
  - Intention tremor: during voluntary movement
    - Common in MS, Parkinson’s
  - Resting tremor: in the absence of voluntary movement
  - Pill-rolling tremor
**Abnormalities of Coordination**

- **Choreiform movements**
  - Involuntary, purposeless, jerky displacements of short duration of limb and face
  - Coordinated but performed involuntarily
- **Athetoid movements**
  - Unstable, slow, wormlike
- **Spasticity**
  - Exaggerated reflex
  - Hypertonia
  - Clonus (rapid muscle contractions)
  - Muscle spasms

**Disorders Affecting Motor Control**

- **Cerebral palsy**
  - Affects 0.2% newborns
  - Abnormal tone and abnormal reflexes (non-progressive)
  - Can be: spastic; athetoid; ataxic; and mixed
- **Cerebral vascular accident (stroke)**
  - Hemiparesis: paralysis of one side of the body
  - Hemiplegia: weakness of one side of the body
- **Spinal cord injury**
  - Quadriplegia: all four limbs and trunk paralyzed
  - Paraplegia: only low extremities and possibly trunk
- **Traumatic brain injury**
  - Motor involvement may vary from severe (all four extremities involved) to mild
- **Progressive conditions**
  - MS, muscular dystrophy, Parkinson’s, ALS
Neuromuscular Diseases

- **Myopathy**
  - Generic term for a muscular disease that result in muscular weakness

- **Muscular Distrophy** (e.g., Duchenne’s)
  - Genetic, hereditary, progressive
  - Muscle fibers being destroyed

- **Amyotrophic Lateral Sclerosis (ALS, Lou Gehrig’s disease)**
  - Progressive deterioration of motor neurons
  - Muscles weaken; atrophy
  - Patients ultimately lose their ability to initiate and control all voluntary movement except of the eyes

Neuromuscular Diseases

- **Spinal Muscular Atrophies**
  - Progressive degeneration of motor neurons in spinal cord
  - Muscles weaken; atrophy

- **Multiple Sclerosis (MS)**
  - Chronic, inflammatory disease of the central nervous system
  - May cause changes in sensation, visual problems, muscle weakness, depression, difficulties with coordination and speech, fatigue and pain

- **Parkinson’ Disease**
  - Degenerative disorder of central nervous system
  - Impairs motor skills and speech

- **Polio**
  - Virally induced infectious disease affecting the central nervous system
  - May result in tremor, rigidity, akinesia