CMPE 80A: Universal Access: Disability, Technology, and Society

Neuroskeletal System

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
► Osteoporosis (Check http://www.nof.org)
  ▪ Fragile bones, which lead to increased risk of fractures
  ▪ Common in elderly and persons who do not weightbear regularly through joints (e.g. because bedridden)
► Heterotopic ossification
  ▪ Abnormal formation of true bone within extraskeletal soft tissues
  ▪ 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 connective tissue, cartilage, or synovial fluid

► Classification of joints:
  - If not moving (e.g., skull): synarthrosis
  - Limited movement (e.g., vertebrae): amphiarthrosis
  - Freely moving: diarthrosis

Articulatory 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

Common Joint Problems

► 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

(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 efferent 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 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)
    - Brain and spinal cord
  - 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)

CNS: Brain & 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 these functions (*plasticity*)

► **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

Cerebral vascular accident (stroke)

► Occurs when blood vessels carrying oxygen and other nutrient to a specific part of the brain suddenly burst or become blocked
  - **Hemiplegia** - paralysis of one side of the body
  - **Hemiparesis** - weakness of one side of the body
  - **Dysphagia** - difficulty swallowing
  - **Aphasia** - loss of ability to speak or to understand language: *Expressive (Broca's)* and *Receptive (Wernicke's)*
  - Spatial-perceptual deficits
  - Learning difficulties
  - **Memory loss**
  - Behavioral/emotional changes
  - Loss of motor skills

Traumatic brain injury

► **Leading causes:** falls, motor vehicle crashes, struck by/against events, assaults

► **Mild:**
  - Memory loss
  - Loss of emotional control
  - Loss of concentration capacity
  - Visual deficits

► **Severe:**
  - Hemiplegia
  - Profound personality changes
  - Impulse control/Anger/Inappropriateness
  - Spasticity
  - Poor balance
  - Aphasia

Peripheral Nervous System

► **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 nerves connected to autonomic nervous system

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
  - **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
► Causes:
  ▪ Trauma (motor vehicle accidents, acts of violence, falls, sport injuries - primarily diving accidents)
  ▪ Paralysis below the level of the injury
  ▪ Tumor
  ▪ Developmental/neurodegenerative diseases
► May be complete or incomplete
  ▪ Complete: no function (sensation or voluntary movement) below the level of injury
  ▪ Incomplete: some functioning remaining
► Leads to loss of bowel and bladder control

Complete SCI
► 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 - digestion

ANS and Spinal Cord Injury
► 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
<table>
<thead>
<tr>
<th>Disorders Affecting Motor Control</th>
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<tbody>
<tr>
<td><strong>Cerebral palsy</strong></td>
<td><strong>Muscular Dystrophy</strong> (e.g., Duchenne’s)</td>
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<tr>
<td>• Affects 0.2% of newborns</td>
<td>• 8000 (male) persons in US (Prevalence: 1/37,500)</td>
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<tr>
<td>• Abnormal tone and abnormal reflexes (non-progressive)</td>
<td>• Genetic, hereditary, progressive</td>
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<tr>
<td>• Can be: spastic; athetoid; ataxic; and mixed</td>
<td>• Muscle fibers being destroyed</td>
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<tr>
<td><strong>Spina bifida</strong></td>
<td><strong>Amyotrophic Lateral Sclerosis</strong> (ALS, Lou Gehrig’s disease)</td>
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<td>• Birth defect resulting in incompletely formed spinal cord and open/ unfused vertebrae</td>
<td>• 1000 persons in US (Prevalence: 1 in 250,000)</td>
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<td>• Can be corrected by surgery but nerve damage is permanent</td>
<td>• Progressive deterioration of motor neurons</td>
</tr>
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<td>• Level of paralysis determined by level of lesion</td>
<td>• Muscles weaken; atrophy</td>
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<td><strong>Polio</strong></td>
<td>• Patients ultimately lose their ability to initiate and control all voluntary movement except of the eyes</td>
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<td>• Virally induced infectious disease affecting the central nervous system</td>
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<td>• After surviving acute infection, post-polio syndrome includes muscle weakness, extreme fatigue, or paralysis</td>
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<td><strong>Multiple Sclerosis</strong> (MS)</td>
<td><strong>Parkinson’s Disease</strong></td>
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<tr>
<td>• About 250,000 in US (Prevalence: 1/1200)</td>
<td>• About 1,000,000 in US (prevalence: 1/300)</td>
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<td>• Chronic, inflammatory disease of the central nervous system</td>
<td>• Degenerative disorder of central nervous system</td>
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<td>• May cause changes in sensation, visual problems, muscle weakness, depression, difficulties with coordination and speech, fatigue and pain</td>
<td>• Impairs motor skills and speech</td>
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<td><strong>Parkinson’s Disease</strong></td>
<td><strong>Note:</strong></td>
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<td>• About 1,000,000 in US (prevalence: 1/300)</td>
<td>• Prevalence: # of affected individuals / total population</td>
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<td>• Degenerative disorder of central nervous system</td>
<td>• Incidence: # of individuals affected in 1 year / total population</td>
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**Note:**
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- Incidence: # of individuals affected in 1 year / total population