What is Kinesiology?

- The study of movement, but this definition is too broad
- Brings together anatomy, physiology, physics, geometry and relates them to human movement
Basic Biomechanics

…the body as a living machine for locomotion…
Mechanics

- The study of forces and motions produced by their actions

Lippert pg 93
Biomechanics

• Mechanical principles applied to
  • Human body
    • Structure of the body
    • Function of the body
Mechanics

- **Static**
  - Forces associated with non-moving or nearly moving systems
Mechanics

- **Dynamics**- moving systems
  - **Kinetics**-
    - Deals with forces causing movement in a system
  - **Kinematics**-
    - Involves the time, space and mass aspects of a moving system
Mechanics

- **Kinematics**-
  - Linear motion (translatory motion)- When all parts of a “body” move in the same direction as every other part
    - Rectilinear motion = straight line motions (sliding surfaces)
    - Curvilinear motion = curved line of motion (the motion of a ball when tossed)
  - Angular motion (rotary motion)- the arc of motion around a fixed axis of rotation or a “pivot point”
    - Joints have “pivot points” which are used as reference points from which to measure the range of motion (ROM) of that joint
Kinematics of Walking

- The hips are moving forward and marked to indicate the curvilinear path that they take in the translatory motion of walking.
Kinematics of Motion

- Movement of the body = the translation of the body’s center of mass
  - Center of Mass/Center of Gravity
Kinematics of Motion: Active versus Passive

- **Active**-
  - Generated by muscle contraction
- **Passive**-
  - Occur due to stresses placed on the tissue other than muscle contraction
    - Gravity
    - Resistance
    - An applied stretch from someone or something else
Kinesiology Terminology
Terminology

- Required to describe:
  - Movement
  - Position
  - Location of anatomic features
Anatomic Position

- Standard Reference Point
  - Axis of rotation
  - Planes of motion
  - Actions of muscles are referenced from anatomic position
Anatomic Position

- Standing in upright position
- Eyes facing forward
- Feet parallel and close together
- Arms at the sides of the body with palms facing forward
Fundamental Position

- Same as anatomic position, EXCEPT…
  - Palms face the side of the body
Terminology

- Deep-
  - toward the inside of the body
- Superficial-
  - Towards the outside of the body
- Origin-
  - the proximal attachment of a muscle or ligament
- Insertion-
  - the distal attachment of a muscle or ligament
Terminology

- **Bilateral**
  - 2 or both sides

- **Unilateral**
  - 1 side

- **Contralateral**
  - Refers to the opposite side of the body

- **Ipsilateral**
  - Refers to the same side of the body
Terminology

- **Medial**
  - Refers to a location towards the midline of the body

- **Lateral**
  - Refers to a location farther from the midline of the body
Terminology

• **Anterior (ventral)**
  • Refers to the front of the body or a position closer to the front

• **Posterior (dorsal)**
  • Refers to the back of the body or a position more towards the back
Terminology

- **Proximal**
  - Towards the trunk

- **Distal**
  - Away from the trunk
Terminology

- **Superior**
  - Indicates the location of a structure is above another

- **Inferior**
  - Indicates the location of a structure is below another
Terminology

Now it’s your turn! Use each of the terms to describe something in the image below:

- Bilateral
- Unilateral
- Contralateral
- Ipsilateral
- Medial
- Lateral
- Anterior (ventral)
- Posterior (dorsal)
- Proximal
- Distal
- Superior
- Inferior
Positions of the Body

- **Supine**
  - Lying on back with legs extended
- **Prone**
  - Lying on stomach
- **Sidelying**
- **Hooklying**
  - Lying on back with hips and knees bent
- **Quadruped**
  - Being on hands and knees (4 points)
Osteokinematics and Arthrokinematics

- **Osteokinematics**
  - Focuses on the manner in which bones move in space

- **Arthrokinematics**
  - Deals with the manner in which the adjoining joint surfaces (bones) move in relation to one another
  - Concave/Convex Rule
  - osteokinematics versus arthrokinematics

Lippert pg 93
Osteokinematics -

- Motion of bones through a range of motion relative to the 3 cardinal planes of the body and around the axis in that joint

- **Planes:**
  - Saggital or Median
    - Flexion & extension
  - Frontal or Coronal
    - ABD & ADD
  - Horizontal or Transverse
    - Rotational motions
Planes of the Body

- **Sagittal:** Divides the body into right and left parts
  - Flexion and extension occur in this plane

- **Frontal:**
  - Divides the body into front and back
    - Abduction and adduction occur in this plane

- **Transverse:** Divides the body into top and bottom parts
  - Rotation occurs in this plane

Lippert pg 27
Osteokinematics

- **Axis of Rotation = “pivot point”**
  - It’s ALWAYS perpendicular to the plane of motion!

- **Degrees of Freedom**
  - The number of planes of motion allowed to a joint
    - The shoulder and hip have 3
    - The elbow and knee have just 1
    - The wrist has 2
Axis of Motion

- Sagittal plane
  - Medial-lateral axis of motion

- Frontal plane
  - Anterior-posterior axis of motion

- Transverse plane
  - Superior-inferior axis of motion
Osteokinematics: Fundamental Motions

- Flexion and Extension:
  - Occur in the sagittal plane around a medial/lateral axis
  - Flexion = motion of one bone approaching the anterior aspect of another bone
  - Extension = opposite of flexion
Osteokinematics: Fundamental Motions

- **ABDuction & ADDuction**
  - ABD = movement away from midline
  - ADD = movement toward midline

- **Rotation**
  - Internal Rotation = anterior surface moving toward midline
  - External Rotation = anterior surface moving away from midline
Osteokinematics: Fundamental Motions

- **Circumduction**
  - Circular motion through 2 planes
    - If a joint can draw a circle in the air, it can circumduct

- **Protraction & Retraction**
  - **Protraction**
    - Translation of bone away from midline in a plane parallel to the ground
  - **Retraction**
    - Translation of bone toward midline in a plane parallel to the ground
Osteokinematics: Fundamental Motions

- **Horizontal ABD & ADD**
  - Shoulder flexed to 90°

- **Pronation & Supination**
  - Takes place in the forearm with *pronation* turning the palm down and *supination* turning the palm up
Osteokinematics: Fundamental Motions

- **Radial & Ulnar Deviation**
  - Takes place at the wrist with movement toward either the radius or ulna
Osteokinematics: Fundamental Motions

- **Dorsiflexion & Plantar Flexion**
  - Takes place at the ankle with *dorsiflexion* bringing the foot upward and *plantar flexion* pushing the foot down

- **Inversion & Eversion**
  - The sole of the foot faces medially in *inversion* and laterally in *eversion*
Arthrokinematics

- Manner in which adjoining joint surfaces move in relation to each other or how they fit together
  - helps to improve the movement of the joint
    - Parts may move in
      - the same direction
      - the opposite direction

Help!
Fundamental Movements: Joint Surfaces

- **Roll**
  - Multiple points maintain contact throughout the motion

- **Slide**
  - A single point on one surface contacts multiple points throughout the motion

- **Spin**
  - A single point on one surface rotates on a single point on the other surface
Roll & Slide Mechanics

- **Convex on Concave**
  - When a convex joint surface moves on a concave joint surface
  - The roll and slide occur in opposite directions

- **Concave on Convex**
  - When a concave joint surface moves about a stationary convex joint surface
  - the roll and slide occur in the same direction

- Here's what happens in the knee...
Kinetics

• The effect of forces on the body
  • Force
    • Any action or influence that moves a body or influences the movement of a body
    • Forces “control” movement of the body
      • Internal
        o Muscle contraction
        o Tension from ligaments
        o Muscle lengthening
      • External
        o Gravity
        o An external load
          • A therapist applying resistance or a
          • free-weight for resistance training
Mechanics

- **Force**
  - Any action or influence that moves an object

- **Vector**
  - A quantity having both force and direction
Kinetics

- **Torque**
  - The rotational equivalent of force
    - Force = Distance between the force exerted and the axis of rotation (moment arm)
    - Torque = moment arm x force (resistance)
Mechanics

- **Mass**
  - Amount of matter that a body contains

- **Inertia**
  - Property of matter that causes it to resist any change of its motion in either speed or direction
Mechanics

- Mass is a measure of inertia
  - Resistance to a change in motion
Friction

- A force that is developed by two surfaces
Friction

- Tends to prevent motion of one surface across the other
  - The coefficient of friction must be overcome for movement to occur
Friction

- It is easier to move across something once the coefficient of friction has been met.
Mechanical Advantage

- Ratio between the
  - force arm
    - Distance between the force and the axis
- and the
  - resistance arm
    - Distance between the resistance and the axis
Mechanical Advantage (MA)

- To determine
  - Length of force arm
  - Length of resistance arm

\[ \text{Length of force arm} \div \text{Length of resistance arm} = \text{MA} \]
Mechanical Advantage (MA)

- When the FA is greater than the RA
  - The MA is greater than 1
  - The force arm has more force than the RA
Mechanical Advantage

- It takes less force on your part if you apply resistance distally rather than proximally.
Pulleys

- A Pulley
  - A grooved wheel that turns on an axel with a rope or cable riding in the groove
Pulley

- Function
  - To change the direction of a force
  - To increase or decrease the magnitude of a force

Light Cam  Neutral Cam  Heavy Cam
Pulley

- Function
  - To increase or decrease the magnitude of a force
  - The load is supported on both segments on either side of the pulley, decreasing effort
Biomechanical Levers

- Interaction of internal and external forces control movement and posture through a system of levers within the body.

- The body has Three Classes of Levers
  - First
    - Similar to a “see saw”
  - Second
    - The axis is located at one end to provide “good leverage”
  - Third
    - The axis is also at one end but gravity has more “leverage” than muscle meaning that more muscle force is needed to lift a small load
Biomechanical Levers

- First Class Lever
  - F - A - R
  - Force, Axis, Resistance
- Designed for balance
  - The head sitting on the cervical vertebrae
Biomechanical Levers

- Second Class Lever
  - \( A \rightarrow R \rightarrow F \)
  - Designed for power
    - Ankle plantar flexors are the perfect example of a second class lever.
    - There is excellent leverage so that the body is easily elevated with relatively little force generated by the plantar flexors of the calf.
Biomechanical Levers

- Third Class lever
  - A – F – R
    - Designed for motion
    - The most common lever in the body because they favor large ranges of motion
    - Favor speed and distance
Line of Pull

- A muscle’s line of pull describes the direction of muscular force which can be represented in a vector. *(the motions that are possible)*

- Before a muscle can act upon a joint, it must first cross that joint.

- If a muscle crosses a joint, it acts on that joint.
Kinesiology: Form & Function