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

Lippert pg 3

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 = translation of 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

- 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

Lippert pg 4

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

Lippert pg 4

Fundamental Position

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

Lippert pg 4
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
- **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
- **Superior**
  - Indicates the location of a structure is above another
- ** Inferior**
  - Indicates the location of a structure is below another

Lippert pg 5

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

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:
  - Sagittal or Median
  - Flexion & extension
  - Frontal or Coronal
  - ABD & ADO
  - 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
  - Rotations occur in this plane

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

- 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**.

Mechanics

- **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

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

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 cause movement of the body
      - Internal
        - Muscle contraction
        - Tension from ligaments
        - Muscle shortening
      - External
        - Gravity
        - 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 \( \times \) 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

\[ \frac{\text{Length of force arm}}{\text{Length of resistance arm}} = MA \]

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
  - \( F \cdot A = R \)
  - Force, Axis, Resistance
  - Designed for balance
    - The head sitting on the cervical vertebrae
Biomechanical Levers

- **Second Class Lever**
  - **A – R – 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.

- **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.