



Physiotherapy Department

PT201: Biomechanics

Dr. Surajo Kamilu Sulaiman
PT., Ph.D.

surajo.sulaiman@tiu.edu.iq

10-10-2023

Human Biomechanics



Lecture 1

Basic Principles of Biomechanics

10-10-2023

Synopsis

- Overview of biomechanics
- Basic principles of biomechanics
 - Type of displacement
 - Location in space of the displacement
 - Direction of displacement of the segment
 - Magnitude of the displacement
 - Rate of displacement

Objectives

- By the end of this lecture, students should:
 - ❖ Understand and be able to explain the foundation of biomechanics
 - ❖ Understand and be able to describe the following basic principles of biomechanics:
 - Type of displacement
 - Location in space of the displacement
 - Direction of displacement of the segment
 - Magnitude of the displacement
 - Rate of displacement

Basic principles of biomechanics

- Mechanics is a branch of science that deals with forces and the effects they produce
- Application of mechanics to the biological system is referred to as biomechanics
- Human biomechanics focuses on how forces act on the musculoskeletal system and how the body tissue responds to these forces

Basic principles of biomechanics

- Biomechanics can be viewed in the context of the source of the forces that produce the movement as either:
 - External biomechanics or
 - Internal biomechanics
- External biomechanics describes external forces on body segments and their effect on body movement
- Internal biomechanics deals with forces generated by the body tissues and their effect on movement

Basic principles of biomechanics

- There are two domains of biomechanics (mechanics):
 - Static
 - Dynamic
- Static: Deals with mechanics that analyze the bodies at rest or in uniform motion
- Dynamics: Refers to the study of conditions under which an object moves
- Dynamics concept can be further subdivided under the following
 - Kinetics
 - Kinematics

Basic principles of biomechanics

- Kinetics is the study of motion under the action/influence of forces
- Kinematics is the study of motion without regard to the forces that cause the motion
- Kinematics includes the set of concepts that allow the description of motion/displacement of a segment
- Five kinematic parameters are used to describe the motion or displacement of a body segment

Basic principles of biomechanics

- The parameters include:
 - Type of displacement (motion)
 - Location in space of the displacement
 - Direction of displacement of the segment
 - Magnitude of the displacement
 - Rate of displacement (rate of change of displacement)

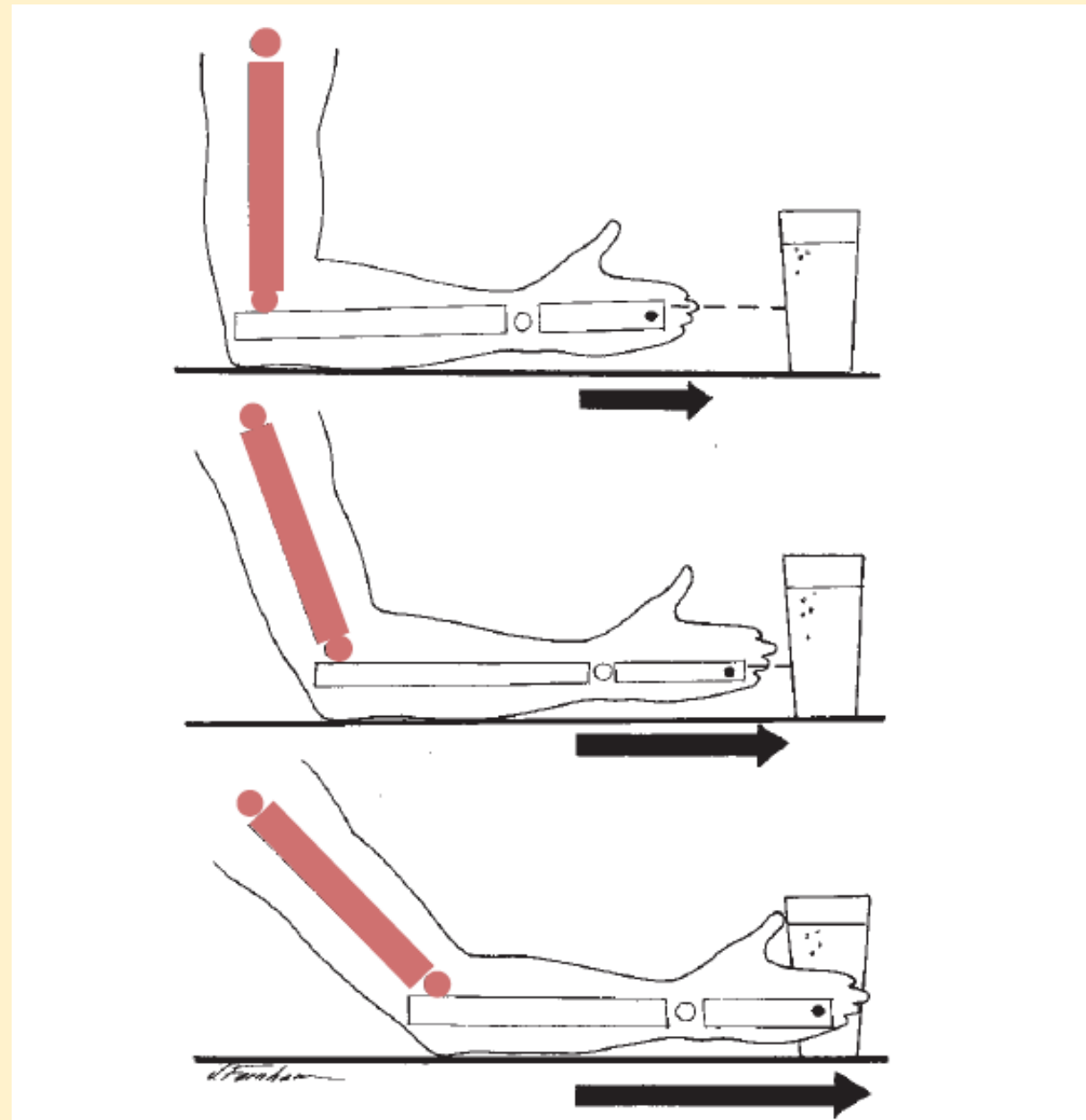
Basic principles of biomechanics

1-Type of displacement

- There are two types of displacements
 - Translatory motion
 - Rotatory motion
- **Translatory motion** (linear displacement) is the movement of a segment in a straight line
- In true translatory motion, each point on the segment moves through the same distance, at the same time, in parallel paths

Basic principles of biomechanics

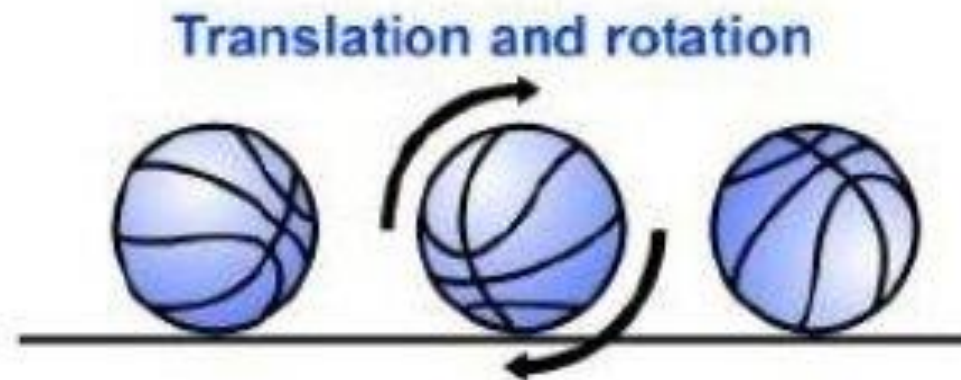
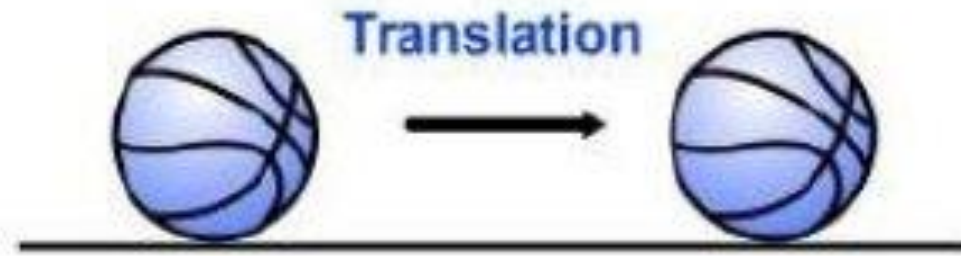
- In human movement, translatory movements are generally approximations of this definition
- An example of translatory motion of a body segment is the movement of the combined forearm-hand segment as it moves forward to grasp an object
- **Rotatory motion** (angular displacement) is movement of a segment around a fixed axis/center of rotation (CoR) in a curved path



Translatory movement

Basic principles of biomechanics

- In true rotatory motion, each point on the segment moves through the same angle, at the same time, at a constant distance from the CoR
- True rotatory motion can occur only if the segment is prevented from translating and is forced to rotate about a fixed axis.
- Pure rotatory motion does not happen in human movement because none of the body segments move around truly fixed axes
- All joint axes shift at least slightly during motion because segments are not sufficiently constrained to produce pure rotation





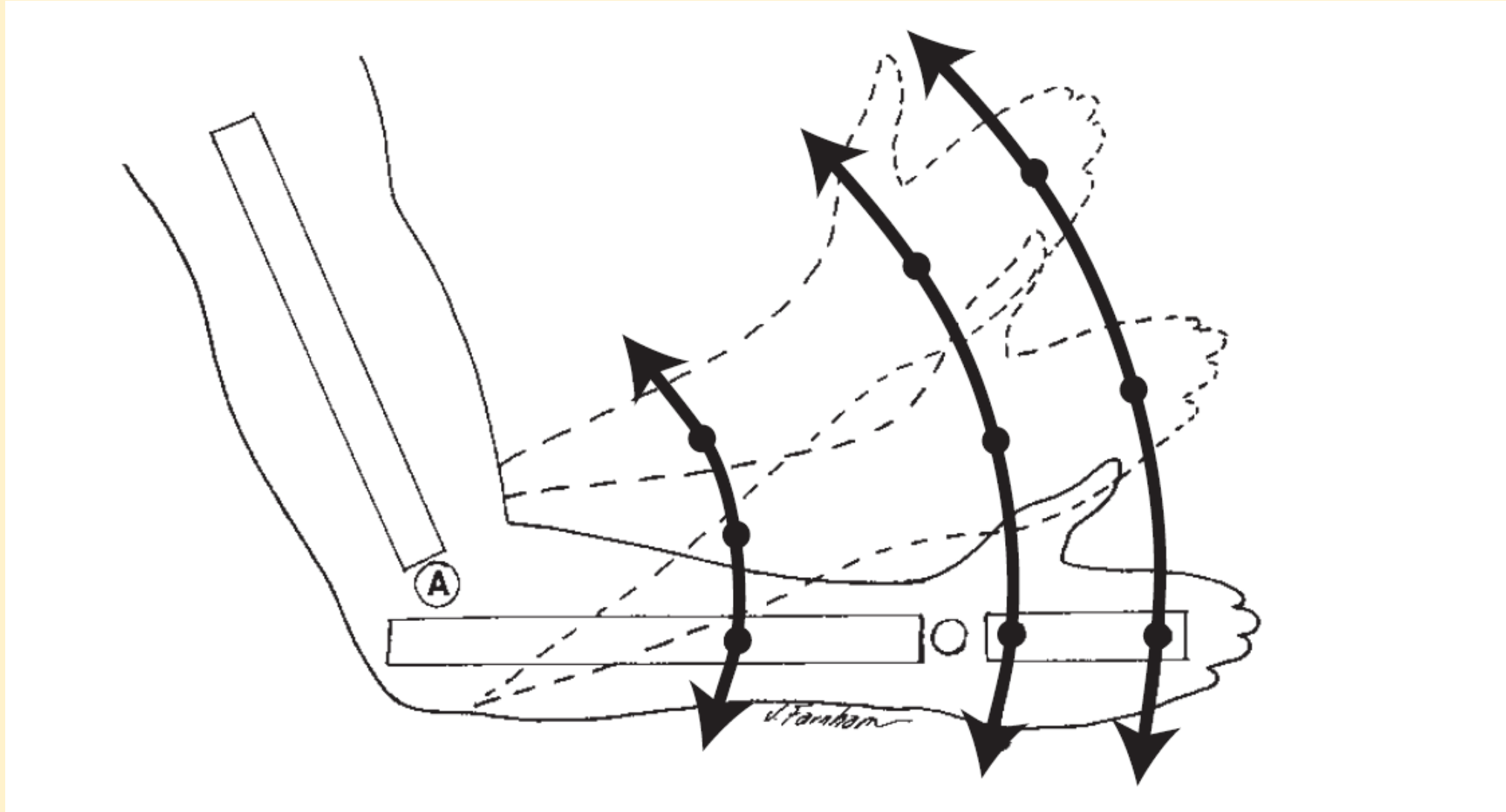
(A) Roll



(B) Spin



(C) Glide



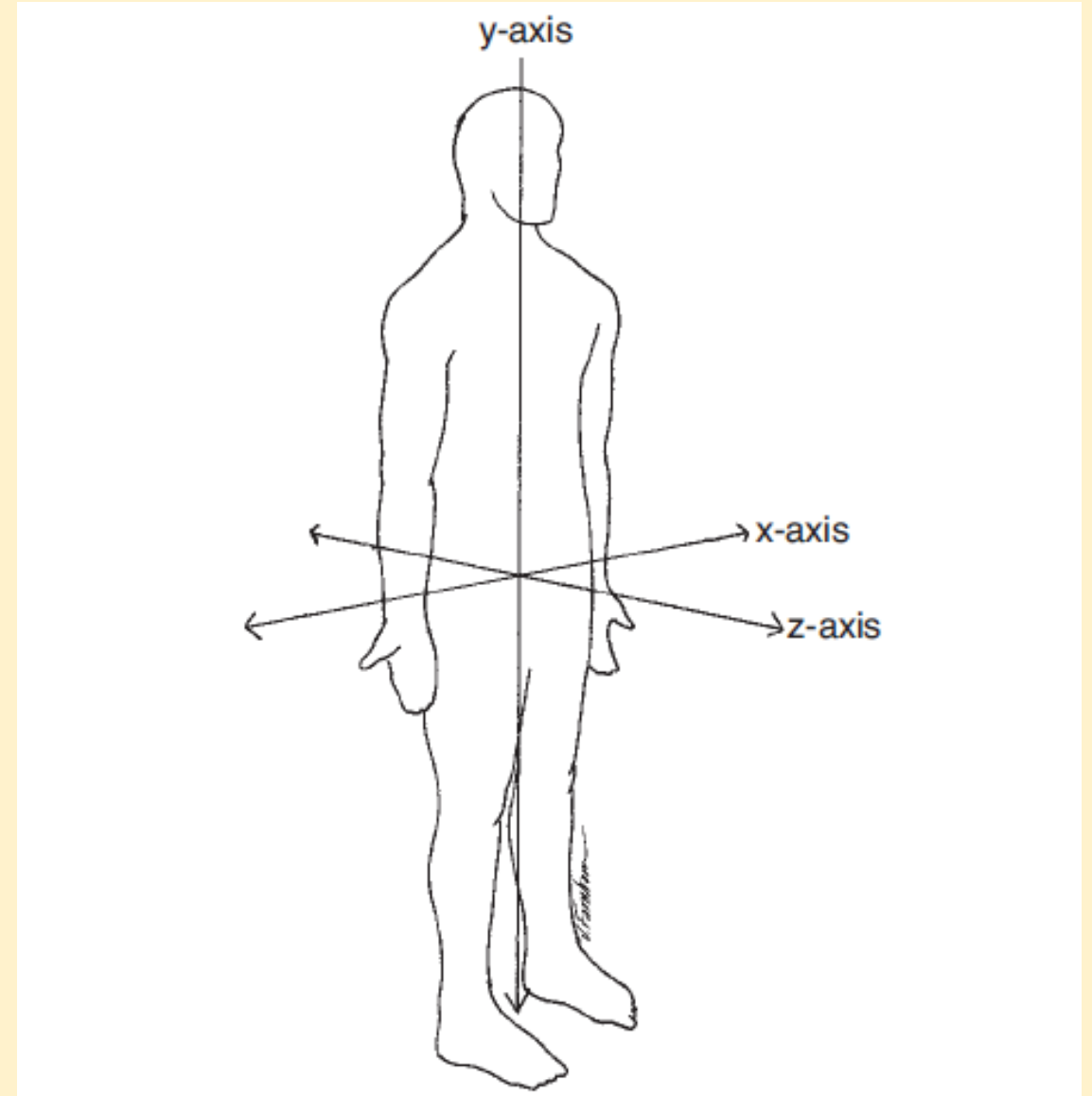
Rotatory movement

Basic principles of biomechanics

2- Location of the displacement (in space)

- The rotatory or translatory displacement of a segment takes place in a space
- Space can be depicted by using the three-dimensional Cartesian coordinate system (x, y, z), which serve as a useful frame of reference
- The origin of the x-axis, y-axis, and z-axis of the coordinate system is traditionally located at the center of mass (CoM) of the human body, when the body is in anatomical position
- Thus, displacement of a segment can occur around the three axes

- Motion of a segment can occur either around an axis (rotation) or along an axis (translation)
- As a segment rotates around a particular axis, the segment also moves in a plane that is both perpendicular to that axis of rotation and parallel to another axis



Basic principles of biomechanics

- X-axis runs side to side in the body and is labeled in the body as the coronal axis
- Y-axis runs up and down in the body and is labeled in the body as the vertical axis
- Z-axis runs front to back in the body and is labeled in the body as the anteroposterior (A-P) axis.

Basic principles of biomechanics

3-Direction of displacement of the segment

- There are two directions of displacement/rotation (positive and negative) around each of the three cardinal axes
- Flexion and extension are motions of a segment occurring around the same axis and in the same plane but in opposite direction
- Abduction and adduction of a segment occur around the same axis and in the same plane but in opposite directions
- Medial (or internal) rotation and lateral (or external) rotation are opposite motions of a segment that generally occur around a vertical axis

Basic principles of biomechanics

4-Magnitude of the displacement

- The magnitude of rotatory motion (or angular displacement) of a segment can be given either in degrees (US units) or in radians (International System of Units)
- If an object rotates through a complete circle, it has moved through 360 degrees, or 6.28 radians
- One radian is equal to 57.3 degrees; 1 degree is equal to 0.01745 radians
- The magnitude of rotatory motion that a body segment moves through or can move through is known as its range of motion (ROM)

Basic principles of biomechanics

5-Rate of displacement (rate of change of displacement)

- Denotes to rate of change in position of a segment, comprises speed, velocity, and acceleration
- **Speed:** displacement per unit time regardless of direction
- **Velocity:** displacement per unit time in a given direction
- **Acceleration:** change in velocity per unit time

Basic principles of biomechanics

- Structures that are involved in the locomotion of the body include:
 - Skeletal muscle
 - Tendon and ligaments
 - Bone
 - Cartilage
 - Joint

Contributions and Questions



Tishk
International University



References

- Levangie, P. K., & Norkin, C. C. (2005). *Joint Structure and Function: A Comprehensive Analysis* (4th ed.). F. A. Davis Company.
- Neumann, D. A. (2017). *Kinesiology of the Musculoskeletal System: Foundations for Rehabilitation* (3rd ed.). Elsevier.
- Norkin, C. C., & White, D. J. (2016). *Measurement of Joint Motion: A Guide to Goniometry* (5th ed.). F. A. Davis Company.
- Oatis, C. A. (2009). *Kinesiology: The Mechanics and Pathomechanics of Human Movement* (2nd ed.). Lippincott Williams & Wilkins.