Biomechanics of the Upper Extremity

K. Renee Thiebaud, PhD, PT
The Orthopedic Store
Physical Therapy

The Basics

- Upper extremity includes:
  - Trunk
  - Head
  - Neck
  - Shoulders
  - Arms
  - Wrist
  - Hands

Trunk – Head - Neck

Structure of the Shoulder

- Sternoclavicular joint: modified ball & socket
- Acromioclavicular joint: irregular joint
- Coracoclavicular joint: syndesmosis
- Glenohumeral joint: ball & socket
- Scapulothoracic joint: articulation between the anterior scapula & thoracic wall

Shoulder Complex Movements

- Scapulohumeral rhythm
- Glenohumeral joint: flexion, extension, abduction, adduction
- Humerus: internal rotation, external rotation, horizontal abduction, horizontal adduction

Structure of the Elbow

- Humeroulnar joint: hinge joint
- Humeroradial joint: gliding joint
- Radioulnar joints:
  - Proximal & distal radioulnar: pivot joints
  - Middle radioulnar joint: syndesmosis
Elbow Movements

Elbow: flexion, extension, pronation, supination

Structure of the Wrist

Radiocarpal joints: condyloid articulation between the radius and 3 carpal bones (lunate, scaphoid, triquetrum)

Retinacula

Wrist Movements

Wrist flexion and extension
Radial and ulnar deviation

Structure of the Hand

Carpometacarpal joints
- Thumb: sliding joint
- Others: gliding joints

Intermetacarpal joints: irregular

Metacarpophalangeal joints: condyloid joints

Interphalangeal joints: hinge joints

Hand Movements

Flexion, extension, abduction, adduction, circumduction, opposition

Joint Motion

Five (5) qualities of joint motion
- Joint play
- Active range of motion
- Passive range of motion
- End feel – elastic barrier of resistance
- Paraphysiologic movement – small amount of movement past the elastic barrier

This presentation is the intellectual property of the author. Contact them for permission to reprint and/or distribute.
Joint Motion (continued)

- Paraphysiologic movement occurs postcavitation
- Movement beyond the paraphysiologic barrier takes a joint beyond its anatomic integrity and into the pathologic zone of movement which causes damage to the joint structure

Concave – Convex Rule

- Concave moves on convex: roll and slide occur in the same direction
- Convex moves on concave: roll and slide occur in opposite directions
- Note:
  - pure roll (rotation) – dislocation
  - Pure slide (translation) - impingement

Biomechanics

- Application of mechanical laws to the human body
- Science that deals with forces and their effects applied to biological systems

Newton Laws

1st Law: Law of Inertia – a body remains at rest or in constant velocity motion until acted upon by an external unbalanced force

2nd Law: Law of Acceleration – the acceleration of a body is proportional to the unbalanced force acting upon it and inversely proportional to the mass of the body

\[ F = ma \]

Newton Laws (continued)

3rd Law: Law of Reaction – for every action, there is an equal and opposite reaction

---

This presentation is the intellectual property of the author. Contact them for permission to reprint and/or distribute.
Basic Mechanics

- Bones form levers
- Ligaments form hinges
- Muscles provide the force to move levers about the joint

Levers

- Lever: rigid bar that pivots around a fixed point when force is applied
- Axis/fulcrum: fixed point
- Force: applied by muscle to move the body part (resistance)

Classes of Levers

- 1st class lever: fulcrum is between the force and the resistance
- 2nd class lever: resistance is between the fulcrum and the force
- 3rd class lever: force is between the fulcrum and resistance [most common in the body]

Lever System Components

- Load/Resistance
- Force
- Fulcrum

1st Class Lever

- Resistance - Fulcrum - Force
- Load/Resistance
- Force
- Fulcrum

1st Class Lever System

This presentation is the intellectual property of the author. Contact them for permission to reprint and/or distribute.
2nd Class Lever

Fulcrum - Resistance - Force

Load/Resistance  Force

Fulcrum

2nd Class Lever System

3rd Class Lever

Resistance – Force - Fulcrum

Load/Resistance  Force

Fulcrum

3rd Class Lever System

3rd Class Lever System

Body Planes & Joint Motion

- Sagittal plane – divides the body into right and left sides
- Coronal (frontal) plane – divides the body into anterior and posterior components
- Transverse plane – divides the body into upper and lower components
Axis of Movement

- Coronal = X
- Sagittal = Z
- Longitudinal = Y

Joint Movement

- Flexion / Extension occurs in the sagittal plane around the coronal axis (X)
- Abduction / Adduction occurs in the coronal (frontal) plane around the sagittal axis (Z)
- Medial / Lateral rotation occurs in the transverse plane around the longitudinal axis (Y)

Forces / Torques / Loads

- Bicep force (Fb) to hold 90 N weight
  \[ F_b = 743.2 \text{ N} \]

Loads on the Shoulder

Biomechanics of the Upper Limbs
Implications of Biomechanics in Training/Rehabilitation

- Mobilization
  - Joint mechanics and structure
  - The effects forces produce on the body
- Activity/Sport
  - Strength requirements
  - Quality of motion
  - Forces imposed on joint/s during specific activity

References:


References (continued):


This presentation is the intellectual property of the author. Contact them for permission to reprint and/or distribute.