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The Biomechanics of the Human Upper Extremity

Dr Ayesha Basharat
BSPT, T-DPT, M.Phil(Gold medalist)
www.revivephysio.net
Nerves and blood vessels pass through a small "outlet" down to the arms and hands.
The sternoclavicular joint

- Joint between the manubrium of the sternum and the clavicle bone.
- Structurally classed as a synovial saddle joint and functionally classed as a diarthrosis and multiaxial joint.
- Composed of two portions separated by an articular disc of fibrocartilage.
- The bone are the sternal end of the clavicle, the upper and lateral part of the sternum, (the clavicular notch), and the cartilage of the first rib, visible from the outside as the suprasternal notch.
- Protected and stabilized by Joint capsule
- Anterior & posterior S-C ligaments
- Intra-articular disc
- Interclavicular ligament
- Costoclavicular ligament

The articular surface of the clavicle is much larger than that of the sternum, and is invested with a layer of cartilage, which is considerably thicker than that on the sternum.
• The costoclavicular ligament is the main limitation to movement, and therefore the main stabilizer of the joint.

• A fibrocartilaginous disc present at the joint increases the range of movement.

• Sternoclavicular dislocation is rare, but may result from direct trauma to the clavicle or indirect forces applied to the shoulder.

• Posterior dislocations deserve special attention, as they have the potential to be life-threatening because of the risk of damage to vital structures in the mediastinum.
Sternoclavicular Joint

- Provides major axis of rotation for movement of clavicle and scapula
- Freely permitted frontal and transverse plane motion.
- Close pack position is with maximum shoulder elevation
Sternoclavicular Joint

Motions:

- Protraction/retraction
- Elevation/depression
- Axial rotation (spin)
Acromioclavicular Joint

- **Plane synovial joint** between the acromion process of the scapula and the distal clavicle.
  - allows limited motions in all three planes.
- Rotation occurs during arm elevation
- **Close-packed position** with humerus abducted to 90 degrees
- **In close-packed position** there is maximum contact between the articulating surfaces and stability is also maximum.
Acromioclavicular Joint

- Protected & stabilized by
- Joint capsule
- A-C ligaments
- Intra-articular disc
- Coracoclavicular ligaments
FIGURE 17.2 Ligaments of the glenohumeral and acromioclavicular joints.
Coracoclavicular Joint

- A syndesmosis with coracoid process of scapula
- Bound to the inferior clavicle by the Coracoclavicular ligament.
- Permits little movement
Glenohumeral Joint

- Most freely moving ball & socket joint in human body formed between head of humerus & glenoide cavity of scapula.

- Stable by: Glenoid Labrum (composed of fibrocartilage rim) & Joint capsul, Tendon of long head of biceps brachii
  - Glenohumeral ligaments
  - Rotator Cuff Muscles

- Most stable in close-packed position, when the humerus is abducted and laterally rotated.
Glenohumeral Motion

Controlled by:

- Passive restraints
- Active restraints
Glenohumeral Motion

Passive Restraints:

- Bony geometry
- Labrum
- Capsuloligamentous structures
- Negative intra-articular pressure
Capsuloligamentous Structures

- GH ligament and its capsule provide (ant, inf, posterior stability)
- SGHL
- MGHL
- IGHL complex
  - anterior band
  - posterior band
  - axillary pouch

*FIGURE 17.2* Ligaments of the glenohumeral and acromioclavicular joints.
• At rest or dependent postion of shoulder joint:
  • SGHL and IGHL taut…, MGHL relax
  • Adhesive and cohesive forces of synovial fluid and negative joint pressure hold surfaces together
  • When the humerus is elevating and scapula is rotating upward
• At 45 degree abduction and neutral rotation = Tension placed on static restraints by the rotator cuff & middle gleno humeral (MGHL) ligament taut others relax (SGH, IGHL)
• 90 abd & neutral rotation = Tension placed on static restraints by the rotator cuff & IGHL taut & MGHL, SGHL relax.
• Glenohumeral ligaments provide inferior translation of humeral head
Active restraints:

- Dynamic restraints
  - rotator cuff muscles (dynamic)
    - the primary biomechanical role of the rotator cuff is stabilizing the glenohumeral joint by compressing the humeral head against the glenoid
  - Biceps Long Head (dynamic) acts as humeral head depressor.
- variable origin from superior labrum
- SGHL and subscapularis thought to play role in stabilizing long head of biceps
Scapulothoracic Joint

- Region between the anterior scapula and thoracic wall.
- Functions of muscles attach to scapula:
  - Contract to stabilize shoulder region
  - Stabilize scapula against chest wall
  - Facilitate movements through appropriate positioning of the Glenohumeral joint.
Movements of the Shoulder Complex

- Humerus movement usually involves some movement at all three shoulder joints to provide full range

- **Flexion**: anterior fibers of deltoid, coracobrachialis, pectoralis major, biceps brachii,

- **Extension**: latissimus dorsi and teres major, posterior fibers of the deltoid, long head of triceps,
• **Abduction:** supraspinatus (first 15 degrees), deltoid; (scapula: Upward rotation) trapezius, serratus anterior

• **Adduction:** (downward rotation of scapula) pectoralis minor, major, subclavius, latissimus dorsi, lower trapezius); **True Adduction:** , pectoralis major, subscapularis, teres major & minor, coracobrachialis, long head of triceps, latissimus dorsi, infraspinatus.

• **Medial rotation:** subscapularis, latissimus dorsi, anterior fibers of deltoid,, pectoralis major,

• **Lateral rotation:** infraspinatus and teres minor, posterior fibers of deltoid

• **Positioning further facilitated by motions of spine**
Horizontal Adduction and Abduction at the Glenohumeral Joint

• HORIZONTAL ADDUCTION: Anterior to joint:
  • Pectoralis major (both heads), anterior deltoid, Coracobrachialis
  • Assisted by short head of biceps brachii

• HORIZONTAL ABDUCTION: Posterior to joint:
  • Middle and posterior deltoid, infraspinatus, teres minor
  • Assisted by teres major, Latissimus dorsi
Scapulohumeral Rhythm

- It’s a rhythm of movement b/w glenohumeral joint & scapula to complete full range of sh.joint.
- The ratio has considerable variation among individuals but is commonly accepted to be 2:1 (2 of glenohumeral motion to 1 of scapular rotation) overall motion.
- During the setting phase (0 to 30 abduction, 0 to 60 flexion), motion is primarily at the glenohumeral joint, whereas the scapula seeks a stable position.
- During the mid-range of humeral motion, the scapula has greater motion, approaching a 1:1 ratio with the humerus
- later in the range, the glenohumeral joint again dominates the motion
Thank You!

[Garfield giving a thumbs up]
رسول اللہ صلی اللہ علیہ وسلم نے فرمایا:
ہم افراد کے بھی کئی کے بارے میں
قیمت کا دو میں خذوں کے دو میں دنا کرنا گا
(دنیا میں ایک) وہ شخص ہے جس کے
مزدور کو کام پر خاص اسے پورا کام لیا
لیکن اس کی ابہمت عطام ان کی .... (بتاری)
Loads on the Shoulder

- Shoulder joint bear most of the weight amongst all articulations of the shoulder girdle.
- Shoulder has to provide direct mechanical support in daily activities provide tensile loading.
- Large leverage, More compressive forces/tensile forces on the shoulder joint.
- Deltoid produces upward shear forces as compared to rotator cuff which produces downward shear forces.
glenohumeral joint is considered to be a load-bearing joint.

- Although calculations the exact forces acting on it are challenging giving the large number of involved muscular and possible positions attainable, several simplifying assumptions allow an estimate of the magnitude of these forces.
Case A. the arm is in 90° of abduction, and it is assumed that only the deltoid muscle is active. The force produced through BY deltoid muscle (D) acts at a distance of 3 cm from the center of rotation. The force produced by the weight of the arm is estimated to be 0.05 times body weight (BW) and acts at a distance of 30 cm from the center of rotation.

The reaction force on the glenohumeral joint (D) may be calculated with the use of the equilibrium equation that states that for a body to be in moment equilibrium must equal zero.

\[ M = 0 \]
\[ (30 \text{ cm} \times 0.05\text{BW}) - (D \times 3 \text{ cm}) = 0 \]

\[ D = \frac{30 \text{ cm} \times 0.05 \text{ BW}}{3\text{cm}} \]

\[ D = 0.5 \text{ BW} \]

Because D and J are almost parallel but opposite, they form a force couple and are of equal magnitude; thus, the joint reaction force is also approximately one-half body weight! (J=joint reaction forces)
Case B. Similar calculations can be made to determine the value for D when a weight equal to 0.025 times body weight is held in the hand (60cm from center of rotation) with the arm in 90" of abduction with moment equilibrium must equal zero.

- $M = 0$
- $(30 \text{ cm} \times 0.05 \text{BW}) + (60 \text{ cm} \times 0.025 \text{ BW}) - (D \times 3 \text{ cm}) = 0$
- $D = (30 \text{ cm} \times 0.05 \text{ BW}) + (60 \text{ cm} \times 0.025 \text{ BW}) \div 3\text{cm}$
- $D = 1 \text{ BW}$

Once again, D and J are essentially equal and opposite, forming a force couple. Thus, the joint reaction force is approximately equal to body weight.
Loads on the Shoulder

- **Further loads quantity depend on Moment arm:**
  - Perpendicular distance between load vector and shoulder (axis)

A **moment arm** is simply the length between a joint axis and the line of force acting on that joint. Every joint that is involved in an exercise has a **moment arm**.

The longer the **moment arm** is; the more load will be applied to the joint axis through leverage.

- Large torques from extended moment arms countered by shoulder muscles
- Load reduced by half with maximal elbow flexion
Common Shoulder Injuries

- Adhesive capsulitis
- Rotator Cuff Damage……..
  - Impingement Theory or syndrome…..
- Subscapular and suprascapular Neuropathy
- Ectopic calcification
  - Hardening of organic tissue through deposit of calcium salts in areas away from the normal sites
- Dislocations
Frozen shoulder/adhesive capsulitis:

- Restricted mobility of the glenohumeral joint characterized by the development of dense adhesions, capsular thickening, and capsular restrictions, especially in folds of the capsule, rather than arthritic changes in the cartilage and bone as a result of prolonged immobilization, or from unknown causes (idiopathic frozen shoulder) or may occur as a result of pathology such as osteoarthritis is called frozen shoulder.
• Impingement syndrome:
  • Mechanical compression and irritation of the soft tissues (rotator cuff/supraspinatous tendon and subacromial bursa) in the suprhumeral space is called *impingement syndrome* & is most common cause of shoulder pain.
Causes of impingement syndrome

- When the arm is raised, the subacromial space narrows; the supraspinatus muscle tendon passes through this space.
- Anything that causes narrowing space has the tendency to impinge the tendon and cause an inflammatory response, resulting in impingement syndrome. Such causes can be bony structures such as subacromial spurs (bony projections from the acromion) and variations in the shape of the acromion (flat, hooked or curved).
- Loss of function of the rotator cuff muscles, due to injury or loss of strength, may cause the humerus to move superiorly, resulting in impingement. Inflammation subacromial bursa may also cause impingement.
Supracapular Neuropathy

- patient is a young overhead athlete who reports posterior shoulder pain.
- Although, athlete can have painless atrophy presenting as supraspinatus and/or infraspinatus weakness, depending on the location of the suprascapular nerve lesion.
- More distal nerve injuries are often relatively painless. In particular, injuries at the spinoglenoid notch that result in selective denervation of the infraspinatus muscle may be painless condition.
more proximal lesions of the suprascapular nerve that affect both the supraspinatus and infraspinatus muscles are more likely to have pain and symptom-limited function.
Subscapular neuropathy

- upper subscapular nerve (short subscapular nerve) enters the upper part of the Subscapularis.

- The lower subscapular nerve (inferior subscapular nerve) is a nerve that supplies the lower part of the subscapularis muscle, and also to teres major muscle.

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Figure 2.13. Posterior wall of the axilla and posterior cord of the brachial plexus.
The subscapularis rotates the head of the humerus medially (internal rotation); medial rotation means when the arm is raised, it draws the humerus head inward and downward. It is a powerful defense to the front of the shoulder-joint, preventing displacement of the head of the humerus.

Subscapular neuropathy results in:

• Weak medial rotation of shoulder joint and decrease stability of shoulder joint
Dislocations

- Loose structure of shoulder leads to extreme mobility = less stability
- It may be Posterior, Anterior or inferior dislocation
- Occurs mostly in Contact sports due to Glenohumeral capsular laxity & weakness of shoulder musculature
Posterior dislocation

- Traumatic posterior shoulder dislocation is less common. The mechanism of injury is usually a force applied to the arm when the humerus is positioned in flexion, adduction, and internal rotation, such as falling on an outstretched arm.

- The person complains of symptoms when doing activities such as push-ups, a bench press.
Anterior shoulder dislocation.

- Anterior dislocation most frequently occurs when there is anteriorly directed posterior force act the arm while the humerus is in a position of elevation, external rotation, and horizontal abduction.

- In that position, stability is provided by the subscapularis, GH ligaments and long head of the biceps. A significant force to the arm may damage these structures, along with the attachment of the anterior capsule and glenoid labrum.
Inferior dislocation

- Inferior dislocation occurs as a result of inferior instability which is typically the result of rotator cuff weakness/paralysis and is frequently seen in patients with hemiplegia.
- It is also prevalent in patients who repetitively reach overhead (workers or swimmers, for example) and those with multidirectional instability.
Awww thank you
مہمی شانی

مذکرہ کرنا سے پہلے رسمی رسمی بھی
خاموش رہنے سے کم بھوجاتی ہے
صدر کرنے سے ختم بھوجاتی ہے - اور
اپنا مکمل، ادا کرنے سے خوشی ملیں بدل جانے ہے
Elbow Articulations

- **Humeroulnar Joint**
  - True elbow joint
  - Strong bony configuration
  - Hinge joint

- **Humeroradial Joint**
  - Slides along capitulum
  - Modified ball and socket joint
  - Provides no ABD or ADD

- **Proximal Radioulnar Joint**
  - Annular ligament
  - Movements
  - Interosseous membrane
Functions as a fulcrum for forearm lever

In patients using crutches, it functions as a weight bearing joint.

During throwing activities, there is transfer of energy between the shoulder and elbow, crucial for activities of daily living.
Joint Capsule/Stability of joint

- Anterior
- Posterior
- Medial
- Lateral
- Large, loose and weak
- Reinforced by other ligaments. MCL & LCL
- Close pack position: extension
Loads on the Elbow

- Large loads generate by muscles that cross elbow during forceful activities, Also in weight lifting, gymnastics, other sports

- Extensor moment arm shorter than flexor moment arm, (whole moment arm small and inefficient, lead to degeneration) as joint reaction forces are large.

- Triceps attachment to ulna closer to elbow joint center than brachialis on ulna and biceps on radius (not far from center of rotation) source of degeneration. (ecentric vs concentric loading)

- Moment arm varies with position of elbow

- Axial loading in extended elbow, 40% of weight is through HU joint, 60% of weight is through HR joint
Common injuries:

- Tennis elbow
- Golfers elbow
- Fractures
- Unlar nerve entrapment syndrome
- Cubitus valgus & varus
Wrist and Hand Bones

- Wrist
  - Scaphoid
  - Lunate
  - Triquetrium
  - Pisiform
  - Trapezium
  - Trapezoid
  - Capitate
  - Hamate
Wrist and Hand Bones

- Hand
  - Metacarpals
  - Phalanges 2-5
    - Proximal
    - Middle
    - Distal
  - Phalange 1 (Thumb)
    - Proximal
    - Distal
Movements of the Wrist

- Sagittal and frontal plane movements
- Rotary motion
- Flexion
- Extension
- Radial Deviation
- Ulnar Deviation
Joint Structure of the Hand

- Carpometacarpal (CM)
- Metacarpophalangeal (MP)
- Interphalangeal (IP)
Common Injuries of the Wrist and Hand

- Sprains and strains rare, but occur due to a fall on hyperextended wrist
- Certain injuries characteristic of sport type
  - Metacarpal fractures (football)
  - Ulnar collateral ligament (hockey)
  - Wrist fracture (skate/snowboarding)
  - Wrist injuries in non-dominant hand for golfers
- Carpal Tunnel Syndrome
Closer Look at the Carpal Tunnel

- Structures within Tunnel
  - FDS
  - FDP
  - FPL
  - Median Nerve
Carpal tunnel syndrome (CTS) is a medical condition due to compression of the median nerve as it travels through the wrist at the carpal tunnel. The main symptoms are pain, numbness and tingling in the thumb, index finger, middle finger and the thumb side of the ring fingers.
• Swan neck deformity === (DIP hyperflexion with PIP hyperextension).
• Boutonniere deformity (PIP flexion with DIP hyperextension).
Mallet finger

- Mallet finger, also baseball finger, dropped finger, dolphin finger, due to an injury of the extensor digitorum tendon of the fingers at the distal interphalangeal joint (DIP).
Monteggia fracture. This injury affects both bones of the forearm. There is usually a fracture in the upper 1/3 ulna along with dislocation of the radius head. This is a very severe injury and requires urgent care.
• The Galeazzi fracture is a fracture of the distal third of the radius with dislocation of the distal radioulnar joint.

Bennett fracture is a fracture of the base of the first metacarpal bone which extends into the carpometacarpal (CMC) joint. This intra articular fracture is the most common fracture of the thumb, and is accompanied by some degree of subluxation or dislocation of the carpometacarpal joint.
De-Quervain's tenosynovitis

- A painful **inflammation** of tendons (Abd. Pollicis longus & ext. pollicis brevis) in your wrist and base of thumb. When the swollen tendons rub against the narrow tunnel (anatomical snuff box) they pass through, it causes pain at the base of your thumb and into the lower arm.
Claw hand:

- An **ulnar claw**, also known as **claw hand**, or 'Spinster's Claw' is a deformity or an abnormal attitude of the hand that develops due to **ulnar nerve** damage causing paralysis of the lumbricals.

- A claw hand presents with a hyperextension at the metacarpophalangeal joints and flexion at the proximal and distal inter-phalangeal joints of the 4th and 5th fingers.
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