THROWING BIOMECHANICS-2

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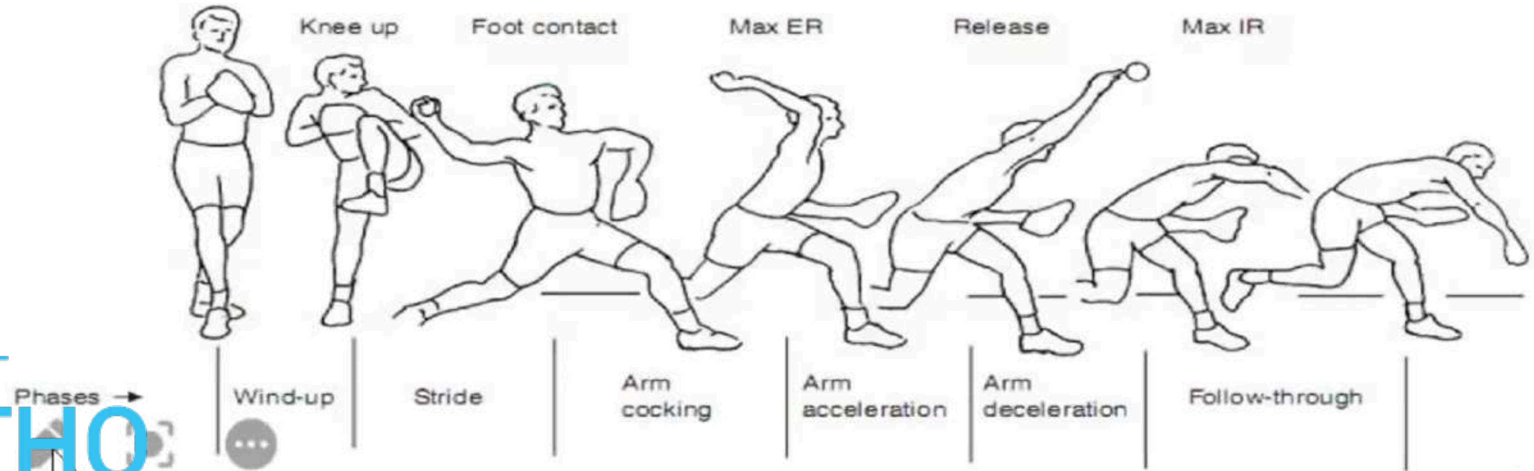
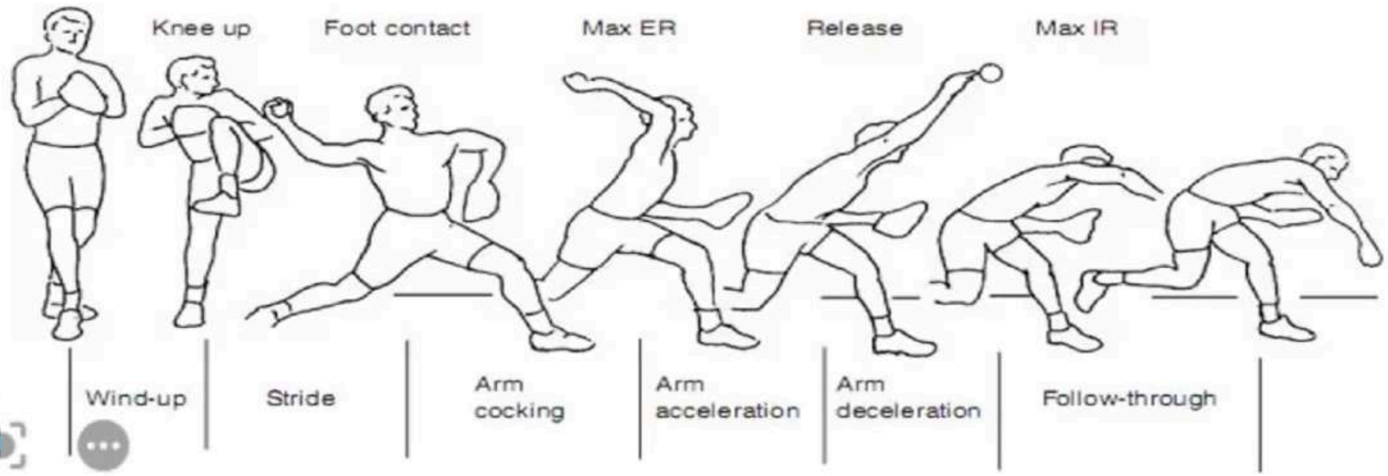
PHASES OF THROWING

1. Biomechanics
   - Entire throwing motion takes app 2 seconds.
   - Wind up & accleration phase take app 75% time(1.5s)



PHASES OF THROWING

1. Preparation/ wind-up
2. Stride
3. Cocking
4. Acceleration
5. Deceleration
6. Follow-through



Wind-up

- The wind-up phase is defined as the initial movement to maximum knee lift of stride leg.
- During the initial movements, the pitcher brings his or her hands overhead and lowers to chest level.
- EMG studies show that the upper trapezius has a maximum voluntary isometric contraction (MVIC) of 18%, serratus anterior 20%, and anterior deltoid 15%.
- During this phase,muscles of the shoulder are relatively inactive... reasons risk of injury is low as well.
- The wind-up phase lasts 500- 1000 milliseconds.

The ipsilateral leg and trunk rotate approximately 90° and the contralateral hip and knee flex

WIND UP

- The purpose of wind-up is threefold:

1. To establish a rhythm to achieve correct timing for subsequent movements,
2. To conceal the ball and distract the hitter and
3. To place the body in a position that may contribute to the propulsion of the ball

Muscle activation

- Minimal muscle activity and muscle fire at low intensity.
- As the stride leg is flexed, the weight is transferred from stride leg to pivot leg and hip abductor, adductor and extensors of pivot leg act as weight absorber.

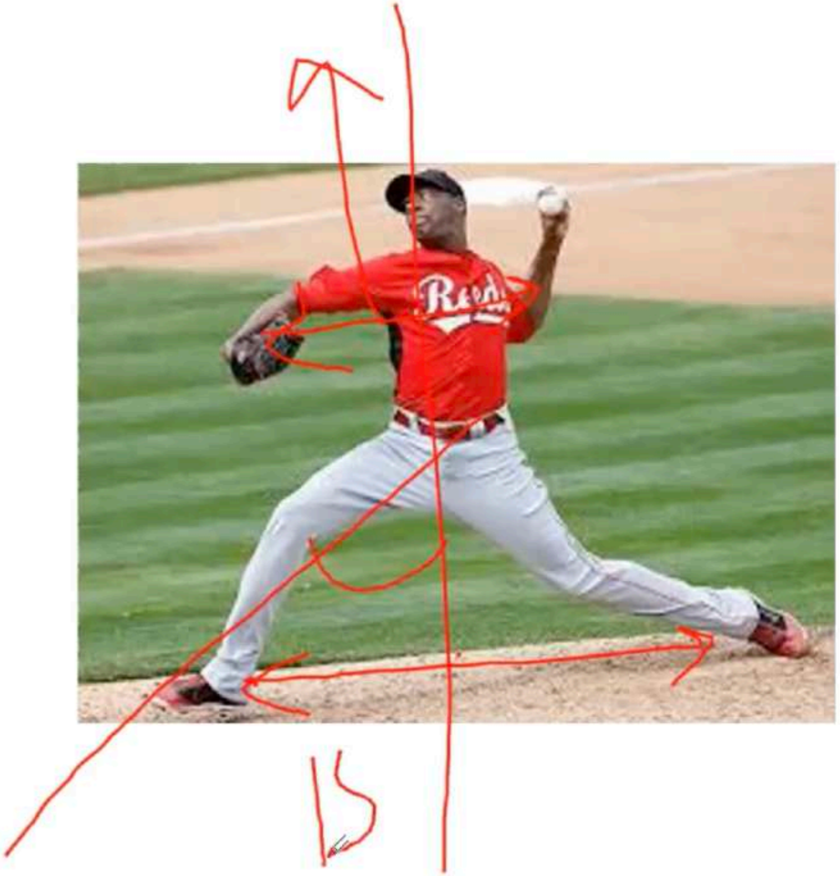
1. Anterior deltoid and pectoralis major work concentrically at the glenohumeral joint.

2. Upper trapezius, Serratus anterior and Lower trapezius work to produce upward rotation of the scapula.

3. The abdominal muscles work to rotate and stabilize the trunk.

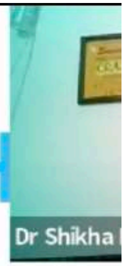
Stride Phase

- 15-degree angle of the foot away from the centre of the mound.
- The stride ankle also typically lands approximately 10cm away from the same midline with a distance from the rubber averaging 87% of the pitcher's height.
- 3.0N increase in anterior force at the shoulder for every extra cm and a 2.1N increase in anterior force at the shoulder with every degree increase of foot angle.



Arm Cocking Phase

- Beginning of lead foot contact and ends at maximum shoulder external rotation.
- Kinetic energy is transmitted to the shoulder, approximately 80% of body weight, from the lower extremities and trunk rotation.
- Scapula and Shoulder muscles are highly activated to promote and sustain movements of the shoulder, especially external rotation.

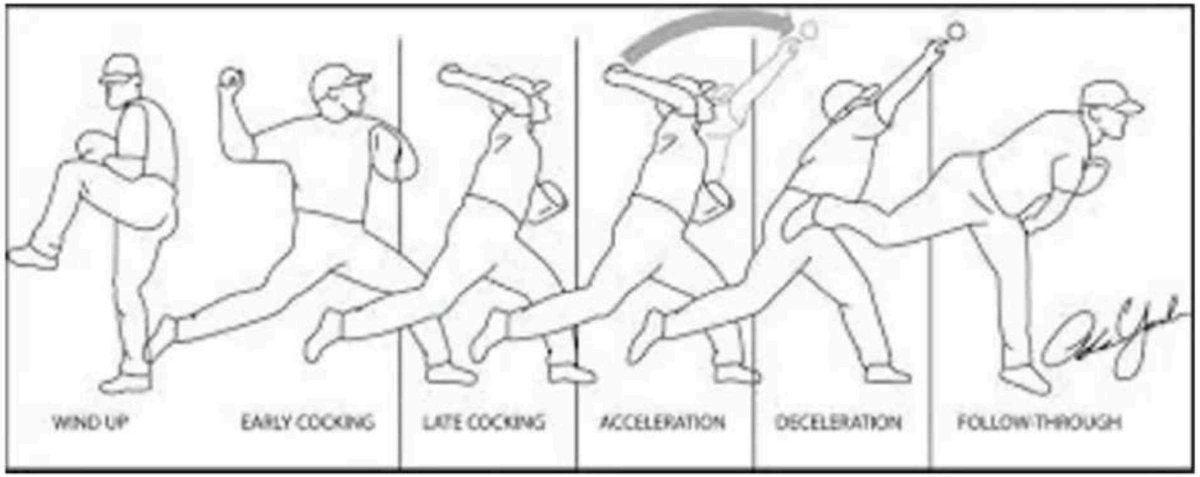


Throwers with chronic anterior instability, stimulation of mechanoreceptors within the glenohumeral joint excited and/or inhibited certain muscles.
The Biceps Brachii and supraspinatus are shown to be initiated or excited by these mechanoreceptors and assist with the prevention of anterior instability.
Excessive utilization of the biceps brachii could lead to a superior labrum anterior to posterior (SLAP) tear.
Pectoralis major, subscapularis, and serratus anterior are inhibited.

2 subphases

- 1. Early Cocking
  - **peak mucle activation**
    - DELTOID
- I/L extensor carpi radialis longus and brevis, extensor digitorum communis, Gluteus maximus and C/L oblique
  - Erector spinae and Gluteus maximus
- 2. Late Cocking
  - high torque phase with Maximun shoulder ER
    - peak mucle activation
  - Supraspinats, Infraspinatus, Teres minor Subscapularis
-

Early cocking phase



- It begins with the end of the windup phase or when the stride leg reaches its maximum height and it ends when the stride leg contacts the mound/ground.

- At this point the throwing arm is in 'semi-cocked' position.
- With the arm approximately 90° abduction, 30° horizontal abduction, and 50° external rotation

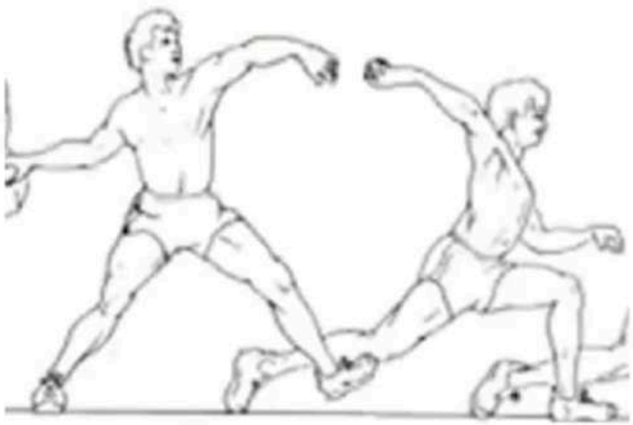
- As the ball is removed from the glove, the centre of gravity is lowered by flexing the knee of the pivot leg and the stride leg gradually extends and moves towards the batter.
- Its main function is to allow a linear and angular motion of the trunk, which lands directly in front of the pivot leg with the toes pointing slightly in.
- The knee and hip of the pivot leg extend and initiate pelvic rotation and forward tilting followed by upper torso rotation

Muscle activation in Early cocking:

- Hip extensors and abductors, knee flexors and ankle plantar flexors of the pivot leg work to propel the weight forward as the stride leg is moving forward.
- And hip extensors and abductors, knee extensors and ankle plantar flexors of stride leg work eccentrically to control the lowering of body's centre of gravity.
- Abdominal obliques work eccentrically to control excess lumbar hyperextension.

Late Cocking phase

- Begins from the point where the stride leg contacts the ground to the point of maximum external rotation of the throwing arm.
- During this phase, the trunk is perpendicular to the batter The pelvis reaches its maximum rotation and the upper torso continues to rotate and tilt forward and laterally.
- The shoulder is abducted about 90°, 10° to 20° horizontally adducted and laterally rotates to about 175°.
- The wrist is in neutral and the elbow is elevated to about shoulder height and is 90° flexed.
- During this phase, a varus torque of about 64 N-m is generated at the elbow and about 67 N-m internal rotation torque is generated at the shoulder.

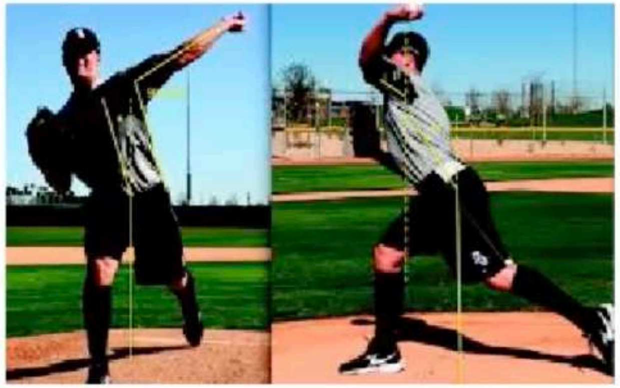


Muscle activation in Late cocking:

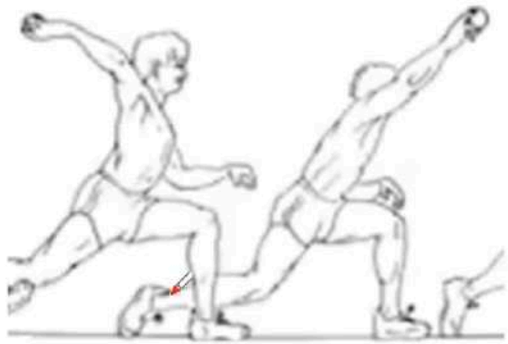
- Pivot leg hip extensor, knee flexor and calf muscles work concentrically to transfer the force up the kinetic chain and aide in force generation at the arm.
- Biceps brachii presents with peak activity during flexion of the elbow in the late cocking phase as it limits anterior translation and compression forces of the humeral head.
- Wrist extensor is at its greatest activity.

Arm Acceleration Phase

- Begins at maximum shoulder external rotation and ends at ball release.
- Forward acceleration of the arm which is equivalent of a peak internal rotation angular velocity of approximately 6500º/sec near ball release.
- Risk of various shoulder injuries due to the high kinetic energy generated from the lower extremities



MAX ER
BALL RELEASE



Late Cocking   Acceleration

1. During this phase, the shoulder moves into horizontal adduction and internal rotation. A rapid shoulder internal rotation takes place and shoulder moves from point of 175 deg of humeral external rotation to 100 deg of humeral internal rotation in about 42 to 58 milliseconds.
2. Ball release takes place between 40-60 deg of humeral external rotation. The elbow first moves to about 120 deg of flexion and then rapidly extends to about 25deg of flexion at ball release.
3. At ball release elbow extension velocity peaks at approximately 2500deg/sec. The wrist moves into flexion from an extended position and ends in neutral, while the forearm is in about 90deg pronation at release.

Muscle activation

1. Acceleration phase is the most explosive phase of the pitching, and trunk achieves its greatest rotation speed which leads to peak activity of obliques.

- Latissimus dorsi becomes active
- Subscapularis at its greatest activity
- Triceps is also at its greatest activity

Arm Deceleration Phase

- Begins at ball release and ends at maximum shoulder internal rotation.
- Posterior muscles are highly susceptible to tensile overload

HIGHEST TRACTION FORCE

1. The shoulder is abducted 100 deg, humeral rotation reaches 0 deg and arm is horizontally adducted to 35deg.
2. The greatest amount of joint loading is generated during this phase.
3. The posterior shear force of about 400 N, the inferior shear force of 300 N, 1090 N of compressive forces and about 97 N-m of horizontal abduction torque are generated during this phase after ball release.

Muscle activation

1. Trapezius, serratus anterior and rhomboids produce high MVIC to assist in deceleration of shoulder girdle.
2. Teres minor presents with its peak activity during this phase as it resists anterior humeral head translation, horizontal adduction and internal rotation.
3. Infraspinatus, supraspinatus and deltoid also present high MVIC to decelerate the arm in space as it moves forward.
4. Biceps brachii and brachialis produces marked eccentric contraction to decelerate the elbow extension and forearm pronation.

Follow-through

- Phase where the body continues to move forward until the arm has ceased motion.
- Elbow-
  - rebound effect
  - flexed to 45.

Muscle activation

- Trunk extensors work concentrically to bring the trunk in an upright position.
- As the rest of the body catches up with the arm, the pivot leg hip flexors move the leg forward and the pitcher assumes a fielding position.

BIOMECHANICS OF THE ELBOW IN THE THROWING ATHLETE

1. Wind-up
2. Stride
3. Arm cocking
4. Arm acceleration
5. Arm deceleration
6. Follow-through.

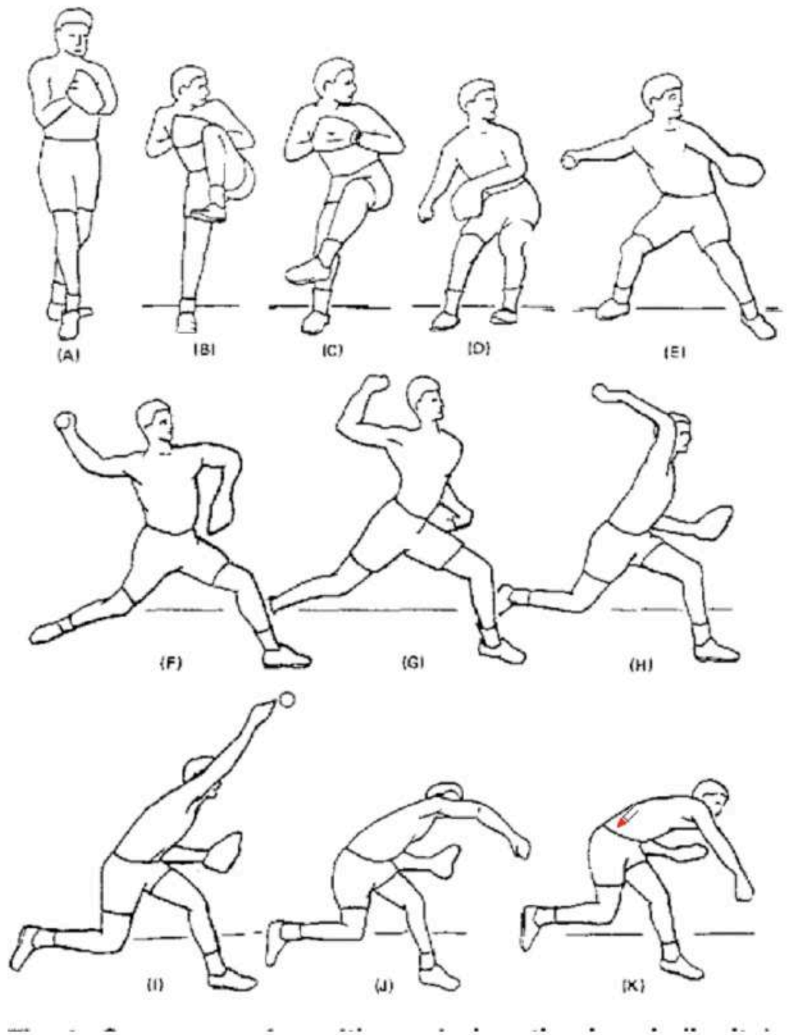
- The wind-up and stride position the body in preparation for the highly dynamic movements that follow.
- Low muscle activity and low elbow joint forces and torques occur during the wind-up and stride phases.
- High muscle activity and high elbow joint forces and torques are generated during the arm cocking, arm acceleration, and arm deceleration phases.

Wind-Up

The time from when the stance foot pivots to when the knee has achieved maximum height and the pitcher is in a balanced position is typically 0.5 to 1.0 second.

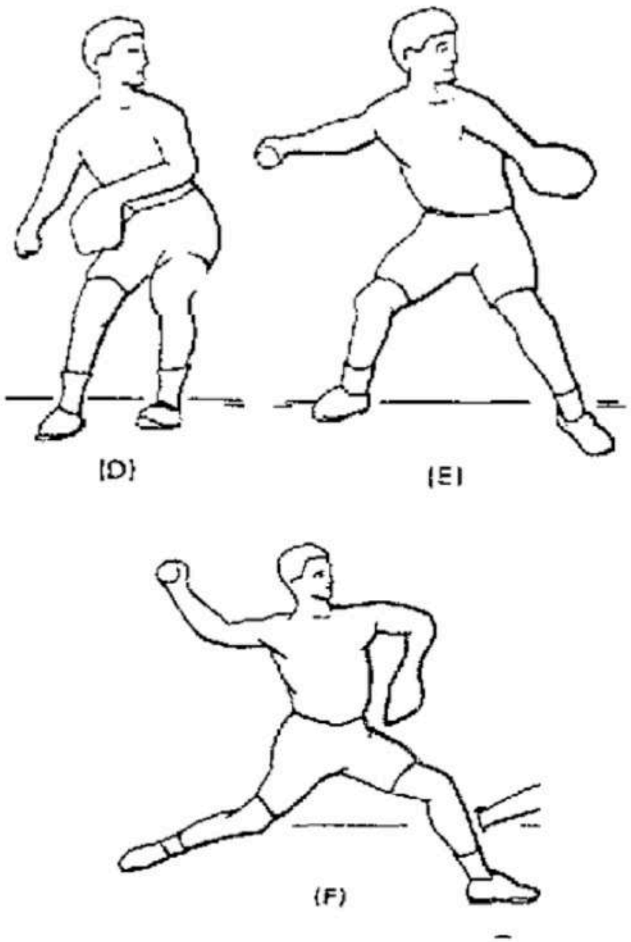
Minimal elbow kinetics and muscle activity are present during thisphase.

The elbow is flexed througout the phase, and elbow flexion is maintained by isometric contractions of the elbow flexors



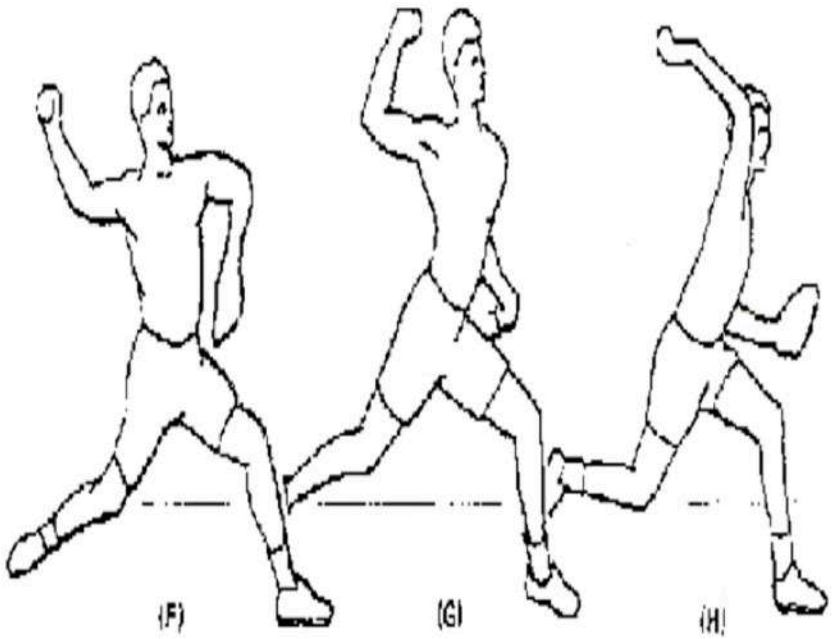
Stride

- The stride phase begins when the lead leg begins to fall and move toward the ground and the two arms separate from each other. (FIG 1D-E)
- The stride phase ends when the lead foot contacts the mound (Fig 1F)
- A typical stride lasts 0.50 to 0.75 seconds.
- Moderate activity from the elbow flexors are needed to control elbow flexion and extension.
- As the hands separate the elbow flexors first contract eccentrically as the elbow extends, and then concentrically as the elbow flexes near the completion of the stride.
- The elbow is flexed 80 ° to 100 ° at lead foot contact.
- Minimal elbow kinetics and muscle activity are present during the stride phas



Arm Cocking

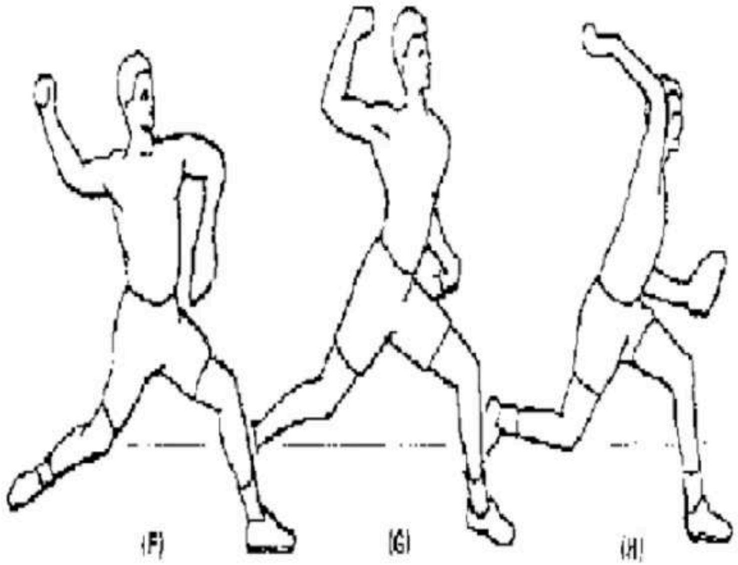
- The arm cocking phase, which lasts 0.10 to 0.15 seconds,begins at lead foot contact and ends at maximum shoulder external rotation (MER) (Figs 1F-H).
- "Arm cocking" phase than "cocking," because only the arm is cocked during this entire phase.
- Shortly after the arm cocking phase begins, the pelvis and upper torso rotate to face the batter.



FC to MER

ARM COCKING

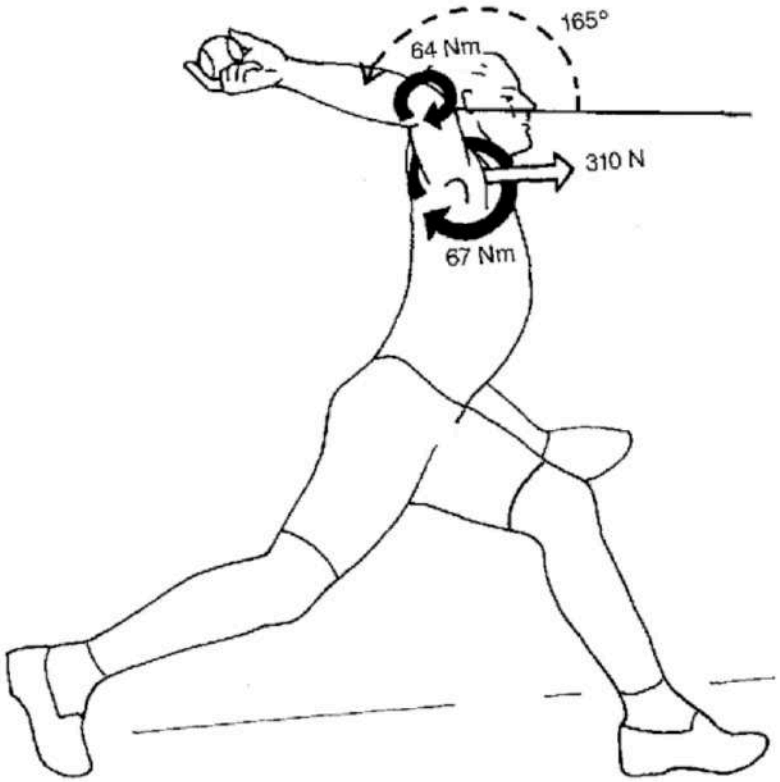
- A low to moderate flexion torque of 0 to 32 nm is produced at the elbow throughout the arm cocking phase.
- Elbow flexors show low to moderate activity, but primarily during the middle third of the arm cocking phase



Arm Cocking

Dr Shikha

- A large valgus torque is produced at the elbow---BY
  - pelvis and upper torso rotation & rapid shoulder external rotation.
- A maximum varus torque of 52 to 76 nm (mean of 64 nm) is generated shortly before MER to resist valgus torque at the elbow (Fig) by .
  - The flexor and pronator muscle mass of the forearm



Arm Cocking

Valgus torque placed on the arm

↓

Large tensile forces on the medial aspect of the elbow.

↓

Repetitive valgus loading /Valgus torque can cause compression between the radial head and humeral capitellum.

↓

Injury to the ulnar collateral ligament (UCL)/ Medial epicondylitis or Flexor/pronator tendinitis

REASON FOR ELBOW INJURY

- Maximum 240 to 360 N medial force(++VARUS TORQUE) is applied by the upper arm onto the forearm to resist lateral translation of the forearm at the elbow.

1. A maximum anterior force of 80 to 240 N is applied by the upper arm onto the forearm to resist posterior translation of the forearm at the elbow.

2. A maximum compressive force of 150 to 390 N is applied by the upper arm to the forearm to resist elbow distraction.

ROLE OF TRICEPS

- The elbow achieves a maximum flexion of 85 ° to 105 ° approximately 30 milliseconds before MER --controlled by the triceps muscle.

↓

- If the triceps muscle is paralyzed by a radial nerve block, the elbow "collapses" and continues flexing near its limit (approximately 145 ° elbow flexion).

↓

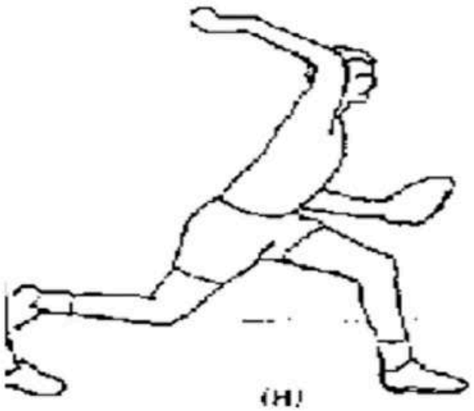
- Collapse is caused by a centripetal flexion torque at the elbow created by the rapidly rotating upper torso and arm.

❖ The triceps muscle contracts eccentrically and then isometrically in resisting the centripetal elbow flexion torque that occurs during late arm cocking.

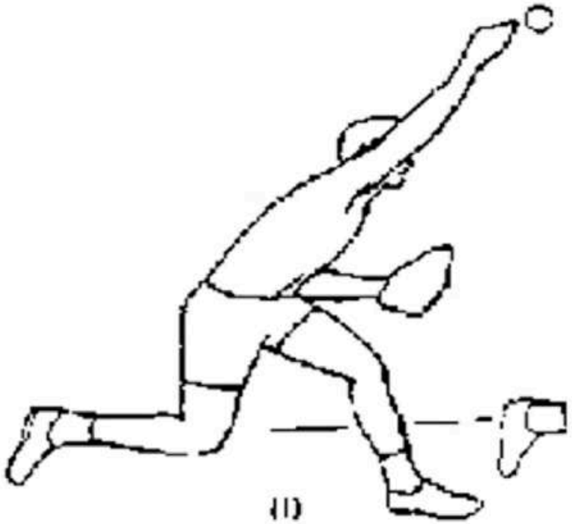
❖ At approximately the time that the elbow reaches maximum elbow flexion (ie, approximately 30 milliseconds before MER), the elbow flexors become inactive and the triceps contract concentrically to aid in elbow extension.

Arm Acceleration

- Short time from MER to ball release (Fig 1H and 1I).
- The entire phase lasts only a few hundredths of a second.
- Maximum elbow flexor torque of 40 to 60 nm is generated by low to moderate activity from the elbow flexors.
- A maximum elbow angular velocity of 2,100 °-2,700 ° per second occurs at approximately halfway through the acceleration phase.



(H)



(I)

Role of the triceps during the acceleration phase --- ELBOW

Thrower with a paralyzed triceps (differential nerve block) was able to throw a ball over 80% of the speed attained before paralyzation.

↓

Elbow extension ---Triceps contraction ++Centrifugal force (major).

Triceps and anconeus ---- initiating angular velocity ----- *may function more as elbow stabilizers than as accelerators.*

"Valgus Hyperextension Overload"

- During arm acceleration, the need to resist valgus stress at the elbow can result in a wedging of the olecranon against the medial aspect of the trochlear groove and the olecranon fossa.

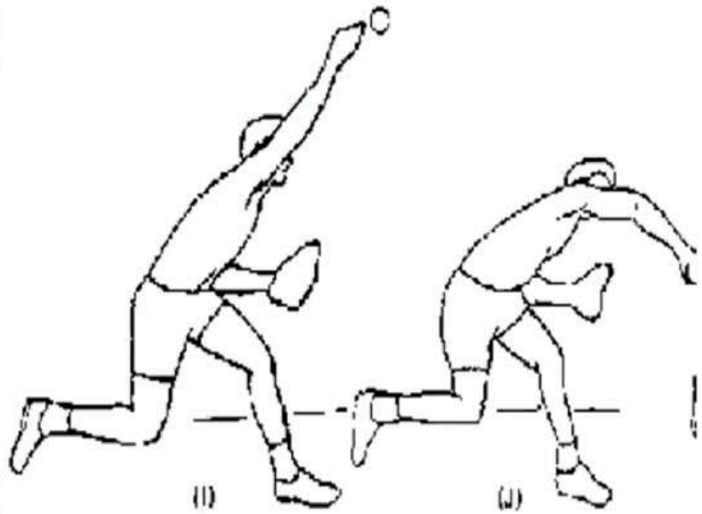
- This impingement leads to osteophyte production at the posterior and posteromedial aspect of the olecranon tip and can cause chondromalacia and loose body formation.

- Substantial varus torque is generated throughout the arm cocking and arm acceleration phases to resist valgus torque.

- During these phases, the elbow extends through a range of approximately 65 ° (approximately 85 ° to approximately 20 °).

Arm Deceleration

- Only lasts a few hundredths of a second, begins at ball release and ends when the shoulder has reached its maximum internal rotation.
- An eccentric elbow flexion torque (eccentric contractions of the elbow flexors)of approximately 10 to 35 nm is produced throughout the arm deceleration phase to decelerate elbow extension.



BALL RELEASE
MIR

Force

- Maximal muscle force(MMF) α the physiologic cross-sectional area(PCA) of the muscle,
- PCSA =(**muscle volume /musclefiberlength**).
- MMF = PCA X Conversion Factor
- 4.7 kg/cm2 with the elbow flexed
- 6.3 kg/cm2 with the elbow extended
- Max----9.2 kg/cm2