

# Throwing Mechanics

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## 효과적인 thrower의 조건

- 1) Velocity
- 2) Accuracy
- 3) Spin production
- 4) Endurance

• 이상의 상태를 얻기 위해서는 고도의 neuromuscular control이 요구

### ● 투수에서 동작 분석 연구가 많이 이루어지는 이유

- (1) 운동 행위가 일정하게 반복
- (2) 분석 동작 촬영 및 근전도 검사가 용이
- (3) 상지 관절 손상이 자주 발생

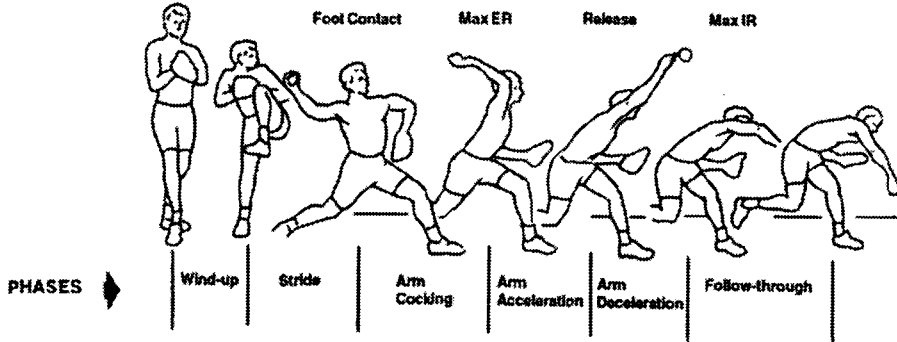
## 1) Throwing의 point와 phase

### ● Tullos & King<sup>1,2</sup> : 3 Phases

- (1) Cocking
- (2) Acceleration
- (3) Follow through

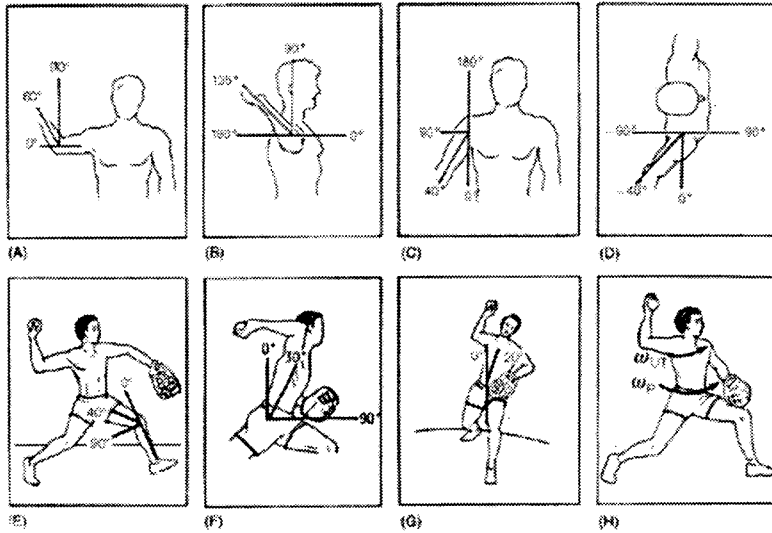
### ● Pettrone 등<sup>3</sup>

- (1) Windup
- (2) Cocking
- (3) Acceleration
- (4) Deceleration
- (5) Follow through



2) 투구 동작의 관절각

	Wind-Up	Arm Cocking	Arm Acceleration	Arm Deceleration	Follow-Through
GH joint position	Neutral	90° Abduction Maximum EROT	90° Abduction Moving to IROT	90° Abduction IROT	Horizontal Flexion IROT Decreasing abduction
GH joint Stresses	Low joint stresses	Anterior joint capsule Inferior joint capsule	Anterior joint capsule	Posterior joint capsule Distraction of GH joint	Posterior joint capsule Distraction of GH joint
Elbow position	Some degrees of flexion	Approximately 90° of flexion	90° of flexion moving into extension	20-30° flexion moving into extension	Extension
Concentric Contraction	Muscular forces are mostly generated by lower extremity	External rotators	Internal rotators Serratus anterior Upper trapezius Trunk & lower extremity	Internal rotators Triceps brachii	Internal rotators
Eccentric Contraction		Internal rotators	External rotators Rhomboids Trapezius	External rotators Biceps brachii Brachialis	External rotators
Center of Gravity	Elevated over pivot foot	Over pivot foot	Between pivot & plant foot	Over plant foot	Forward of plant foot



Definition of kinematic parameters: (A) elbow flexion, (B) shoulder external/internal rotation, (C) shoulder abduction, (D) shoulder horizontal adduction, (E) lead knee flexion, (F) forward trunk tilt, (G) lateral trunk tilt, and (H) pelvis angular velocity ( $\omega_p$ ) and upper torso angular velocity ( $\omega_u$ ).

(1) Wind up phase

- Quiet individual
- 볼이 글러브에서 빠져 나오면 wind up phase는 끝난다.
- Shoulder girdle과 상지의 EMG activity는 낮은 상태

(2) "Cocking" phase

① Early cocking phase

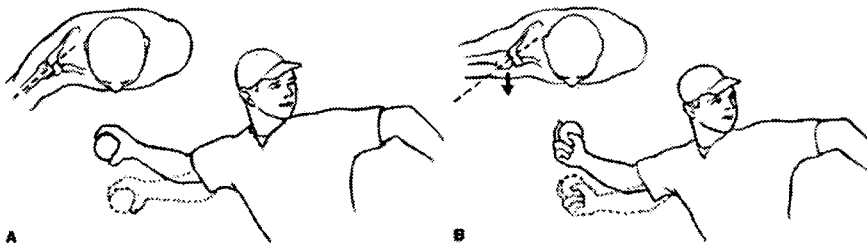


FIG. 4. A. Good mechanics. The hand is on top of the ball as it comes out of the glove and stays on top until the end of early cocking. This position allows the humerus to stay internally rotated with the humeral head safe within the glenoid. B. Pathologic mechanics. The hand is under the ball in early cocking. This position causes the humerus to externally rotate and lever the humeral head anteriorly in the glenoid, which can lead to instability.

- Dominant glenohumeral joint
  - 90° abd. hyperextension, and ext. rotation with ant. capsule taut and biceps and triceps muscles tense

- deltoid와 supraspinatus에 의해 외전 시킴
- 들었던 발이 땅에 닿으면 이 phase는 끝난다.

- Elbow

- \* Brachioradialis muscle에 의해 굴곡

② Late cocking phase

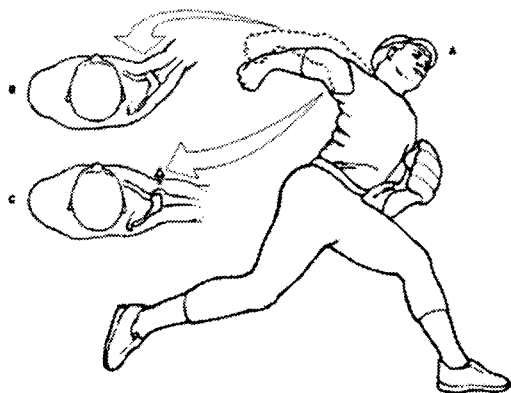


FIG. 5. A. Baseball pitching mechanics with the humerus moving from the scapular plane to the coronal plane. B and C. Overhead view of the humerus moving from the scapular plane (normal mechanics) to the coronal plane (poor mechanics). (Reprinted with permission from Pink MM, Perry J. Biomechanics. In: Jobe FW, ed. *Operative Techniques in Upper Extremity Sports Injuries*. St. Louis, MO: Mosby-Year, 1996:116.)

- Trunk의 rapid forward motion이 발생
  - Dominant shoulder는 전방 회전
  - Shoulder와 elbow에 large torque가 발생
    - Static stabilizer 인 anterior inferior glenohumeral ligament가 안정성을 부여하고 pectoralis major와 latissimus dorsi가 이 인대를 보강
    - Scapulothoracic muscle이 작용하여 protract, upward rotation하여 humeral head가 glenoid에 담이지게 한다.
  - Elbow에는 valgus force가 가해져서 medial stabilizer에 strain이 가게된다.
- (3) “Acceleration” phase 가속기
- Shoulder and elbow
    - Brought forward, leaving wrist and hand behind.
    - 동시에 humerus is whipped from extreme ext. rotation to int. rotation

with ball being released at about head level

→ 견관절에서는 심한 내회전에서 외회전으로 변하는 과정이 발생하고 ball release 와 동시에 끝난다.

→ 860 Nm의 compressive force가 가해진다.

→ Pectoralis major, lattismus dorsi, subscapularis m.이 concentric 하게 수축하여 상완골을 돌린다.

\* 이때 humeral internal rotational torque는 14,000 inch/lb이고 angular velocity는 6,100 degree/sec이다<sup>4,5</sup>.

(4) "Follow-through" or deceleration phase. 후속기 4,5

• After ball release

\* Trunk와 dominant lower extremity는 전방회전

\* Shoulder는 adduction & 30도 internal rotation

\* 반면 Elbow는 50도 flexion, forearm은 forcefully pronated

## Summary

Throwing motion은 축구 kick의 4배에 달하는 운동 에너지(27,000 inch/lb)가 요구4 이러한 엄청난 torque 때문에 손상의 가능성은 높아지는 것이다.

## References

- 1) Tullos HS, King JW. Throwing mechanism in sports. Orthop Clin North Am 1973;4-3:709-20.
- 2) Woods GW, Tullos HS, King JW. The throwing arm: elbow joint injuries. J Sports Med 1973;1-4:43-7.
- 3) Petterone FA. Pitching mechanism. In: AAOS symposium on upper extremity injuries in athletes., 1st ed. Saint Louis, 1986:59-63.
- 4) Janda DH, Wojtys EM, Hankin FM, Benedict ME. Softball sliding injuries. A prospective study comparing standard and modified bases. Jama 1988;259-12:1848-50.
- 5) Gainor BJ, Piotrowski G, Puhl J, Allen WC, Hagen R. The throw: biomechanics and acute injury. Am J Sports Med 1980;8-2:114-8.