Biomechanics and Injuries of the Shoulder During Throwing

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The shoulder complex is the most mobile joint in the human body. The stability of this joint provides support to the arm and allows the hand to perform certain tasks. The mobility of this joint allows the hand to reach a greater area. Throwing is one of the most demanding activities on the shoulder. Overuse and faulty throwing mechanics lead to shoulder injuries (Fleisig et al., 1996a). An understanding and application of proper throwing mechanics can improve performance and reduce the risk of injury. This paper discusses the motion and force of the shoulder during throwing and the implications for shoulder injuries.

KEY POINTS

- During throwing, the shoulder internally rotates at 7,000° per second.
- The force applied to the shoulder is greater than 800 N, equivalent to a 180-lb person hanging by one hand.
- Common shoulder injuries result from overuse and faulty mechanics.

Motions at the Shoulder During Throwing

To simplify the analysis, Dillman and his coworkers (1993) divided the throwing motion into six phases. Wind-up begins when the athlete initiates motion and ends when the body is rotated and the striding leg is elevated and flexed (Figures 1A, 1B). Stride ends when the lead foot contacts the ground (Figures 1B–1E). Arm cocking begins at lead foot contact and ends at maximum shoulder external rotation (Figures 1E, 1H). Arm acceleration follows arm cocking and ends at ball release (Figures 1H,1I). Arm deceleration begins at ball release and ends when the shoulder reaches maximum internal rotation (Figures 1I, 1J). Follow-through follows arm deceleration and ends when the arm completes its movement (Figures 1J, 1K).

Shoulder rotation can be described in three directions for overhead throwing as abduction/adduction, horizontal abduction/adduction, and internal/external rotation. Data were collected from 29 healthy professional and college pitchers with ball speed at least 84 mph. Figure 2 shows the averages of the shoulder motions during throwing. Shoulder abduction was about 100° at foot contact and ball release, with little change from foot contact to ball release.

Prior to foot contact, the elbow remained behind the trunk while shoulder horizontal abduction was greater than 30°. The elbow moved to the front of the trunk shortly before ball release, and the shoulder was horizontally adducted about 15° at the end of arm cocking. The shoulder horizontal adduction at ball release was almost zero. The shoulder began to externally rotate before foot contact, reaching about 50° of external rotation at foot contact. The shoulder reached the maximum external rotation (MER, almost 180°) at the end of arm cocking. During the arm acceleration phase, the arm was rapidly internally rotated from MER. The shoulder internally rotated more than 60° in less than 1/100 of a second.

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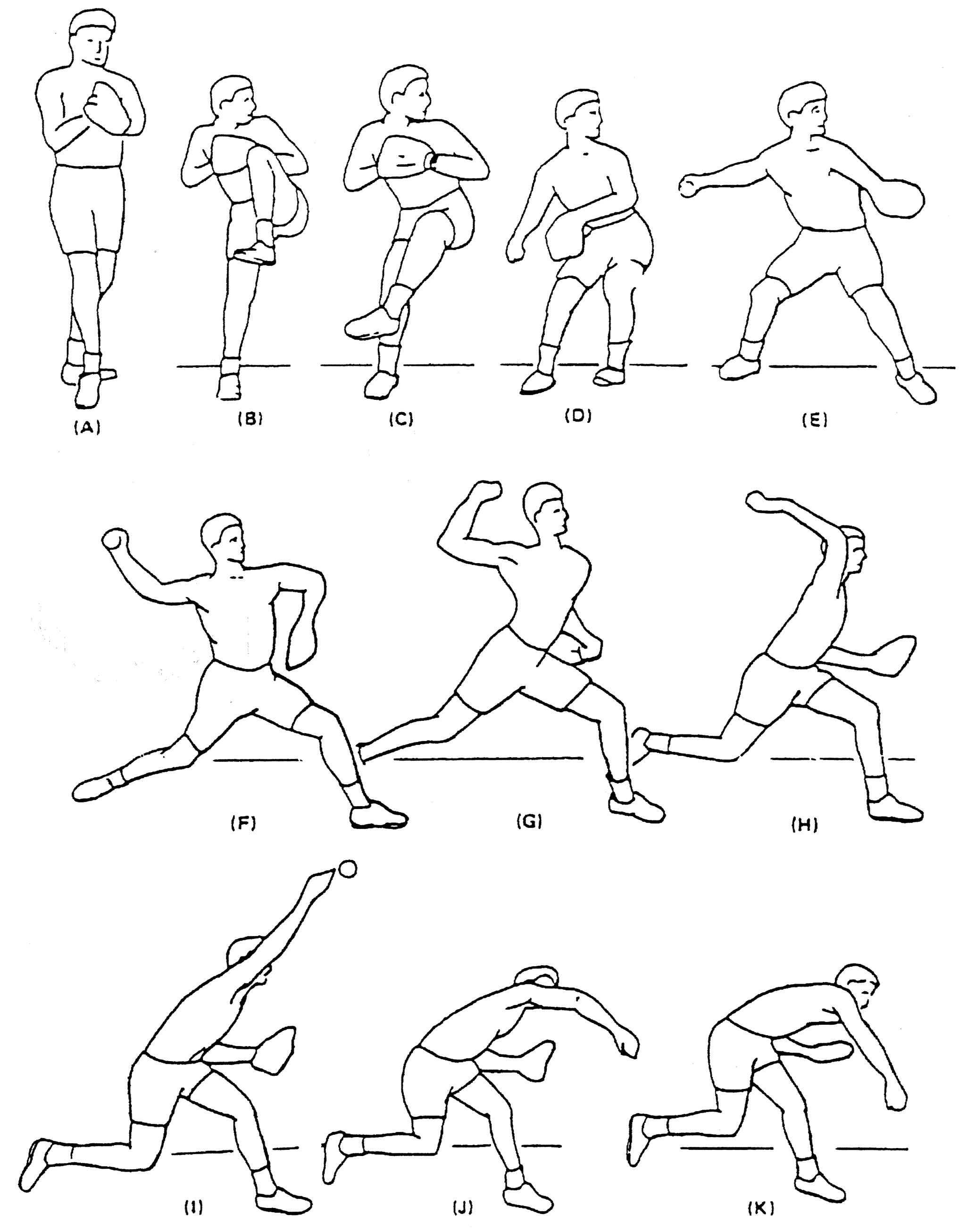

Figure 1 (A through K): Sequence of motion in pitching. From C.J. Dillman et al. (1993), "Biomechanics of pitching with emphasis upon shoulder kinematics," *Journal of Orthopaedic and Sports Physical Therapy*, Vol. 18(2):402–408. Reprinted with permission.

A typical shoulder internal rotation velocity during baseball pitching is over 7,000°/sec, making it one of the fastest human motions in sports.

Forces and Torques at the Shoulder During Throwing

A force is needed to speed up or slow down a linear velocity. A torque is needed to speed up or slow down an angular velocity; a torque is the product of a force and the distance of the force from the center of the rotation. There are rapid changes in shoulder rotation velocities, for example, when the shoulder internal rotation velocity increases to 7,000°/sec in 1/100 of a second. The shoulder muscles must generate a large torque to speed up the shoulder internal rotation velocity. To produce a large torque, the musculature must generate large forces because of the short