INTRODUCTION

Baseball is one of the oldest and most popular spectator sports today. It has been played in the United States since the mid-1800s, although pinpointing its exact origin is debated to this day. Supposedly, Abner Doubleday created the game in 1839, but there is little support for this story, not to mention evidence of versions of the game as far back as 5th century Egypt. What is certain is the first professional game was played on May 4th, 1871 between Forest City and Fort Wayne, and baseball never looked back. Today, the game is played worldwide, most notably in the Dominican Republic, Cuba, and Japan. Today, professional baseball attracts millions of spectators to ballparks each year and entertains millions more through radio and television broadcasts.

THE ATHLETE

Baseball values all-around ability, particularly in the younger players, yet many are successful in performing one or two skills well. The two most essential skills of the game are throwing and hitting the ball. Most players who go on to play baseball competitively can do both reasonably well, but almost all ballplayers have to be able to hit to be successful. Both are extremely complex activities that utilize multiple abilities and faculties.
Players are divided into pitchers and fielders. Both hit in the lineup, and fielders are usually everyday players. Because of the stress on their arms, pitchers who start games throw every fourth or fifth day, while relievers may pitch every other day, but much fewer innings. In younger levels of baseball, pitchers may play in the field on non-throwing days. In collegiate and professional baseball, pitchers usually just pitch and do not hit when they are not throwing.

Players need to perform different tasks during a game, depending on the position. The following are tasks that the typical baseball player needs to do during a game:

1) Swing a bat to hit a pitched ball (hand-eye coordination)

2) Run fast from base to base or in the field to get to a hit ball (speed)

3) Catch a ball that is pitched, airborne, or hit on the ground (agility)

4) Throw a ball hard and accurate from the outfield, infield, or pitchers mound (arm speed and torque)

Athlete metabolism is primarily anaerobic, mixing sprints into significant periods of inactivity, either from sitting on the bench or standing in the field. Therefore, flexibility and muscle endurance are necessary to avoid muscle injuries. Off-season workouts help to develop this, but in-season flexibility and strength training must be done to keep off-season gains.

The repetitive swinging of a bat thousands of times a season demands strong core stability, which involves the abdominal region and lower lumbosacral spine and pelvis.

THROWING
Basic biomechanics of the shoulder and elbow

The primary motions that occur during throwing are abduction (ABD), horizontal adduction, internal rotation (IR), and external rotation. Shoulder abduction is a motion that should stay constant throughout throwing. The arm stays abducted approximately 90-100 degrees until ball is released. This has been identified as the ideal angle for the throwing arm, and variance in this angle will alter the stress load and increases risk of injury. The shoulder has less hyper-angulation forces with lower ball deliveries, which may explain fewer injuries with pitchers who deliver side arm “submariner”. However, the side-arm delivery is not the optimal angle to release the ball because the ball flight is flat and easier to hit. The change in trunk position also can lower the arm can change the abduction angle as well.

The motion of horizontal adduction is an important position concerning hyperangulation. There is approximately 30 degrees of motion between a horizontal abduction position and horizontal adducted position. The elbow is flexed approximately 90 degrees and will quickly extend to 20 degrees (13, 14, 2). Wilk et al has recently described a concept called total motion (15). Total motion is the throwers maximal external rotation plus maximal internal rotation. Many have published findings that pitchers have greater amounts of ER than position players do (9, 10, 15). However, this is compensated by decrease in internal rotation. Some theorize that the posterior capsule scars and tightens with repetitive throwing, leading to restriction of IR, particularly if the athlete becomes a thrower later in the teen years. Others suggest that the glenoid itself remodels during bone growth to a point where internal rotation has a bony block. The concept of total motion takes this into consideration, since the normal arc of motion of
pitchers is shifted compared to position players or the nondominant arm, but the total motion would be near the same. Large discrepancies

**Throwing phases**

The baseball pitch can be broken down into specific phases, each with specific muscle firing patterns and biomechanical activity. From beginning to end, the average pitch takes under two seconds to fully complete. However, deficiencies in any phases can dramatically alter performance and increase the risk of injury.

*Windup (balance)*: The thrower assumes this readying position as he or she faces the target to prepare to throw. This phase generates little energy, and only minimally loads the shoulder. Pitchers will take a step backward with the lead leg, keeping the push-off leg on the rubber. The athlete stays balanced, and the weight is placed over the push-off leg letting the trunk/core start to generate the arm into external rotation (early cocking). Windup is optimal when the weight is shifted from the push-off leg to the leading leg. The hands separate at the end of the windup, the body rotates 90 degrees, and the stride leg is elevated as the body faces the batter. The body should be balanced as the stride leg reaches maximal height and late cocking phase. The forearm is slightly pronated, shoulder slightly internally rotated, and the elbow flexed (24). Muscle firing is low at this point.

*Early cocking (stride)*: The stride motion begins at the end of the windup phase as the lead leg moves toward the target or plate. The key to high arm velocity is to keep the
trunk coiled as long as possible and delivery arm close to the body, to store the energy
before the transfer. As the lead leg moves toward the target the ball, the energy is
uncoiled and the push-off leg begins to move the body forward. As the stride foot makes
contact with the ground, the arm is semi-cocked. The stride length of a pitcher is slightly
less then their body height (2, 14).

Mechanics often break down at this point. If the stride foot too closed, the pitcher
will tend to throw across the body. If the stride foot is too open (“flying out”), then the
stored energy dissipates. Good foot position is slightly closed to neutral when the lead
foot hits the ground. Early activation of the deltoid occurs, while the supraspinatus,
infraspinatus, teres minor fire late.

Late cocking: Hip rotation starts in late cocking to prepare for acceleration. The shoulder
is at maximal external rotation, which eccentrically loads and stretches the internal
rotators. The shoulder has a large amount of energy available from the stored energy of
the legs, hips, and trunk. At this point, tremendous stress is on the anterior shoulder. The
forearm continues to stay pronated through out this phase. The subscapularis and
pectoralis major fire to form an anterior wall to prevent humeral subluxation.

The wrist begins to cock in preparation for the throw and final release. The elbow
remains flexed between 60-75 degrees, while the extensor carpi radialis brevis and longus
show high levels of activity. The medial elbow encounters high valgus load.

The deltoid firing decreases from early cocking, but the supraspinatus,
infraspinatus. teres minor reach maximal activity. Subscapularis, pectoralis major,
latissimus dorsi eccentrically fire to stabilize the humeral head as it moves posteriorly, then anteriorly in the following phases.

Arm Acceleration: The arm is ready to move to the target. The elbow begins to extend, closely followed by the beginning of humeral internal rotation. The trunk begins to flex as medial elbow endures tremendous load, specifically the medial collateral ligament (MCL) and the pronator/flexor muscle group (2). The pronator teres, flexor carpi radialis and ulnaris maximally fire at this point.

The triceps fires early in the phase, while the pectoralis major, latissimus dorsi, and serratus anterior fire late. The humerus moves through horizontal abduction to neutral, so the posterior capsule and cuff absorb minimal shear stress. This may explain why some pitchers are able to still play throw with profound posterior cuff weakness or injury. Arm acceleration is completed when the ball is released.

Arm Deceleration: The most violent phase of throwing occurs after the ball is released. The arm and body continue to follow toward the target, and the leg kick helps to decelerate the body’s momentum. The lead leg begins to extend as the push-off leg comes to meet it. Arm deceleration has reached its end point when internal rotation is at 0 degrees. The posterior rotator cuff and shoulder muscles fire eccentrically to slow internal rotation and prevent distraction at the glenohumeral joint, and the long head of the bicep adds traction to slow down the arm. Deceleration is also the largest amount of muscle activity by the elbow flexors. Significant eccentric activity occurs in the latissimus dorsi, subscapularis, and infraspinatus muscles.
Follow through: The follow through phase dissipates all the energy used to accelerate and decelerate the arm. It adds nothing to the velocity or control of the pitch, but a proper follow through minimizes injury risk. Shoulder abduction holds at about 100° and horizontal adduction increases to 35°. The follow through should have a longer path to have time to disperse energy. Large body regions should be involved, such as trunk flexion. Follow through ends with the throwing shoulder and hand ends at the opposite knee. Shoulder distraction and injury risk increases if the arm ends up towards the target instead of across the body at the opposite limb.

As stated previously in the above phases, the pitching delivery is different mechanically than position player throwing form. An infielder often throws off balance and side arm rushing to get the batter or runner out. Their deliveries are usually much shorter, quicker cocking and release phases. Outfielders often use a crow hop delivery. Crow hop delivery consists of a hop, skip, and throw. Crow hops can also be used as a drill for throwers having difficulty involving the core or trunk to help any thrower.

MUSCLE ACTIVITY

Muscle firing

EMG studies have reported that the supraspinatus is most active at late cocking, as anterior translation and migration off the glenoid is being controlled (16, 17). The upper trapezius, supraspinatus, and deltoid are maximally recruited during early cocking phase (18). The infraspinatus and teres minor are most active during late cocking and follow-through. The serratus anterior and subscapularis muscles are also active from acceleration to follow-through. The rotator cuff is not a prime mover in throwers, but
rather a stabilizer, particularly after 90° of elevation. The latissimus dorsi, pectoralis muscles, and the subscapularis muscle are the prime movers during internal rotation and acceleration phase. The lower and middle trapezius continues to stabilize the scapula through acceleration. Furthermore, the core or trunk generates significant power; as the latissimus dorsi originates from the thoracolumbar fascia and lumbopelvis. Thus, latissimus stretches should be part of the warmup.

There are significant force couples that exist at the shoulder complex. The joint couples are the rotator cuff/deltoid, subscapularis/infraspinatus, and trapezius/serratus anterior (19). The serratus and lower trap muscles work together at about 120 to 140° of elevation to limit the amount of scapular posterior tilt to help the acromion clear the GH joint. Happee noted 40% thoracoscapular muscle activity with forward arm movement versus 18% noted at the rotator cuff (20). So far in sited research on high amounts of eccentric EMG activity on the cuff at the deceleration phases seems vague. During deceleration phase the teres minor, lower trap, subscapularis, and posterior deltoid are recruited most to resist the amount of force moving forward towards the target (18).

**Ground Reaction Forces and the Kinetic Chain**

Many have hypothesized that the breakdown in the kinetic chain is the reason for shoulder problems (13, 21, 22, 23). The ground reaction force is the beginning of the kinetic chain and defines the art of throwing, and disputes that it’s not just an arm (shoulder) only activity. The transfer process in throwing starts from the ground, to the legs, then the trunk, the shoulder, next to the arm, and finally to the ball. Kibler (orthopedic surgeon) notes that the hip and trunk provide the most energy (51-54%),
while the shoulder only provided 13% of the energy and 21% of the force to the link in overhead activities (22, 23).

MacWilliams et al (24) evaluated ground reaction forces and showed that push-off forces gradually increased during wind-up and reached the highest before foot contact. After the lead foot hits the ground, the energy is then transferred through the body via the trunk and into the arm to deliver the ball. This study also suggested that the greater the push-off magnitude, the greater the kinetic energy into the upper limb. Hence, lower extremity problems or dysfunctions can break down the transfer process in the kinetic chain. Do not overlook the disadvantages to uncontrolled lower body power and shoulder girdle weakness. This possibly could create sheer forces that can cause damage to the shoulder complex.

**COMMON INJURIES**

Baseball injuries are usually a result of breakdown, as opposed to high-energy collision sports such as football and hockey. Baseball has minimal player-to-player contact, very few off-days in the major and minor league seasons, and adolescent players who demonstrate velocity or precocious skills tend to play as much and as long as they can. Accumulation of wear and tear without ample opportunity to recover can lead to chronic injuries. This precept admittedly applies to almost any sport, but the repetitious nature of the sport subjects the body to consistent loads that challenges collagen tensile strength and muscle endurance. For instance, a major league pitcher who starts 35 games for a team and throws 90-100 pitches will have thrown up 3500 pitches in a season, not including warm-ups, spring training, and in-between days. Depending on the pitcher,
those pitches can vary in difficulty and torsional force (fastball versus split-finger). An average major league batter may swing at anywhere from 4-10 pitches each game, which can extrapolate to anywhere from 2400 to 6000 swings in roughly 600 plate appearances, and that does not including daily batting practice. This accumulation of low load activity yearly can be difficult to tolerate if little effort is made in conditioning and flexibility.

Injuries are a part of sports, but many in baseball can be limited or prevented by conditioning, training, and practice. Baseball players will use the off-season to make gains in flexibility, strength, muscle endurance, and core stability. In-season programs, years ago considered detrimental to performance, are now mandatory on major league teams. These are designed to maintain endurance and any off-season gains that were made, not necessarily to build strength. Programs need to be tailored to the position and athlete, depending on their skills and needs.

The throwing athlete must be an efficient mechanical machine reproducing optimal mechanics as often as humanly possible. Though we will discuss specific injuries in the elbow, shoulder, and spine, all are interconnected and impact each other. Shoulder instability can initially manifest as elbow pain, lumbar pain can limit follow-through and cause rotator cuff impingement, and mid-thoracic pain can limit retraction of the scapula, which is crucial to the cocking phase. This is the kinetic chain in action.

**Common areas of breakdown**

Throwing a baseball is an unnatural act for the shoulder. Even if an athlete is well prepared and healthy, he or she can still develop shoulder pain just by throwing too much or without proper rest or warm-up. Cohen et al describe four categories of causes for
injuries to the pitching arm: 1) conditioning, 2) fatigue, 3) overuse, and 4) mechanical flaws (Cohen et al. Shoulder injuries. In Brotzman, Wilk ed: Clinical orthopedic rehabilitation. St Louis, Mosby, 2003.) In all these cases, the essential underlying element is the failure of soft-tissue constraints to withstand the stress loads from throwing pitches. Whether the cuff fatigues from too many pitches, the anterior capsule strains from the shoulder opening too quickly during the throwing motion, or poor conditioning causes the trunk and legs to tighten later in the season, the end result is an unstable and inefficient joint.

Changes in the throwing mechanics often lead to shoulder and elbow injury, even from body regions far from the shoulder, as any injury or dysfunction can disrupt the kinetic chain (Kibler, Gambetta, McMullen, Gray). For instance, Achilles tendinitis can affect a pitcher's push off the mound. This limits the generated force to the trunk, which the shoulder and elbow tries to replace. Often, the effort to compensate for a force deficit alters the natural motion and energy distribution in the kinetic chain. Complete wind-up with the lead leg reaching its highest point must happen to insure optimal energy coil, as well as preventing a free fall towards the plate that would decrease velocity. Tissue has finite stress loads, so structures like the ulnar collateral ligament or the rotator cuff break down when so goes the kinetic chain.

Another example is improper foot planting during follow through. The foot should be in front and pointing to home plate. A front foot planted outside the plate (towards 1st base for a right-handed pitcher) leads to early opening of the hips during delivery, hyperextending the shoulder and increasing load on the shoulder and medial elbow as it lags through the delivery. The front foot planted too far in (towards 3rd base)
usually leads to early ball release and loss of accuracy. It could restrict hip rotation, limiting momentum and energy transfer, and cause the arm to be the main source of velocity (Meister).

Other examples of mechanical breakdown are as follows:

1) The forearm does not pronate fully before ball release. For right-handed pitchers, the ball should face the shortstop, while the left-hander should have the ball facing the second baseman before release.

2) Shoulder hyperangulation is another problem. If the arm moves out of the scapular plane and excessively abducts during late cocking, the humerus overrotates and increases internal impingement. This position during pitching is known as the “slot”, which is usually overhead or three-quarters. In either case, the humerus should ideally stay at 90-100° to the scapula. Throwing outside of that range increases the risk of injury.

**Medial collateral ligament injury**

In baseball, medial collateral ligament (MCL) tears are usually season-ending injuries. Complete tears require reconstruction, 12-15 months of rehabilitation before returning to the sport, and a 70-90% chance of returning to previous level of competition, while partial MCL tears had a 42% failure rate of nonoperative treatment in returning to the mound (athlete’s elbow).

Failure occurs usually after chronic repetitive overload of the ligament; very few ruptures occur acutely in baseball. This load comes from the tremendous valgus force generated by throwing a pitch. These are highest during late cocking and early
acceleration, which is when the elbow moves from flexion to extension (athletes elbow). Valgus stability comes primarily from the anterior bundle of the medial collateral ligament and secondarily from the radiocapitellar joint. Repetitive valgus load from pitching explains such chronic changes as MCL thickening, radiocapitellar osteophytosis, and osteochondritic dissecans of the capitellum.

Once the ligament is attenuated and valgus laxity develops, several subsequent problems can occur:

1. Bony impingement of the olecranon and its fossa, which can lead to irritation, chondral lesions, and osteophytes, which leads to increased impingement.

2. Ulnar nerve traction injury, which can cause ulnar neuritis, nerve compression in the cubital tunnel, and even neuropathy. Some studies noted 40% of patients with valgus instability had ulnar nerve symptoms (Conway, Azar).

3. Increased compression in the radiocapitellar joint, which can lead to reactive bony changes, osteochondritis dissecans, and degenerative osteoarthritis.

The athlete with chronic injury will present with medial elbow pain while throwing, sometimes with radiation around and down the ulna. Intensity of pain may increase with more throwing or longer duration of symptoms. Pain usually occurs during early acceleration phase, and velocity may decrease. An acute on chronic injury will typically have a moment with a “pop” and subsequent inability to throw hard. This may follow a period of time where the athlete has minimal or mild medial elbow symptoms. An acute traumatic injury is rarely seen in baseball.

Physical exam should target several issues:
1. Etiology and reproduction of the pain and symptoms
2. Irritability of the ulnar nerve
3. Assess valgus stability and MCL competency
4. Evaluate for posterior olecranon impingement.

Standard Treatment

Nonoperative management of MCL disruption in non-throwing athletes is effective, even with acute traumatic complete ruptures. Less success is seen in the competitive thrower, with less than half recovering from the injury without surgery. Rehabilitation focuses on improving muscle endurance in the periscapular and shoulder girdle muscle, strength in the wrist flexors, pronator, and rotator cuff muscles. Complete tears in throwing athletes are often reconstructed to allow return to play. Partial tears that fail rehabilitation and throwing program are also candidates for reconstruction.

Manual medicine approach

The elbow needs a smooth transition from flexion to extension during the acceleration phase. Reasons for restriction include proximal radioulnar joint dysfunction, distal bicipital dysfunction, and dysfunctional extension of the olecranon into its fossa. Bear in mind that arthritic changes may be resistant to manual treatments, and that many pitchers develop slight flexion contractures (usually less than 10°) during their career, yet perform without difficulty, since the arm never truly reaches full extension during a pitch. So every pitcher with a contracture may not need treatment, yet those with arthritic changes could still benefit.
Extension dysfunction can be treated by muscle energy to the biceps that engages the extension barrier. Radial head dysfunctions can be treated with muscle energy or HVLA, while joint play techniques can improve medial or lateral tilt of the olecranon so as to allow unrestricted end-range extension.

Valgus overload leads to attenuation and eventual failure of the MCL if nothing intervenes in the process, so early identification of medial symptoms is crucial. However, the factors relating to MCL injuries are usually seen away from the elbow. Common related factors include: violent or inefficient throwing mechanics, excessive pitch counts with insufficient recovery, premature shoulder extension during transition to acceleration phase, and poor shoulder stability.

The scapula is a crucial link for energy distribution in the kinetic chain. The scapula must retract fully during cocking, then protract during acceleration. Restriction in either motion will destabilize the shoulder and invite compensation from the surrounding muscles to accomplish the task. Invariably, the force not dissipated by the restricted and unstable scapula gets transmitted to the elbow and increases valgus load. The cumulative effect of this load over time is ligament failure. Counterstrain, myofascial release, and muscle energy techniques can be applied to muscles that restrict the scapula as discussed in the shoulder section. Specific trouble areas to evaluate are levator scapulae, latissimus dorsi, and the mid-thoracic spine and its muscles that originate from there. Counterstrain trigger points can be easily identified and treated.

Any thrower with elbow pain recalcitrant to standard treatment should have a complete musculoskeletal assessment done to diagnose and treat any somatic dysfunctions along the kinetic chain.
**Thoracic dysfunction**

Many players will complain about stiffness or discomfort between the scapula. Throwers use the thoracic spine between T1-T8 to be the anchor for the medial scapula from where retraction and protraction occurs. The cocking phase is when the scapula is fully retracted against the spine, so any limitation to scapular retraction affects the scapular position and destabilizes the shoulder from cocking into acceleration. As the upper body cocks, the thoracic spine extends, then flexes through late acceleration, deceleration, and follow through.

Additionally, the batting swing violently torques the thoracic spine, although the amount of motion is limited due to the rib cage and multiple ligamentous and muscular attachments. Thoracic extension lesions are also generated by weight lifting, specifically bench press. Any lifting that requires or encourages thoracic extension may promote extended vertebral dysfunctions.

These are not typically serious injuries that disable a player, although the possibility of a herniated disc or thoracic vertebral fracture must be entertained in significant long-standing pain resistant to conservative therapy. This area frequently becomes dysfunctional, restricts motion, and can affect muscle firing and scapular retraction.

**Manual medicine**

Soft tissue should be prepped with massage techniques to loosen up the muscles and subcutaneous tissue. The use of HVLA in the thoracic spine is acceptable and can restore
mobility and give relief. Paravertebral muscle spasm would make HVLA more difficult. Single segmental dysfunctions can also be treated easily with muscle energy or counterstrain.

   Myofascial techniques should then be applied to the scapula, including scapular rotation myofascial release. Muscle energy to the levator scapulae, trapezius, and C7-T1-1\textsuperscript{st} rib complex (using the scalenes) should follow. Dysfunctions in glenohumeral articulation or cervical spine can be diagnosed and treated as well.

**Glenohumeral instability**

Throwing a 90 mph fastball is not a natural act for the shoulder. When the small rotator cuff muscles are abused, the glenohumeral joint destabilizes, and throwing becomes difficult. The four muscles work with the static shoulder stabilizers (capsule, glenohumeral ligaments, labrum) to form a kinematic, not anatomic, ball-and-socket joint. These kinematics allow the humerus to rotate enough to allow a throw, yet the stability is not from bony elements, like the hip ball-and-socket, but from soft tissue. Any breakdown in the soft tissue constraints such as mentioned above will disrupt these kinematics. Various factors can cause glenohumeral instability, such as the following:

- Anterior instability (pitchers)
- Posterior instability (hitters)
- Acquired capsular laxity versus posterior capsule scarring, leading to anterior instability
- Humeral subluxation/dislocation (sliding/diving)
- SICK scapula syndrome
• Rotator cuff weakness secondary to tendinitis, SLAP tear (can be to overuse, excessive distraction forces)

• Labral pathology (SLAP, posterior impingement syndrome)

• Internal impingement (posterior-superior labral pathology)

Instability in a baseball player is classified into groupings based on whether the cause is from microtrauma, hyperlaxity, or a traumatic event (Jobe FW. Operative techniques in upper extremity sports injuries. St Louis, Mosby, 1996). Identifying the category for the athlete will aid in developing an effective treatment program.

Just throwing a baseball will stress these constraints, and they need strengthening and proper rest. Any pain from the shoulder needs to be treated to avoid inhibiting and weakening the rotator cuff, which may mean no throwing for several days. A painful rotator cuff will get weak and allow the humeral head to move out of its stable position in the glenoid fossa, primarily due to imbalance with deltoid contraction.

*Standard treatment*

In general, the underlying causes of instability must first be diagnosed and treated. This is paramount, because early instability is when nonsurgical injuries can become surgical problems if not addressed by the coaches, trainers, or doctors.

Next, rehabilitation moves in phases, which will be adjusted if the athlete needs surgery for stabilization. Some the basic aspects are as follows:

• Establishing full range of motion

• RC **eccentric** strength (first isometric, then isotonic, then end ranges of motion, then functional proprioceptive neural facilitation)
- Scapular stabilization (lower and upper trap, forced couples, serratus anterior, eccentric control of the rhomboids).
- Rhythmic stabilizations using dynamic proprioception exercises.
- Throwing program (chapter 14) before return to play.

In particular, scapular stabilization is crucial due to its effects along the kinetic chain. For instance, a thrower with poor rhomboid strength requires the lumbar paraspinal muscles to work too hard to compensate. This weakens important scapular stabilizers (serratus anterior, upper and lower trapezius). Every muscle off the coracoid process then tightens, which increases protraction and anterior tilt, which inhibits muscle firing of the posterior scapular muscles, making the scapula, and the whole shoulder, less stable.

**Manual medicine**

Batters and pitchers need to be able to transfer energy from their legs and trunk into their arms and hands, and manual medicine techniques should be used to facilitate this. No amount of manipulation will repair structural damage or eliminate cuff tendinitis, and proper recognition of its limitations is important, particularly in the elite baseball athlete.

Manual medicine is most effective during the early onset of symptoms, near return to play, and maintaining homeostasis in a long season. Because the baseball seasons are longer than any other sport, the accumulation of repetitive stress over months can cause fatigue, microtrauma, and compensatory changes that affect the kinetic chain. Manual medicine can catch and eliminate those changes before dysfunction becomes injury, or possibly surgery.

Manual medicine techniques are effective to the following areas:
1. Latissimus dorsi, trapezius, and levator scapulae inflexibility: This increases supraspinatus impingement.
   Techniques: stretching, muscle energy, counterstrain, functional, massage

2. Glenohumeral mobility: Loss of internal rotation and posterior capsular tightness
   Techniques:
   - Anterior, inferior, posterior capsular stretching
   - Muscle energy
   - Seven stages of Spencer
   - Counterstrain to posterior rotator cuff, latissimus, and teres major
   - Thoracic mobilization
   - Scapular myofascial release (rhomboids, serratus, trapezius)
   - Articulatory release to C7-T1-1st rib complex

3. Thoracic vertebral dysfunction: Scapula not able to retract properly
   Techniques:
   - HVLA thoracic mobilization
   - Muscle energy or Counterstrain

4. Excessive shoulder protraction from tight pectoralis minor
   Techniques:
   - Myofascial release
   - Counterstrain to weak posterior scapular muscles

5. Lumbosacral dysfunction: This often manifests as pain in extension, localized at the left or right PSIS, and lower lumbar stiffness. The components of this
dysfunction usually include a sacral torsion, rotated or sheared innominate, L5 dysfunction, ipsilateral gluteus medius trigger point, iliopsoas or anterior hip capsule restriction, and unilateral hip internal rotation limitation. Erector spinae spasm, piriformis dysfunction, iliolumbar ligament pain, and pubic symphysis dysfunction may also be noted.

This problem can affect a pitcher in late cocking and early acceleration, and somewhat in deceleration and follow through if there is muscle tightness limiting flexion. A batter can have problems with the end-range of the swing, limiting available torque power, and potentially limiting the player from reaching out for pitches. The techniques preferred by the author for this scenario is the following (reevaluation is done after each technique, so that steps are not performed if the lesion is already resolved):

Pubic symphysis release and piriformis stretching → lumbar articulatory technique → muscle energy for sacral torsion (treat with posterior ILA down) → muscle energy L5 (and higher) dysfunction → muscle energy and/or joint play mobilization for iliopsoas and anterior hip capsule → muscle energy for rotated innominate or shear, or HVLA for an upslip innominate → treat dysfunctions elsewhere found on screening exam.

PREVENTION

Throwers need to be educated about what they can do for themselves, and compliance should be mandated. A basic thrower injury prevention program includes self-stretches for the capsule, shoulder girdle, neck, and core; overall conditioning of the entire player;
proper warm-up and cool-downs during workouts and games; pitch counts to monitor fatigue and limit overuse; strengthening and proprioception training of the rotator cuff, shoulder girdle and scapular stabilizing muscles, both off-season and maintenance during the season. The in-season program should be less intense than the off-season one. The “thrower’s ten” exercises described by Andrews and Wilk and discussed in chapter 14 are designed to strengthen those muscles used in throwing.

USA Baseball updated recommendations for youth baseball in July 2003 to prevent injury. One of the most important points made was on using and enforcing pitch counts. Pitchers 9-10 years old should not throw more than 50 in a game, while ages 11-12 and 13-14 can throw up to 75 per game. Weekly, seasonal, and yearly counts should be kept and monitored as well. Also, breaking ball pitches should not be thrown until at least 13 years old, and only if taught by a coach. Mechanics should be emphasized over learning new pitches.


- Discussion:

- phases of throwing:

  - windup

  - early cocking

  - late cocking

    - wrist begins to cock in preparation for the throw and final energy release.

    - begins when the pitcher's front foot touches the ground and terminates with maximal humeral external rotation;

    - elbow remains flexed between 60 deg to 75 deg

    - ECRB and ECRL show relatively high levels of activity;

    - significant valgus force at elbow occurs at this stage (maximal MCL stress);

  - acceleration

    - starts with maximal humeral external rotation and ends with ball release;

    - elbow experiences a rapid combination of valgus and extension;

    - significant valgus force at elbow occurs at this stage (maximal MCL stress);

    - maximal activity in pronator teres, FCR and FCU;

    - extended wrist flexes at this stage;

  - deceleration

    - shows the largest amount of muscle activity by the elbow flexors

    - follow through

- Diff Dx:
- **osteoochondritis dissecans of the capitellum**:

- **osteocondrosis of the medial epicondyle**:

- **posteromedial olecranon osteophytosis**:

  - chronic repitative throwing in the young adolescent w/ lax joints, can cause impingement of the medial tip of the olecranon on the posteromedial tip of the olecranon fossa during the terminal swing phase of throwing;

  - results in posterior ulnohumeral impingement, restriction range of motion (extension), ulnar nerve compression neuritis, and loose body formation;

  - patient may show tenderness over the posteromedial aspect of the olecranon and a mild **flexion contracture**;

  - posteromedial tenderness may be exentuated as the elbow is brought into extension;

  - either open or endoscopic osteophyte removal is curative;

- **medial tension overload**:

  - muscular (flexor pronator group)

  - strain (minor tears)

  - **MCL strain or rupture**:

    - ulnar traction spurs

    - calcium deposits

    - medial ligament instability

  - fascial compartment syndrome
- **medial epicondylitis**

- medial epicondyle apophysitis (little leaguer's elbow);
  - look for irregular ossification and overgrowth of the medial epicondylar apophysis;
  - w/ cessation of throwing, tenderness will resolve, and ROM will be restored;
  - reference:
    - Little leaguer's elbow.

- **avulsion of the medial epicondyle**

- misc:
  - extension overload
  - triceps muscle strain
  - **avulsion fracture** tip of olecranon
  - olecranon hypertrophy
  - loose bodies in the olecranon fossa
  - tears of brachialis and anterior capsule
  - **fixed flexion contracture**;
  - **posterolateral instability**

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Ulnar nerve entrapment syndrome in baseball players.

**Anterior angulation deformity of the radial head. An unusual lesion** occurring in juvenile baseball players.
Correctable elbow lesions in professional baseball players. A review of 25 cases.

Medial instability of the elbow in throwing athletes. Treatment by repair or reconstruction of the ulnar collateral ligament.

Olecranon stress fractures in throwers. A report of two cases and a review of the literature.

Traumatic ulnar neuropathy in adolescent baseball pitchers.

Bony Injuries about the Elbow in Young Throwing Athletes.

Throwing injuries of the elbow.

An electromyographic analysis of the elbow is normal and injured pitchers with medial collateral ligament insufficiency.

Elbow Problems Associated with Baseball during Childhood and Adolescence.

Persistence of the olecranon physis: a cause of "little league elbow."

An electromyographic analysis of the upper extremity in pitching.

watching the “pitch count”, and warming up properly.


Softball Delivery: Windmill softball pitch is very unique throwing style. The fastball softball pitch is very different than the overhead throwing style. The overhead throwing style has been extensively analyzed and to date there are significantly more research
studies completed. However, the fastball softball pitch has not been as critically evaluated. The softball pitch does however how distinctive phases, which can be depicted. Maffet et al (26) depicted 6 phases to the windmill pitch: 1) Windup 2) 6 O’clock 3) 3 O’clock 4) 12 O’clock 5) 9 O’clock 6) Ball release and follow-thru.

The windup and 6 o’clock phase consist of the windup stage. The 3-12 o’clock phase provides the stride component. The 12 to 9 o’clock together is the delivery stage, and finally the ball release and ending arm position is the follow-thru stage. Biomechanically, the internal rotation velocity of a windmill softball pitch is over 4,000 degrees per second (27). This probably contributes to very high levels of pectoralis major and subscapularis activity (motion of adduction and internal rotation). The windmill pitch is a circumduction of the arm about the glenohumeral joint from the beginning of the stride phase to completion is a total of 485 degrees (27). Although, there is probably a fair amount of humeral rotation, there undoubtedly demands placed on the elbow and wrist musculature. The fingers also must play a role on ball release to provide a variety of spin, and ultimately creating different ball movement. One of the most prominent contributors to ball velocity is the internal rotation of the humerus as a resultant of the shoulder’s internal rotation torque. The windmill pitch has a few differences, which are less acute to the rotator cuff than the overhead style. For example, the windmill pitch is in the sagittal plane or the plane of the body, decreasing significantly the amount of torque on the posterior cuff muscles at deceleration (28). Furthermore, the eccentric phase to the rotator cuff after ball release is drastically less
than the overhead throw because the hand hits the thigh (thigh slap) to help decelerate the arm (28).

Glenohumeral instability:

Anterior instability (pitchers)
Acquired laxity versus posterior capsule scarring leading to anterior instability
Posterior instability (hitters)
Subluxation/dislocation (sliding/diving)
SICK scap
Rotator cuff weakness secondary to tendinitis, SLAP (can be to overuse, excessive distraction forces)
Labral pathology (SLAP versus posterior impingement syndrome)
Internal impingement

Standard treatment (GH instability)
Correct pathology if possible
Rhythmic stabilizations: Dynamic proprioception exercises
RC eccentric strength (first isometric, then isotonic, then end ranges of motion, then functional PNF)
Scapular stabilization (lower and upper trap, forced couples, serratus anterior, eccentric control of the rhomboids).
With poor rhomboid strength, lumbar paraspinals work too hard, serratus/upper and lower trap weaken, then more scap inst.
Everything off of coracoid process tightens, which increases protraction and anterior tilt, which inhibits muscle firing of the posterior scapular mms.

Throwing program (thrower’s ten exercises, pre and post program exercises)

Manual medicine
Lat, trap flex (Stretch, muscle energy)
Thoracic mobilization
Scapular myofascial
Seven stages of Spencer
C7-T1-1st rib

Elbow:
Medial collateral ligament failure
Grade 1 through 3
Excessive valgus loads
Throwing mechanics
Premature hip rotation during throwing (plant foot, hip path/dysfunction/restriction)
Body (shoulder) leads elbow
Violent (overthrowing)
Inability to retract scapula to a stable base (rhomboid weakness, thoracic dysfunction, anterior muscle restriction)

Standard treatment (grade 1 or 2):
Acute phase
Correct flaws
Treat shoulder and mechanics
Throwing program

Manual techniques
Joint play olecranon tilt
Radial head treatments
Shoulder and scapular treatments
Elbow extension muscle energy

Little Leaguer’s elbow (pitch types)
Medial epicondylitis

Lumbosacral dysfunction
Pitchers versus position players
Hip flexor dysfunctions
Hamstring (acute/chronic) pathology
Dynamic short leg syndrome

Manual treatment