ICSC06 Upper Extremity Module 6
Part 2 Basics of Biomechanics
Instructor: Steven Smilkstein
Video Lesson: 48:444 minutes

This is a simple guide to pick up on normal and abnormal biomechanical limb in the upper extremity. In this section, we will be looking at basic concepts in joint anatomy and the types of diarthrodial joints, joint function in the form of kinematic chains and arthrokinematics. We will also be looking at muscle and tendon physiology, muscle physiology and biomechanics, common injuries in muscles, injury-grading of muscles, and related sports and rehabilitation. We will also be looking at ligament physiology, common injuries in ligaments, injury-grading of ligament injuries, and related sports and rehabilitation.

The shoulder complex may seem very complicated, but if we divide it into the four main joints that compose the shoulder complex, we are able to simplify it by understanding the anatomy, the structure, and the function of each joint. We will look at the sternoclavicular or SC joint, the scapulothoracic or ST joint, the acromioclavicular or AC joint, and the glenohumeral, or GH joint. We are going to look at the concepts of stabilization and the ranges of motion that the shoulder can go about.

As said previously, the shoulder can be divided into four separate joints: three true joints and one false or pseudo joint. The three true joints are the acromioclavicular or AC joint, the sternoclavicular or SC joint, and the glenohumeral or GH joint. The pseudo joint or false joint is the scapulothoracic joint, which interacts with the posterior chest wall. It is known as an intermuscular joint as the surface of the subscapularis and the chest wall interact with each other.

The sternoclavicular joint or SC joint. This is the direct link for the entire shoulder complex to the axial skeleton directly. It consists of two concave surfaces separated by an intra-articular joint disc. This is the main connection between the manubrium of the sternum and the medial head of the clavicle. It is a planar type of joint with three degrees of freedom. The movements that we can see at this joint are elevation and depression of the clavicle, protraction-retraction of the clavicle, and anterior and posterior rotation of the clavicular complex. It is supported and limited by very strong and elastic ligaments, namely the sternoclavicular, the costoclavicular, and the interclavicular ligaments.

The most common injury seen at the SC joint is 'SC joint separation' or 'subluxation'. It is commonly seen in contact sports or where there is impact to the shoulder. The subluxation can occur either in an anterior manner where we see the clavicle displaced anteriorly, or in a posterior manner where the clavicle has displaced posteriorly. A posterior subluxation can result in respiratory distress and needs to be treated as a medical emergency, which either includes immediate reduction or manipulation of the arm to the point where the [inaudible] the stress is eliminated before we can get the patient to an emergency room.

The acromioclavicular joint, or AC joint, forms, a protective bony arch above the glenohumeral joint. This is a planar synovial joint where the two convex surfaces, one from the acromion process of the scapula, and the second from the lateral head of the clavicle, will slide across each other. The joint is supported by a very strong joint capsule and is further supported by two major extrinsic ligaments being the coracoacromial ligament and the coracoclavicular ligament. There may be an intra-articular disc. The primary motions at the acromioclavicular joint are seen as anterior or posterior tipping of the scapula, or medial or lateral rotation of the scapula, or superior and inferior translation of the clavicle on the acromion or the acromion on the clavicle. The SC joint is susceptible to degeneration and trauma due to the of muscle tissue and fat pads that protect most joints.

Most common injury to the AC joint is AC joint separation. It is commonly injured in contact and impact sports. It is graded by the direction and amount of displacement noted. There are two main thoughts of classification regarding AC joint separation. The first is the standard ligament injury grading system where you see Type 1, which is minor microscopic injury to the ligament with little or no displacement of the joint. Type 2 with macroscopic but non full thickness tearing of the ligament, which can be seen in ultrasound and or felt in palpation. There is some minor displacement or instability found at the joint. Type 3 is macroscopic full-thickness tear of the ligament tissue, and you can see quite apparent displacement of the joint itself.

Your second type of classification is your Rockwood's six types of classification of AC joint separation. Your first three stages are the same as your standard grading ligament injuries system. Your Type 4, you see separation but also minor injury to the trapezius and deltoid muscles. Your Type 5 is the complete separation of the clavicle away from the joint itself and sometimes, penetration through the trapezius muscle. Your type 6 classification, this is only in an overhead injury where the scapula is over-rotated over the clavicle, and the clavicle is displaced and moved under the bicep’s tendon and pectoralis minor muscle. This is clinically significant as it may be impinging on the apex of the lung and all pulling onto the brachial plexus. This is quite a radical injury and needs immediate surgical intervention.

The scapulothoracic or ST joint. This joint is considered to be a false joint, or a pseudo joint, as it does not have the typical characteristics of a normal diarthrodial joint. The joint itself is lacking any synovial lining or hyaline cartilage interactions. The joint is made up of an inter-muscular articulation between the anterior surface of the scapula covered by the subscapularis muscle, and the posterior chest wall and intercostal muscles. The joint itself does form a true closed kinematic chain and support system for the AC and SC joints while allowing dynamic motion to occur at the glenohumeral joint with dynamic support. The movements that can be seen at the scapulothoracic joint are elevation and depression of the scapula, protraction and retraction of the scapula on the chest wall, and upward and downward rotation, or tipping, of the scapula.

Scapula winging or dyskinesis. This kind of injury is commonly caused by falls, impact, and or contact sports. It can also happen insidiously by postural changes and or connective tissue disorders. There are three types of scapular wing: true winging, pseudo-winging or false winging and voluntary winging. True winging is due to weakness only of the serratus anterior muscle which may be caused by a long thoracic nerve palsy. This can happen due to tackles under the arm into the chest region just in line or anterior to the scapula, and or falls onto the side of the chest. Rhomboid or pseudo-winging is caused by palsies to the rhomboid muscle or damage to the rhomboid muscles. The third or voluntary winging is commonly caused by connective tissue disorders, where the patient is able to move the scapula and also lifted voluntarily off the chest wall.

Pay attention to the difference in characteristics of each type of winging. For example, in true winging, the interior angle of the scapula lifts off the chest wall. This is due to the anatomical location of the serratus anterior and therefore, the rest of the scapula is able to stabilize and plant itself on the chest wall. In false winging or pseudo-winging, we see the complete medial border of the scapula lifting. Therefore, the two differences in patterns do indicate what structures are causing the problem. Involuntary winging. A clear history will indicate whether the patient is in a state of voluntary winging or if the other two pathologies are more prominent.

Glenohumeral joint or GH joint. This is the most mobile yet most unstable joint in the entire body. It is a ball-and-socket joint with three degrees of freedom. The humeral head is three times larger than that of the surface of the glenoid. Therefore, it is extremely mobile but very unstable. In order to support this, the body has grown very strong ligaments, but they are not able to support the extremes of motion. The glenoid labrum develops in order to deepen the glenoid socket in order to create congruency for the articulation.

The glenohumeral joint is stabilized by two main factors: one, static stabilization, and the second, dynamic stabilization. This incorporates both the rotator interval capsule and the rotator cuff muscles. Accessory, stabilizers are also incorporated, that being the two heads of the biceps brachii muscles. In these two images, you will see the dense connective tissue and ligaments that support the glenohumeral joint. Also, the design and the shape of the glenoid labrum in order to deepen the socket for the glenohumeral joint. This is the most important factor that stabilizes the shoulder.

Glenohumoral dislocations and subluxations. Dislocations and subluxations are the most common injuries in high force contact sports such as rugby and football. They can also be due to instabilities caused by throwing sports such as water polo, cricket, or baseball. All glenohumeral dislocations result in an inferior displacement of the humerus, but also have a distinct pattern depending on the direction of displacement anterior or posterior to the glenoid. On an anterior dislocation, the humerus is usually displaced in an abduction, external rotation, and extension combination of movements. Therefore, the upper limb will be stuck in abduction, extension, and external rotation. In a case of a posterior dislocation, the humerus is usually displaced in adduction, internal rotation and flexion. Therefore, the upper limb will be fixated in an adduction, internal rotation, and flexion position.

When dealing with a patient with a shoulder dislocation or instability, it is very important to remember several factors which may influence your decision to reduce on size. The most important factors are: 'are you able to reduce it immediately?', 'are you able to get the patient to hospital, which is a primary care facility?', 'do you have a good follow on post-adduction imaging system such as x-rays or CT scans?', 'do you have sufficient professional involvement in EMTs or other doctors?', 'what is the risk reward factor of reducing on-site immediately?'

Posterior dislocations of the shoulder are the less common version of shoulder dislocations because it needs quite a hard force at the length of the humerus in order to displace the head of the humerus posteriorly against the bony protective acromial arch. The patients present with the shoulder slightly flawed, forward inflection, adduct it, therefore the elbow, would be closer towards the trunk, and internally rotated as the posterior lip of the glenoid will be pushing on the anterior aspect of the intertubercular groove.

Anterior dislocation of the shoulder is the most common version of shoulder dislocation due to the lack of bony restraint on the anterior aspect of the glenohemural joint. Anterior dislocations present with the shoulder in an external rotation, abduction, and extension position. Therefore, the patient will present with the elbow tucked posteriorly, the arm externally rotated, and the shoulder or elbow slightly abducted away from the torso of the patient.

Biomechanics of the shoulder as a whole. The first shoulder biomechanical concept that we will be discussing is 'scapulohumeral rhythm.' This is the rate of movement between the shoulder at the glenohumeral joint and the scapulothoracic joint in order to accommodate the glenoid surface to maintain congruency of the glenohemural joint during movements of abduction. It is the overall contributions of movement from scapular and the humerus in the motion of abduction. When the arm is abducted in an arc of 0 degrees to 180 degrees, the humerus and the scapula move at a ratio of two to one. The scapula movement allows for stability and increased congruency between the glenoid and the head of the humerus during abduction. Any pathology of the shoulder has a tendency to reverse the ratio, and we see a one to two ratio called 'reverse scapulohumeral rhythm.

It is thickened by mechanical concept that we will be discussing true shoulder stabilization. This can be divided into two forms of stabilization at the glenohumeral joint. Firstly, static stabilization with the rotator interval capsule and resting muscle tone are responsible for stabilization at the glenohumeral joint while the arm is dependent. The second dynamic stabilization is when active rotator cuff muscle interaction creates a counter force and a compressive joint force on the glenohumeral joint.

Static stabilization of the glenohumeral joint. When the arm hangs at the side, the humeral head rests in the glenoid fossa and labrum. Gravity, being the main force that acts on the upper limb, will pull down in a parallel force to the shaft of the humerus. The upper limb needs to maintain equilibrium or an inferior dislocation of the joint will occur. There is no muscle contraction found in this mechanism. Gravity acts on the humerus as a translate-free force distant from the center of the rotation, and results in an adduction moment on the joint. The adduction moment is counterbalanced by the tension of the rotator interval capsule. Only when the passive counter force of the rotator interval capsule is inadequate for static stabilization, there will be involvement from the supraspinatus muscle. Although the supraspinatus and subscapularis muscles are not active in the unloaded arm at the side, if they are paralyzed or dysfunctional, it can lead to a gradual inferior subluxation of the glenohumeral joint as their fibers invest in the rotator interval capsule.

In these two diagrams, you can see how static stabilization maintains equilibrium by creating a vector-pulling force that will draw the humerus out of an adduction moment. If you look at the green cross in figure 7.34, it signifies the axis of rotation at the glenohumeral joint. The act of gravity will pull the humerus parallel to the shaft, and due to the shape of the humeral head and the angle of inclination, the humerus will have a tendency to move into an adduction position. Hence, the term 'adduction moment.'

The natural muscle tone of the supraspinatus and subscapularis muscles will counterbalance that adduction moment unless they are paralyzed. The rotator interval capsule is a small triangular piece of anterior capsule found between the tendons of the supraspinatus muscle and the subscapularis muscle. Therefore, any damage or injury to the muscles will have an effect on the rotator interval capsule that makes stabilization of the glenohumeral joint. This is where stabilization is implemented during the initiation of abduction.

The direct action of the deltoid muscle can be identified as two components: one, a large translate reforms upwards; and two, a small compressive force or rotary component as an abduction moment. Abduction from the deltoid can only be achieved when the humerus has abducted past 15 degrees, which is initiated by the supraspinatus muscle. The translatory upward force of the deltoid, if unopposed, would cause the humeral head to shift upwards and impact against the correct acromial arch. The inferior translatory pull of gravity is not enough to offset the resultant force of the deltoid because that forced must exceed that of gravity before any rotation can occur. Therefore, another force or state of forces must be introduced to the glenohumeral joint.

The rotator cuff tendons blend with and reinforce the glenohumeral joint capsule. The component forces of the calf muscles create some rotation of the humerus and also compresses the head of the humerus into the glenoid fossa. Combined with contraction of the rotator cuff creates a downward translatory force that is strong enough to counteract the pull of the deltoid.

The supraspinatus contraction has a rotary component that generates a compressive force and provides a stable force as it compresses the humeral head into the fossa. This creates the rotary potential needed for the deltoid in order to elevate the arm in abduction.

The elbow and forearm complex. In this section, we are going to look at the anatomy structure and function of the humero-ulnar joint, the radio-ulnar joint, and the associated ligaments around the elbow and forearm complex. We will also look at the common injuries around it as they are mostly biomechanically implicated.

The ulnar joints anatomy is very simple. It is composed of three bones forming four articular components that influence the movement of the hand. These four articulations are: the humero-ulnar joint, the humero-radial joint, and the proximal and distal radio-ulnar joints. The elbow, as a whole, is a hinge-type joint with a uniaxial or single degree of motion. We only see flexion and extension at the elbow joint.

There are three ligaments that protect the elbow joint: the radial co-lateral ligament or RCL, the ulnar co-lateral ligament or UCL, and the annular ligament. There are five major muscles that directly work on the joint through reflexes and to extensors. The articulating surfaces are the most significant in the biomechanics of the elbow and dictate tension on the RCL and UCL, common extensors and flexors, and the epicondylar apophyses.

In this diagram, we can see the articulations of the elbow joint and the close relations that the radial collateral ligament, or RCL, in yellow, the ulnar collateral ligament, UCL, in red, and the annular ligament in blue, have to the joint capsule and influence the lineup of the elbow joint.

The ulnar collateral, ligament or UCL. It is comprised of three parts: the anterior bundle, posterior bundle, and transverse bundle or Cooper's ligament. The anterior bundle is the primary stabilizer for all valgus force from 20 degrees to 120 degrees of elbow flexion. The posterior bundle is less involved in checking valgus force, but it guides the interaction of the Olecranon process and the trochlea. The transverse bundle or Cooper's, ligament is between the Olecranon and ulnar coronoid process and it is believed to maintain a varus compressive force on the humeroulnar articulation.

The radial collateral ligament or RCL. This is a fan-shaped ligament and it offers the small degree of resistance against varus stress because the bony elements of the humerus, being larger on the lateral aspect, do not allow for varus movement. This prevents joint distraction and is more elastic than the UCL. The fibers are taut at about 110 degrees of elbow flexion.

The annular ligament. This is a strong ligament which forms a four fifths ring encircling the radial head. Its inner surface is covered with cartilage and therefore, serves as a joint surface for the head of the radius. The lateral aspect is reinforced by fibers from the LCL. It maintains radial head interaction with the ulnar and allows for pivoting in pronation and supination of the forearm.

The interosseous membrane. This is a broad dense membrane rich in collagen, which runs between the radius and the ulna from proximal to distal. It runs distally and medially. It allows transmission of forces from the hand and distal end of the radius to the ulna, especially in forces of compression from the hand upwards into the upper limb. Indirectly, it acts as a locking mechanism for the elbow and wrist during weight bearing and gripping.

This is a simple diagram to let you remember before on flexor muscles, that come from the common flexor tendon. This diagram represents the complex forearm extensor muscles as seen from the common extensor tendon.

The most common biomechanical injuries that we see in the elbow is lateral epicondylitis or 'tennis elbow' and medial epicondylitis or 'golfer's elbow.' In tennis elbow, it is commonly seen in racket-based sports which directly increases the length of the forearm lever, which increases the stress on the elbow. This is caused by repeated forceful contractions of the wrist extensors, and because of this repeated tensile stress on the inelastic tendon, it can result in microscopic tears at the muscular tenderness junction, and thus forming tendinitis. For golfer's elbow, it is also caused by extension or instrument-based sports such as golf. It is caused by forceful repetitive contractions of the pronator teres, flexor carpi radialis and flexor carpi ulnaris. The injury usually involves elbow extension, pronation and wrist flexion. The most common form of treatment can include a brace around the forearm just distal to the muscle insertion site in order to move the point of leverage and allow the person to still use the arm while in the healing phase.

Elbow dislocations. This is a common contact sport injury usually found in sports such as football, ice hockey, basketball, gymnastics, rugby, and wrestling. It commonly displaces posteriorly, behind the joint. It is uncommon for an anterior displacement and usually associated` with a supracondylar fracture. It is always important to send these patients to the emergency room as reduction may result in laceration of the brachial artery and result in a Volkmann's Ischaemic contracture. The process of reduction and immobilization needs to be considered with the following factors: reduce as soon as possibl; is there a hospital availability; follow on post-reduction: x-rays, CT, or MRI; check for professional involvement especially with orthopedic surgeons; and risk for potential return to play from coaches or from parents.

Forearm fractures. Even though they are uncommon, they do happen in contact sports. They are usually overlooked by EMTs and emergency medical personnel. It is always important that if you suspect a forearm fracture, look for the following symptoms. It is always important to notice whether the forearm is in locked in a position or unable to move in another position. In this case, this young man was a 26-year old rugby player. He fractured his forearm while in a tackle. This was missed by EMTs and was allowed to return to play. The arm was locked in pronation and he was unable to supinate actively. The protocol followed was to splint, immobilize, send for X-rays, and refer on for further cause. The wrist and hand complex with regards to prehension and gripping. In this section, we will be looking at the anatomy, structure, and function of the wrist and hand complex. Also, the relation to grip and the types of grip that we see in sports.

The structure and function of the wrist. It is the most complex joint in the body, both anatomically and physiologically. It is also known as the 'carpus' and consists of two compound joints: the radiocarpal joint and the midcarpal joint. The function of the wrist is to control and allow fine adjustments of grip and manipulation of objects within our hands. The secondary function is placement of the hand in space. It is a biaxial joint with movements of flexion and extension around the coronal axis, and radial and ulnar deviation, or abduction and adduction, around an AP axis. Variations in movements are due to ligament laxity, the shape of the articular surfaces, and the constraining effects of muscles.

The Carpal Rows. Anatomically, it is always important to know which carpal bone you are looking at. There is a simple way to remember this, from proximal to distal, and from radial to ulnar. The order of the bones are as follows: the scaphoid, lunate, triquetrum, and pisiform, the trapezium, trapezoid, the capitate, and the hamate. In the Carpal Rows, there is a two joint system at the wrist in order to facilitate the following: a large range of motion, prevention of structural pinch at the extremes of ranges of motion for the carpal tunnel contents, and for flatter multi-joint surfaces more capability of withstanding pressure from the hand into the forearm.

The intercalated segment. How does the intercalated segment work? When compressive forces are applied across an intercalated segment, the middle segment tends to collapse and move in the opposite direction from the segments above and below. Example: compressive-extensive forces across the wrist complex results in proximal row of the carpals flexing and the distal row extending. However, some stabilization is required in order to prevent complete collapse of the middle segment.

This mechanism involves the scaphoid and its attachments to the lunate and to the distal carpal row. The scaphoid tends to Flags, while the lunate and the triquetrum tend to extend. These counter rotations within the proximal row are prevented by ligaments of the wrist. These linkages will cause the proximal couples to collapse synchronously into flexion and pronation, while the distal carpals move into extension and supination. This counter rotation between the rows increases ligamentous tension and thereby increases stability,

Here is a simple diagram that shows how an intercalated segment works while under compression. As you can see, there is also two instances of complete instability if the intercalated segment does not function properly. The first being VISI or volar intercalated segment instability with displacement of the carpal row moves anteriorly during extension, or DISI or dorsal intercalated segments instability, where on extension, the Carpal Row shifts dorsally.

Anatomy of the Hand. Here is a simple diagram to refresh your anatomical knowledge on the hand. Prehension. This is the act of grasping or taking hold of an object between any two surfaces of the hand. The fingers, usually function to hold an object into the palm. They sustain flexion which varies with size, shape, and weight of the object. The thumb creates an additional surface area for contact, ie: it adducts in order to clamp the object down in the hand.

Prehension can be divided into two forms of grip: power grip and precision handling. Power grip is the forceful act resulting in flexion at all the finger joints so that the objects are held between the thumb and the palm. Precision handling is more skillful with the placement of an object between the fingers or finger-and-thumb, or the palm is not involved.

Power grip can be subdivided into four more types of grip, being cylindrical grip, spherical grip, hook grip, or lateral prehension. Cylindrical grip uses flexors to carry the fingers around and maintain the grasp on an object, mainly in the flexor digitorum profundus. Contraction. Power grip. This uses the flexors to carry fingers around and maintain the grasp on an object.

The interossei flex the metacarpophalangeal joints with some abduction over adduction. The thumb usually flexes and adducts to close the grip. The wrist is usually in the neutral position with slight ulnar deviation. This puts the thumb in line with the form and positions the object better to be able to be moved by pronation or supination of the forearm, and maintains long finger. flexors' optimum length to tension relationship. The more on the deviation by the flexor carpi ulnaris, the more tension on the flexor retinaculum, which gives hypothenar muscles, a more stable base on which to contract.

Spherical grip is similar to cylindrical grip except that the fingers are more spread out to encompass the object. Therefore, there's more interosseous activity. The metacarpophalangeal joints do not all deviates ulnarly, but tend to abduct. This allows for more wrist rotation or manipulation of the hand while gripping.

Hook grip. This primarily involves the fingers. It may include the palm but it never includes the thumb. This can be sustained for a long period of time. For example, for carrying bags or handles on suitcases.

Lateral prehension. This is seen as contact between two adjacent fingers. It is not considered a conventional form of power grip but similar in that position is maintained so that the object can be moved by the more proximal joints. The metacarpophalangeal joints and the interphalangeal joints generally extend, and the metacarpophalangeal can adduct or abduct. The extensor muscles play a part in this by maintaining the finger position.

Precision grips. It can be divided into three different categories of what surface of the hand is being used in order to maintain grip. This is divided into pad to pad grip, tip to tip grip, or pad to side grip.

The biomechanics of throwing. Here is a simple diagram that shows you the several phases of throwing. As you can see from beginning: the wind up, early cocking phase, late cocking phase, acceleration phase, the deceleration phase, and the follow-through. Bear these in mind as we discuss the biomechanics of throwing. **The wind up phase.** This is the preparatory phase. It usually involves two-legged stance. The arm begins movement towards cocking, there is little or no strain on the shoulder, and any loss of control of balance or stability will cause an increased demand of force on the shoulder.

The cocking phases of throwing can be divided into early cocking and late cocking. In early cocking phase, the arm moves towards full external rotation at 90 degrees of abduction. The external rotators, ie: the infraspinatus and teres minor muscles, are active and thus, store elastic energy. In late cocking, there is strong activity of the internal rotators, ie: the subscapularis and latismus dorsi, to decelerate the externally rotating arm. The glenohumeral joint capsule is stretched anteriorly and rotation wrings the capsule posteriorly compromising the vascularity of the upper rotator cuff tendons. The trunk begins to rotate and medial motion of the humerus, signifies the onset of the acceleration phase.

The acceleration phase. This is where medial rotation and for translation of the arm takes place, ending with the release of the object being thrown. The shoulder remains at 90 degree abduction. The lateral trunk flexes in order to give the appearance of side arm throwing.

The release phase. The arm is parallel to the line of the shoulders. The external rotators undergo eccentric loading in order to decelerate the arm which can lead to overuse or high-force trauma injuries to the shoulder.

The follow-through phase. This is where the external rotators and posterior fibers of the deltoid contract eccentricly in order to decelerate the arm. The serratus anterior and trapezius muscles stabilize the scapula. The forward movement of the arm, medial rotation of the shoulder, and protraction of the scapula are decelerated by eccentric contraction. The long, deep follow through, the arm passes down and across the body so that the hand finishes lateral to the contralateral knee. The shallow, follow through increases contribution of smaller muscles, therefore requires more muscle contraction and flexibility. The trunk flexes and rotates. Weight is transferred to the leading leg, and the hip and knee flex in order to lower the center of gravity which allows larger muscles to assist in deceleration.

The pathomechanics in throwing. There are two noticeable points where pathomechanics can be identified. One, in cocking patterns, and two, in follow through. Pathomechanical cocking patterns can be seen when externally rotating the shoulder too early causes an increased stress on the anterior shoulder as the trunk rotates and the shoulders remain in an open position. It can also be seen where over extension of the elbow in early cocking causes the arm to arrive late in the late cocking position, and the acceleration stresses the rotator cuff muscles. Bringing the arm too far back across the midline due to excessive trunk rotation requires rapid acceleration for the arm to catch up with the trunk, and thus stresses both the shoulder and the elbow.

Pathomechanical follow through. This is seen as a shallow follow through. It increases contribution of smaller muscles and therefore requires flexibility. The trunk flexes and rotates, and weight is transferred to the landing leg. The hip and knee flex in order to lower the center of gravity, which allows larger muscles to assist in deceleration. This large force couple can A, end up in throwing the body off balance, or B, cause muscle injury due to large eccentric muscle contraction?

Thank you for taking the time to learn about the basics of biomechanics.

[END]