

Throwing Arm Injuries

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Abstract

Throwing arm injuries are common, especially in overhead or throwing sports. They can lead to loss of performance, periods of time off the court or even surgery. This review article discusses the anatomy and biomechanics of the shoulder, in order to explain how we can avoid these injuries and improve performance.

Keywords: Shoulder; Tennis; Throwing arm; Rotator cuff; Labrum; Biceps; Rehabilitation

Introduction

The extensive range of motion of the shoulder joint allows the athlete to engage in a multitude of sporting activities [1]. This is particularly true of sports which involve overhead throwing. The act of throwing means different things in different sports but essentially the biomechanics are such that it involves the sequential coordination of a range of muscles from the athlete's feet to their fingers, known as the kinetic chain [2,3]. Studies on baseball, cricket and tennis players, the so-called overhead throwing athletes, have shown that the repetitive straining of the balance between shoulder mobility and stability can lead to some common throwing arm injuries [4-6]. The aim of this article is to outline the mechanisms behind these injuries and the various ways in which they can be managed.

The Mechanics of the Throwing Shoulder

In abduction the average shoulder can externally rotate to 90 degrees and rotate through an arc of 180 degrees (i.e. from vertically up down to vertically down).

This arc of movement is controlled by the external and internal rotators.

The problem is that when we throw, the ball is released from the overhead position (i.e. position B). By that point however, the arm must have reached maximal acceleration in order for the ball to be thrown at fast pace. The analogy is that of a catapult - the further back you pull the elastic, the faster the missile flies out when released (the shoulder being the elastic and the ball being the missile). If however, the point of release is actually the furthest back (into ER) the shoulder can normally move, either the ball falls to the ground with no speed imparted, or the shoulder and arm needs to start/be wound back into an abnormal range of movement (Zone A-B).

It is therefore an advantage to overhead throwers who are hypermobile or even just flexible, so that they can increase their range of motion into this zone. In order to throw as fast as possible, this "acceleration" zone should be as long as possible and the athlete will naturally train his technique and his Internal Rotators (IR) to create maximal rapid force in this zone. We are therefore training overhead

athletes to move their shoulders in abnormal ranges and at excessive forces.

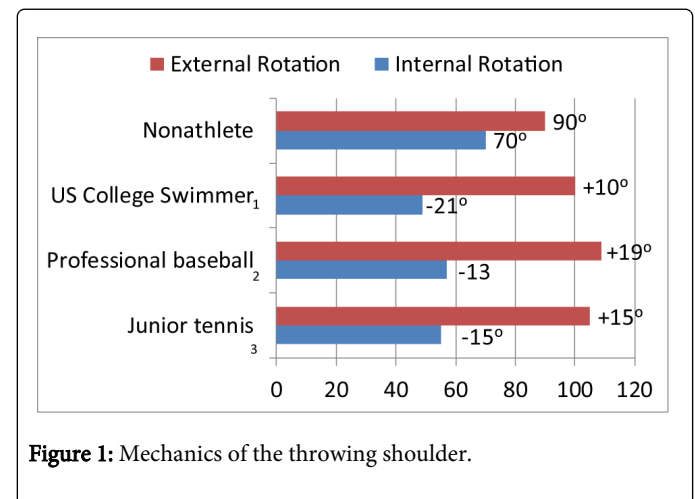


Figure 1: Mechanics of the throwing shoulder.

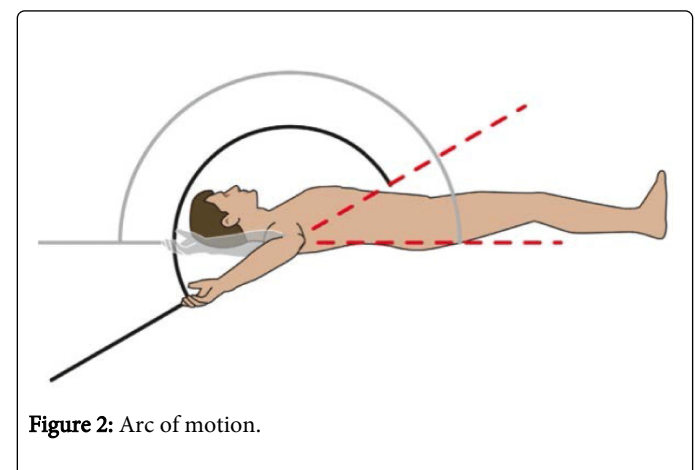


Figure 2: Arc of motion.

In these abnormal zones, tissues can be impinged upon. Internal impingement is a physiological phenomenon in which the undersurface of the rotator cuff contacts the postero-superior aspect of the labrum with the arm in maximal ER and abduction. This can lead to symptoms from repetitive microtrauma leading to failure of the

undersurface cuff fibres and bicipito-labral complex. This is caused by poor conditioning or over-throwing [7-14].

We can change this arc of motion but it is more difficult to increase the 180 degree range and studies show that people who participate in such sports are able to start the arc further back, but conversely stop further forwards. This leads to the Glenohumeral Internal Rotation Deficit (GIRD) (Figures 1 and 2).

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Most of the science comes from baseball and tennis (and some from cricket). These show that from wind up to ball release, it takes about 1.5 seconds to generate angular velocities of up to 7000 degrees/sec to bowl a ball of about 90mph. These forces approach the fatigue strength of many of the soft tissue constraints of the shoulder.

All six phases of throwing take approximately 2 seconds and the acceleration phase 4 is the shortest, lasting approx only 0.05 seconds. However, during this shortest phase, the greatest angular velocities are created and the forces (resulting in the greatest change in rotation) occur. This is the most vulnerable point for the shoulder, and that is why most overhead athletes initially report a “catch” of pain as symptoms first appear. This catch usually only occurs at this point and is therefore ignored. Unfortunately it develops through all phases and then into other activities.

At the point of release, the arm/ball needs to be moving at maximal acceleration. The ball is released, and then the shoulder needs to stop - the “deceleration” zone.

At the point of release, the arm is essentially trying to fling itself out of the shoulder joint. These humeral distraction forces (up to approx 950N; cf compressive forces created by the cuff and deltoid after ball release of up to 1100N) approach the ultimate tensile strength of the shoulder capsule and ligaments stabilizing the shoulder). So if the compressive forces do not cancel out the distraction forces, injuries will occur.

We do not directly have brakes in the body to stop acceleration. In this scenario, the acceleration comes from concentric IR activity and the “brakes” come on by eccentric activation of the External Rotators (ER).

There are only two problems now. The first is whether the “braking distance” is long enough. The second is whether the balance between the concentric IR’s and eccentric ER’s in this zone are balanced and controlled. Studies have shown that in high-velocity throwers, such as fast bowlers in cricket, if there is imbalance between IR and ER in this phase, there is resultant dynamic excess IR and this leads to narrowing of the subacromial space and resultant dynamic SA impingement [15-28].

Don’t Forget the Hyper-Mobility

Given that we have decided that our optimal high-velocity overhead thrower is tall (long levers to generate greater moments of inertia) and that they train so that their shoulders now move in abnormal range at massive forces, it comes as no surprise that when we also like our

athletes to be hypermobile injuries occur. This is of greatest importance during the deceleration phase especially in high-velocity throwing where distraction forces may be highest (Table 1).

Injury	Pathomechanics
SLAP Tear	GIRD, Internal Impingement, insufficient braking distance
Dynamic SA Impingement	Acceleration Deceleration Imbalance
PASTA lesion	GIRD, Internal Impingement
RC tear	GIRD, Accel-Decel imbalance, Hypermobility-distraction, progression of Dynamic impingement
Anterior Labral tear/Instability	Hypermobility

Table 1: What injuries occur.

Prevention and Treatment

Fortunately most overhead-throwing sportsmen do not need surgery and symptoms become apparent before an operation is required. The problem becomes apparent to athletes and their coaches/physiotherapists when the catch of pain upon release affects their performance and when symptoms encroach into fielding and even daily activities including their sleep.

In general, the earlier this is picked up, the quicker the recovery and the less likely it is that recurrent episodes will affect their career.

There are three main areas to work on:

1. Range of motion: By changing the arc of rotation, the GIRD is created, which is associated with internal impingement and a reduced “braking distance”. However two simple stretching exercises can improve this range, reducing the rate of injury by up to 38% (in tennis players) [29].

One thing to note is that static stretching alone may not be enough and actually might be counterproductive before a match. The recommendations are that some basic cardio warm ups followed by dynamic stretching and sports specific exercises are best [30].

2. Strength and conditioning: It’s not just about pushing weights. It’s about developing a forceful balanced rapid bowling action with endurance and control. To my mind, the core is the keystone. The pelvis/core contributes to 54% of shoulder strength so the scientific fact is that a strong core means strong shoulders, and therefore less prone to injury. Sports specific drills are the key. In this instance, the work has just begun with weights and resistance bands for the cuff. Progress from here should involve perhaps Persian clubs (low weight, especially good for batsmen) and combined core/upper body exercises e.g. swiss ball press ups, superman’s and swissball jackknife exercises.

What more do we need from our strength training? We need to develop our controlled strength but also the ability to generate power, or plyometrics. The term plyometrics was first coined by the famous track and field coach Fred Wilt in the 1970’s in the US, but followed on from the “shock training” Eastern European coach of the 60’s, Yuri Verkoshansky, whose high intensity techniques was being pioneered in weightlifting, gymnastics and athletics. In overhead throwing we can split plyometrics into core training drills e.g. vertical and combination box jumps and sports specific drill eg. soft weight throwing and catching drills, onto medicine ball workouts. One thing

to note is that the science tells us that there is little improvement by using weights more twice as heavy than the object you swing/throw in these drills. For instance a bowler should train with a weight no more than twice the weight of a cricket ball, but a shot-putter must use a much heavier weighted ball [31].

3. Balance is just as important as any form of power or strength:

When you bowl or throw, the only way you can hit the ball forcefully, accurately and reliably is if your body underneath is stable and that stability starts from the feet. Every assessment starts with ankle stability (four point hops, wobble board and clinical examination). This follows all the way through the knees and hips and up through the spine to the shoulder girdle. Proprioceptive training has been shown to improve shoulder and core strength and therefore performance.

Some throwing arm injuries may fail to respond to non-surgical intervention. One such injury is a SLAP tear, which involves injury to the superior labrum and biceps anchor at the glenoid attachment. Snyder et al subdivided SLAP tears into 4 main types [32]. The type of lesion a patient has determines the operative management required. Overhead athletes most commonly present with Type II SLAP tears in which the superior labrum is completely torn off the glenoid. These are treated arthroscopically with partial debridement of the loose or frayed edges of the labrum to optimise it for re-attachment to the glenoid. The re-attachment itself is done by suturing the biceps-labral anchor back to the glenoid bone so that the labrum is able to heal back in the correct place.

Another common injury in overhead athletes which can require surgical treatment is a PASTA lesion. This is a partial tear of the supraspinatus tendon of the rotator cuff that does not extend to the full thickness of the rotator cuff. If non-operative rehabilitation has not been effective the tear is assessed for the percentage thickness of the rotator cuff tendon that is torn. If more than half the thickness is affected the tear undergoes surgical debridement. If more than 50% is affected it is treated similarly to a full thickness rotator cuff tear. This typically involves arthroscopic debridement and repair of the torn tendon by reattaching it to the bone using suture anchors. Occasionally it can also be repaired using an open procedure.

Conclusion

Overhead throwing athletes are trained to stretch the limits of the range of movement in their shoulder and load the muscles beyond their normal capacity. Additionally a lot of professional athletes are selected for their hypermobility. This training therefore can lead to a number of shoulder injuries, namely caused by the repetitive microtrauma to the muscle fibres, which can hinder both athletic performances but also everyday activities. In most cases the symptoms of these injuries present early on and can be identified and treated promptly with rehabilitation exercises but some conditions such as SLAP lesions and rotator cuff tears may require surgery.

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