Rehabilitation solutions for the throwing shoulder including preventative strategies in an integrated approach.
BACKGROUND

Experience of working in professional cricket for the past 20 years.

Research predominantly based on baseball pitching as well as an increasing amount of research on throwing in cricket including:

My thesis for MSc Sport and Exercise Medicine:

- The relationship between throwing workloads, glenohumeral rotational range of motion and rotation strength.

PhD by Steve McCaig (Senior Physiotherapist England Development Programme at ECB):

- The role of throwing mechanics in injury prevention and performance.
OVERVIEW

• Throwing related shoulder pain

• Profiling of throwing athlete

• Physical adaptations of throwers

• Throwing technique

• Workload
THROWING RELATED UPPER LIMB PAIN (TRULP)

An integral part of many sports such as cricket, baseball, handball, javelin, water polo and american football.

Baseball 45–58% of all injuries in upper limb were due to throwing (Dick 2007).

Incidence 26–35 injuries per 100 pitchers over a season (Lyman 2003).

Cricket TRULP rarely cause time loss (Orchard 2005).

Cricketers commonly reported pain with throwing but continued to play with decreased throwing power and performance (Ranson 2008).
COMMON SHOULDER CONDITIONS

Shoulder

RC tears & tendinopathies, capsular lesions, SLAP lesions & biceps tendon (Wilk 2009).
COMMON ELBOW CONDITIONS

Elbow
Ulna collateral ligament strains.

Radial head & olecranon osteophytes.
PROFILING OF THROWING ATHLETE

• Injury history
  – previous injury is most significant injury risk indicator

• Objective assessment
  – Shoulder mobility
  – Scapulohumeral rhythm
  – Hip mobility
  – Spinal mobility
  – Musculoskeletal screening
  – Physical adaptations of throwing athletes (symmetry)
  – Functional movement patterns (lunge, squat, jumping/landing)

• Radiological investigations

• Throwing technique
MUSCULOSKELETAL SCREENING – SHOULDERS

• Shoulder elevation test
  – > 10 inches above floor

• GHJ rotation passive range of motion
  – < 85° internal rotation
  – < 115° external rotation
  – < 200° total rotation range of motion
  – > 20° difference with non-dominant

• Humeral retroversion with ultrasound

• GHJ rotation strength with HHD
  – < 10 kg external rotation
  – < 10 kg internal rotation
  – > 1 IR:ER strength ratio
MUSCULOSKELETAL SCREENING – UPPER LIMB STRENGTH

- Grip strength
  - < 45kg

- Inverted pull up test
MUSCULOSKELETAL SCREENING – TRUNK STRENGTH

• Back extension endurance test
  - < 120 seconds

• Side Plank endurance test
  - < 90 seconds

• Double leg lower
  - <20 reps
MUSCULOSKELETAL SCREENING – LEG STRENGTH

Decline squat test <20 reps
Groin Squeeze test < 200mmHg

Hamstring bridge test <15 reps
Single leg calf raise <20 reps

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MUSCULOSKELETAL SCREENING – LOWER LIMB FUNCTION

Lateral agility

Jump test

3 hop test test
MUSCULOSKELETAL SCREENING – LEG MOBILITY

- Ankle dorsiflexion
  - < 10cm
  - difference of > 5cm

- Hip extension
  - above bed/ABD/KF

- Hip Rotation

- Hamstring flexibility/SLR
  - > 80°
RADIOLOGICAL INVESTIGATIONS

- MRI – RC tears/tendinopathies
- CT scan – Bankart’s Lesion
- CT scan – Bankart’s Lesion
- MR arthrogram – SLAP lesions

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DEFINITIVE DIAGNOSIS
PHYSICAL ADAPTATIONS IN THROWING ATHLETES

• Shoulder range of motion
• Scapular motion
• Proprioception
• Elbow motion

ASYMMETRY

• Shoulder strength
• Legs and hip function
• Trunk function
SHOULDER ROTATION ROM CHANGES

• **Increase in external rotation** range of motion as a result of laxity in anterior capsule of the GHJ due to high anterior shear forces from throwing (Borsa 2008).

• **Decrease in internal rotation** range of motion (Borsa 2008), as a result of tightness in the posterior capsule from the stress deceleration in the throwing action (Whiteley 2008).

• Changes occur immediately post throwing (Reinhold 2008).
• Cumulative workload causing changes over a season (Shanley 2012).
HUMERAL RETROVERSION

- Acute angle between the axis of the elbow joint & the centre of the humeral head (Pieper 1998).

- Humeral retroversion as a **protective adaptation** to allow greater external rotation range of motion without stressing the anterior capsule (Whiteley 2009, Roach 2012).

- Throwers with increased humeral torsion have been found to experience less TRULP (Whiteley 2010).

- Total range of motion more important than internal rotation alone (Wilk 2009), evaluate whether the athletes gain in external rotation is equal to their loss of internal rotation. If this loss is greater then they are considered to be restricted in their posterior shoulder.
POSTERIOR CAPSULAR STRETCHES

• Humeral torsion is evaluated as this will effect the amount of rotation range of motion and the perception of posterior tightness (Myers 2009).

• Warm up

• Recovery protocol

• Soft tissue techniques

• Objective marker for fatigue
SCAPULAR MOTION

- Depressed and protracted scapula at rest on dominant side in throwing athletes (Batsan 2006).
- Shoulder elevation increased upward rotation and posterior tilt on dominant side (Myers 2005).
- After throwing and when fatigued scapula upward rotation, external rotation and posterior tilting are reduced (Macrina 2007).
- These changes are associated with reduce subacromial space thus contributing to development or progression of impingement as well as a poorer environment for tissue healing. (Ludewig 2009).
PECTORALS FLEXIBILITY

- Soft tissue techniques
- Stretching (foam roller)
- Scapular
  - Setting
  - Strengthening
  - Taping
- Postural correction

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LATERAL SCAPULAR FLEXIBILITY

- Soft tissue techniques
- Stretching
  - Kneeling
  - Foam roller
- Freestyle Swimming
• Acute impairments of upper limb reposition sense occur after fatigue due to throwing (Tripp 2004).

• Especially in cocking position of throwing position.

• Development of micro-instability at shoulder & lead to injury.

• These changes can last up to 10 minutes after a fatiguing throwing session (Tripp 2007).

• Important to be aware of these changes as a certain measure of fatigue, for example, determining the recovery period between sets of throws during training.
ELBOW MOBILITY

- Posterior impingement
- Elbow flexor tightness
- Wrist extensor fatigue
- UCL stress
SHOULDER STRENGTH ADAPTATIONS IN THROWERS

• Combined **loss ER strength** & **increase in IR strength**.

• Subsequent IR:ER ratio increases (Ellenbecker 1997, Noffal 2003).

• Ratio >1.5 injury indicator (Whitely 2009).

• Contributing factors to TRULP (Wilk 2009, Hurd 2012).
SHOULDER ROTATION STRENGTH
SCAPULAR STRENGTH CLOSED CHAIN
YOGA CLOSED CHAIN EXERCISES

Sun salutation series
SCAPULAR STRENGTH OPEN CHAIN
ELBOW STRENGTHENING

Grip strength to protect ulnar collateral ligament
LEGS & HIP FUNCTION

• Rotation of pelvis occurs due to a combination of bilateral hip rotation, back leg abduction & extension correlated to passive hip joint motion (Robb 2010).

• Inadequate hip rotation results in reduced force transfer to the upper limb (Wight 2003).

• Strength in hip abductors, extensors, quardiceps & hamstrings from high EMG activity during pitching motion (Campbell 2010).

• Leg power in frontal plane (medial to lateral jump) correlation with throwing velocity (Lehman 2013).
HIP MOBILITY & FUNCTIONAL LEG STRENGTH
LEG POWER EXERCISES

• Strong base
• Fast feet
TRUNK FUNCTION AND THrowing

• Trunk rotation and flexion are important components of velocity in throwing (Stodden 2001, Escamilla 2002).

• Adequate range of thoracic rotation is required so that trunk rotation can be delayed while the pelvis rotates.

• Trunk rotation is facilitated by a rapid abdominal contraction of the obliques and immediate relaxation prior to upper limb muscle activity: any increased abdominal stiffness during a throw will impede trunk rotation (McGill 2009).
THORACIC MOBILITY EXERCISES

• Extension

• Rotation

• Thoracic mobilisation

• Breathing pattern

• Postural correction
TRUNK STRENGTH EXERCISES

- Pilates
- Yoga
INTEGRATED INTO WARM UPS

Specific to individual player injury history and profiling.

- Range of motion
- Flexibility
- Spinal mobility
- Strength
- Technical throwing components
- Progressing throwing intensity
INTEGRATED INTO RECOVERY SESSIONS

Specific to individual and workload

• Range of motion

• Flexibility

• Spinal mobility

• Strength

Soft tissue techniques

Swimming
THROWING TECHNIQUE

- Wind Up
- Early Cocking
- Late Cocking
- Acceleration
- Deceleration
- Follow Through
As always with throwing mechanics, it starts from the ground up. If the player's footwork is not athletic, or not working in alignment, it will not be possible for the body to maximally function. From this foundation we work to utilize an ‘athletic position’ at every point in the movement. Then we work to enhance the rotational power of the hips and core, and finally we look at the position and movements of the arms. Each aspect is important for an efficient and consistent throw, and each works up and down the kinetic chain to affect the others.
THROWING TECHNIQUE ANALYSIS

• Technique is identified as a major contributing factor to the development of TRULP (Oyama 2012).

• **Integrated** assessment approach with coaching and conditioning staff.

• 3D motion analysis of throwing techniques is gold standard.

• Benefits of assessing and discussing technique parameters with the athlete and coach outweigh the concerns around the accuracy of developing a valid and reliable field test.

• Key factors have been identified to improve throwing performance (velocity) and reduce injury risk (Whiteley 2007).

• ECB developed a throwing matrix as a simple method of assessing throwing technique for coaches, physiotherapists and trainers working within cricket (Young 2012).
ECB THROWING MATRIX

• Assessment tool for injury risk and performance enhancement.
• High speed video footage of the throwing motion is reviewed and evaluated compared to the scoring criteria.
• Athlete is filmed from the open side, front and behind.
• They are instructed to throw as hard and as accurately as possible at a predetermined target.
• Assess a number of throws as a level of variation exists between throws (Oyama 2012).
• Athletes are given an overall score as a percentage of 100.
• Feedback given to player in form of specific throwing technique drills and targeted conditioning exercises prescribed by the coach and physiotherapist aimed at performance enhancement and reduce risk of injury.
• ECB found correlation between poor matrix score and incidence of TRULP during a 3 month tour (Young 2011).
<table>
<thead>
<tr>
<th>Throwing matrix</th>
<th>Score</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stride length (&gt; 80%)</td>
<td>2</td>
<td></td>
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<tr>
<td>Cocking phase - MER (&gt;160)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Front knee through release (50 to 30)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Lag between hip and shoulder</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Weight transfer (at ball release)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Shoulder rotation (Horizontal abduction)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Front arm - Active pull through</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Armpit angle (&gt; 90)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Stance - Front foot to target</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Follow through (line of arm &amp; length)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><strong>Total Score</strong></td>
<td><strong>20</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Percentage</strong></td>
<td><strong>100%</strong></td>
<td></td>
</tr>
</tbody>
</table>

Scores: 2 = desirable, 1 = restricted / less than ideal, 0 = poor / risk

<table>
<thead>
<tr>
<th>Action points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>
1. STRIDE LENGTH (>80% OF HEIGHT)

- Increases the time over which forces can be developed, increasing acceleration of the upper limb (Stodden 2001).

- Increase in velocity when stride length increased to 85–90% height (Montgomery 2002).
2. OPEN FOOT ALIGNMENT AT FRONT FOOT CONTACT

- Front foot in **open** position this causes the pelvis and trunk to rotate early.
- This causes the arm to lag behind into horizontal abduction & reduce the forces transferred to the upper limb (Fleisig 1994).
- Less powerful throw and increased anterior stress at the shoulder and increased valgus load at the elbow, increasing risk of TRULP.
2. CLOSED FOOT ALIGNMENT AT FRONT FOOT CONTACT

- Front foot in **closed** position this prevents the pelvis and trunk from rotating fully.
- Coaches call this “arming the ball”, as little transfer from the lower limbs and trunk therefore increasing load on the shoulder.
- As this restricts ability of trunk and pelvis to fully rotate, it increases deceleration loads on the upper limb.
3. FRONT LEG KNEE POSITION

• After front foot contact knee must remain stable and extended slightly.

• This is critical to transmit forces developed in the legs to the trunk and ultimately the upper limb (Matsuo 2001).

• If knee flexes, velocity has been shown to reduce (Matsu 2001).
4. PELVIC AND TRUNK ROTATION

- Pelvis and trunk rotation *velocity* is increased in faster throwers (Stodden 2001, Aguinaldo 2007).

- **Timing of these phases** which is critical.

- Maximal pelvic rotational velocity occurs during arm cocking phase.
- Maximal trunk rotational velocity occurs during the acceleration phase.
- This timing creates a lag between the trunk and the pelvis, inducing a stretch shortening cycle in the abdominal muscles, this enabling them to produce a greater force.

- Early pelvic rotation results in an open position, increasing anterior shoulder and valgus stress as the arm lags behind.

- Delayed pelvis and trunk rotation leads to a “leading elbow”.

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EXAMPLES OF PELVIC AND TRUNK ROTATION IN THROWING
5. TRUNK FLEXION

• Trunk flexion in the cocking & acceleration transfers forces from the legs and trunk to the upper limb which is important during follow through to *decelerate* the upper limb.

• Slower throwers are found to throw in a more upright manner.

• Increased lateral flexion of the trunk to throwing side can increase elbow stress (Aguinaldo 2009).
LACK OF TRUNK FLEXION
6. SHOULDER ABDUCTION

- Shoulder abduction (armpit angle) is between 90–110 degrees during throwing (Werner 2001), with 100 degrees optimal to minimise load and maximise velocity (Matsuo 2006).

- Reduced abduction causes elbow valgus stress (Matsuo 2006) or reduced distraction loads on the shoulder (Werner 1993).
7. SHOULDER HORIZONTAL ABDUCTION

- Fastest pitchers had slightly increased horizontal abduction at front foot contact (Escamilla 2002).
- During the late cocking phase the shoulder begins to move towards horizontal adduction.
- Increased horizontal adduction during acceleration and cocking phase increases **valgus stress at the elbow** known as “leading with the elbow” (Fleisig 1994).
8. SHOULDER EXTERNAL ROTATION AT FRONT FOOT CONTACT

• External rotation average 50 degrees (Fleisig 1994).

• Increased external rotation at this stage causes increased anterior stress at the shoulder and valgus stress at the elbow.
9. MAXIMAL EXTERNAL ROTATION

- High ranges of external rotation are critical to high velocity due to greater linear and angular ranges of motion (Matsuo 2001).

- These extreme motions can increase stress at the shoulder and elbow (Sabick 2004).

- Maximum external rotation relative to passive external rotation may be a better marker of injury risk (Miyashita 2008).
10. ELBOW FLEXION

Increased elbow flexion during the cocking and acceleration phases reduced valgus stress at the elbow and distraction force at the shoulder (Werner 2001).
CRICKET THROWING EXAMPLE
CRICKET THROWING EXAMPLE
BASEBALL THROWING TECHNIQUE
CRICKET SPECIFIC THROWING AND FIELDING TECHNIQUES

• Throwing flat

• Relay throw

• Fielding in pairs
QUICK RELEASE VERSUS THROWING FROM A STABLE BASE

Throwing from unstable base can have an impact on:

– Accuracy
– Power of throw
– Increased risk of shoulder and elbow injury
THROWING WORKLOAD
THROWING OVERLOAD

• Increased throwing workload has been linked to shoulder and elbow injuries in baseball, cricket and water polo (Olsen 2006, Saw 2011, Wheeler 2013).

• Linked to decreased throwing performance (Bradbury 2013).

• Research highlights young pitchers who threw more in games, more in a season & threw more in a year were more likely to develop shoulder or elbow injury (Lyman 2002, Fleisig 2011).

• Daily pitching to significantly increase risk of injury (Takahoma 2010).

• Based on above throwing guidelines, adolescent baseball guidelines have been developed (http://www.asmi.org/research.php?page=research&section=positionStatement).
With the rise in elbow and shoulder injuries in youth baseball pitchers, the adult community needs to take steps to prevent these injuries. Research points to overuse as the principle risk factor. Poor pitching mechanics also contribute to injury risk. Another suggested risk factor is poor physical fitness.

1. Watch and respond to signs of fatigue (such as decreased ball velocity, decreased accuracy, upright trunk during pitching, dropped elbow during pitching, or increased time between pitches). If a youth pitcher complains of fatigue or looks fatigued, let him rest from pitching and other throwing.

2. No overhead throwing of any kind for at least 2–3 months per year (4 months is preferred). No competitive baseball pitching for at least 4 months per year.

3. Do not pitch more than 100 innings in games in any calendar year.

4. Follow limits for pitch counts and days rest.

5. Avoid pitching on multiple teams with overlapping seasons.

6. Learn good throwing mechanics as soon as possible. The first steps should be to learn, in order: 1) basic throwing, 2) fastball pitching, 3) change–up pitching.

7. Avoid using radar guns.

8. A pitcher should not also be a catcher for his team. The pitcher–catcher combination results in many throws and may increase the risk of injury.

9. If a pitcher complains of pain in his elbow or shoulder, discontinue pitching until evaluated by a sports medicine physician. Inspire youth pitchers to have fun playing baseball and other sports. Participation and enjoyment of various physical activities will increase the youth's athleticism and interest in sports.
LIMITS FOR NUMBER OF PITCHES THROWN IN ADOLESCENT BASEBALL

<table>
<thead>
<tr>
<th>Age</th>
<th>2006 USA Baseball Guidelines</th>
<th>2010 Little League Baseball Regulations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daily Limits</td>
<td></td>
</tr>
<tr>
<td>17–18</td>
<td>N/A</td>
<td>105/day</td>
</tr>
<tr>
<td>15–16</td>
<td>N/A</td>
<td>95/day</td>
</tr>
<tr>
<td>13–14</td>
<td>75/game</td>
<td>95/day</td>
</tr>
<tr>
<td>11–12</td>
<td>75/game</td>
<td>85/day</td>
</tr>
<tr>
<td>9–10</td>
<td>50/game</td>
<td>75/day</td>
</tr>
<tr>
<td>7–8</td>
<td>N/A</td>
<td>50/day</td>
</tr>
<tr>
<td></td>
<td>Weekly Limits</td>
<td></td>
</tr>
<tr>
<td>13–14</td>
<td>125/week; 1000/season; 3000/year</td>
<td></td>
</tr>
<tr>
<td>11–12</td>
<td>100/week; 1000/season; 3000/year</td>
<td></td>
</tr>
<tr>
<td>9–10</td>
<td>75/week; 1000/season; 2000/year</td>
<td></td>
</tr>
<tr>
<td>7–8</td>
<td></td>
<td>21–35 pitches=1 day rest</td>
</tr>
<tr>
<td></td>
<td></td>
<td>36–50 pitches=2 days rest</td>
</tr>
<tr>
<td></td>
<td></td>
<td>51–65 pitches=3 days rest</td>
</tr>
<tr>
<td></td>
<td></td>
<td>66+ pitches=4 days rest</td>
</tr>
</tbody>
</table>

- Coach education and **compliance** of pitch count recommendations (Fazarale 2012).
THROWING WORKLOADS IN CRICKET

Monitoring of throwing workloads in England matches since 2008 has enabled coaches and support staff to develop throwing programmes for:

- Individual players
- Specific fielding positions
- Specific throwing workloads for different formats (2020/ODI/Tests)

Lead to the development of throwing guidelines as prescribed in adolescent baseball.

Bowling workloads and limits are well documented for adolescent cricketers (http://www.ecb.co.uk/ecb/directives-guidelines/ecb-fast-bowling-directives,100,BP.html)
FIELDING PRACTICE WORKLOADS

Influenced coaches to develop fielding drills based on the data from monitoring throwing workloads in matches.

- Defined by number of throws
- Distance of throws
- Intensity of throws

Fielding drills are designed to be more specific dependent on:
- Individual
- Fielding position
- Format of the game.
KEY MESSAGES

• Early intervention.

• Definitive diagnosis.

• **Prevention** of TRULP as previous injury is biggest injury indicator.

• **Integrated** approach to the throwing shoulder.

• Throwing is a whole body movement.

• Good throwing mechanics

• Progressive workload

• Each throwing athlete is different.
THANK YOU!
References

- Yoshida 2013 humeral retroversion measurement ultrasound