Risky Throwing Mechanics for Young Pitchers

Dennis Coonan, MSE, LAT, ATC
Matthew Brewer, MS, LAT, ATC

SPORTS MEDICINE CENTER

Children's Hospital Colorado

We Have No Disclosures

Resources and Acknowledgements

- Brent Pourciau
  - https://www.topvelocity.net
- Michael Wong, DPT, OCS, FAAOMPT
  and Andrew Morcos DPT, SCS, OCS, ATC, CSCS, FAAOMPT
- Shane Noffinger, DPT, CSCS

Injury Rates Among High-School Baseball Players

Saper et al 2018

- Is there cause for concern?
- Youth baseball accounts for 10% of the total youth sports that are played by males
- Rates of injury for shoulder 1.39 per 10,000 AE and .86 per 10,000 AE for elbow
- ¼ of all high-school baseball players pitch, and the number of high-school pitchers needing surgical intervention for pitching related injuries has increased
- Data is agreement with previous research-validated
- Factors effecting increased upper extremity injuries in pitchers
- Overtraining, weightlifting during season, specialization, year-round training, high pitch counts, inadequate rest, increased velocity, GIRD, RTC weakness, introduction of breaking balls at early age, and playing positions requiring additional throwing

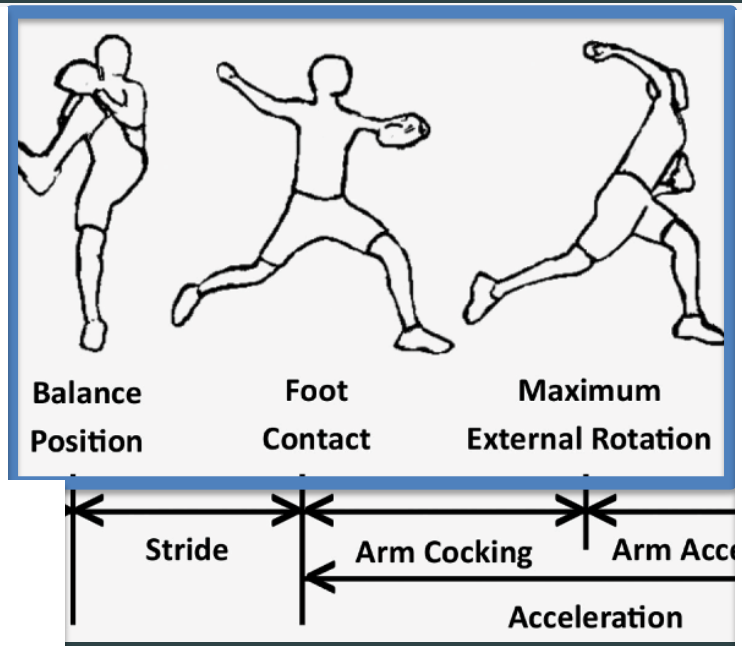
Quickly summarize

TABLE 2
Characteristics of Shoulder and Elbow Injuries in All Players[a]

Characteristic[b]	Shoulder, n (%)	Elbow, n (%)	IPR (95% CI)[c]
Side of body[d]			
Right	145 (71.4)	89 (69.0)	1.05 (0.81-1.37)
Left	58 (28.6)	40 (31.0)	0.94 (0.63-1.40)
New injury or recurrence			
New injury	201 (83.8)	127 (84.7)	0.99 (0.79-1.24)
Recurrence (this academic year)	19 (7.9)	13 (8.7)	
Recurrence (prior academic year)	18 (7.5)	9 (6.0)	
Other	2 (0.8)	1 (0.7)	
Position			
Pitcher	93 (39.6)	83 (56.9)	**0.70 (0.56-0.86)**
Outfielder	57 (24.3)	11 (7.5)	**3.22 (1.69-6.15)**
Infielder	41 (17.4)	20 (13.7)	1.28 (0.75-2.18)
Batter	9 (3.8)	20 (13.7)	**0.28 (0.13-0.60)**
Catcher	19 (8.1)	10 (6.9)	1.18 (0.55-2.54)
Base runner	12 (5.1)	1 (0.7)	N/A
Other	4 (1.7)	1 (0.7)	N/A
Time loss			
<1 wk	94 (39.8)	49 (33.8)	1.18 (0.83-1.66)
1-3 wk	81 (34.3)	53 (36.6)	0.94 (0.66-1.33)
>3 wk	34 (14.4)	32 (22.1)	0.65 (0.40-1.06)
Other[e]	27 (11.4)	11 (7.6)	1.51 (0.75-3.04)
Surgery			
Yes	23 (9.7)	8 (5.4)	1.79 (0.80-4.01)
No	215 (90.3)	140 (94.6)	

Characteristic[b]	Shoulder, n (%)	Elbow, n (%)	IPR (95% CI)[c]
Basic injury mechanism			
No contact	82 (34.2)	60 (40.3)	0.85 (0.61-1.18)
Overuse/chronic	89 (37.1)	50 (33.6)	1.10 (0.78-1.56)
Contact with playing surface	37 (15.4)	7 (4.7)	**3.28 (1.46-7.35)**
Contact with playing apparatus	12 (5.0)	23 (15.4)	**0.32 (0.16-0.65)**
Contact with another person	14 (5.8)	2 (1.3)	**4.46 (1.01-19.63)**
Contact with out-of-bounds object	0 (0.0)	1 (0.7)	N/A
Other	6 (2.5)	6 (4.0)	0.58 (0.19-1.80)
Diagnosis			
Muscle strain	75 (31.3)	9 (6.1)	**5.14 (2.57-10.26)**
Tendinitis	46 (19.2)	27 (18.2)	1.05 (0.68-1.61)
Ligament sprain	13 (5.4)	49 (33.1)	**0.16 (0.09-0.29)**
Contusion	13 (5.4)	23 (15.5)	**0.35 (0.18-0.67)**
Tendon strain	20 (8.3)	15 (10.1)	0.82 (0.43-1.56)
Other	16 (6.7)	8 (5.4)	1.24 (0.54-2.81)
Dislocation	20 (8.3)	0 (0.0)	N/A
Subluxation	12 (5.0)	0 (0.0)	N/A
Torn cartilage	10 (4.2)	0 (0.0)	N/A
Fracture	3 (1.3)	5 (3.4)	0.37 (0.09-1.53)
Inflammation	4 (1.7)	3 (2.0)	0.82 (0.19-3.62)
Nerve injury	2 (0.8)	4 (2.7)	0.31 (0.57-1.66)
Bursitis	3 (1.3)	0 (0.0)	N/A
Hyperextension	0 (0.0)	2 (1.4)	N/A
Separation	2 (0.8)	0 (0.0)	N/A
Stress fracture	1 (0.4)	1 (0.7)	N/A
Apophysitis	0 (0.0)	1 (0.7)	N/A
Laceration	0 (0.0)	1 (0.7)	N/A

Phases of Pitching



Seroyer(2010), Chu(2016), Chalmers(2017), Fortenbaugh(2009)

Pitching Kinetic Chain

- “Transfers torque generated largely by the lower extremity and core musculature with the stride, pelvic rotation, and torso rotation through the upper extremity.”
- “…each subsequent segment receives potential and kinetic energy received and generated from the previous segment…”
- “durability linked to kinematic and kinetic factors as well as the temporal association of segmental body motions.”

Seroyer(2010), Chalmers(2017)

Risk Factors for Injury

- Poor Pelvic and Core Stability
- Not Leading with Hips
- Stride Length/Hip Power Production and Stride Foot Placement
- Upper Torso Mobility and Pelvic Upper Torso Separation
- Improper Timing of External Rotation

Wilk (2014), Otoshi(2018), Provencher(2018), Oyama(2014), Garrison(2013), Chaudhari(2014), Silfies(2015), Saito(2015), Fry(2016), Ramsey(2014)

Single Leg Stance and Pelvic Alignment

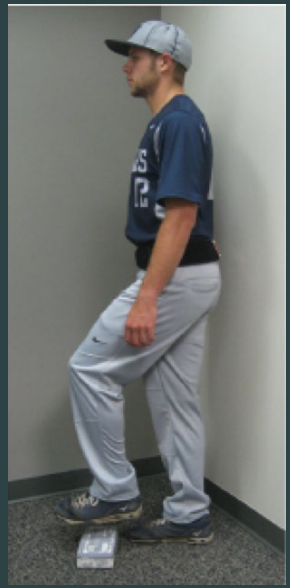
- Zack Greinke
  - 2009-2019:
    - Avg. 31.3 starts
    - Avg. 6.4 innings per start
    - 5 trips to the IL for 15 days or less.
      - Rib fracture
      - Oblique strain
      - Neck soreness

Is There a Link Between Weak Core/Stability and Injuries?

- Core provides foundation upon which bigger muscles move-UE/LE
  - Balance plays key factor in this
- Early activation of synergistic muscles is essential
- Radwan et al 2014 looked at balance and its effect on upper extremity injuries (shoulder dysfunction)
  - Balance tests included SLB, double leg straight leg lowering test (DLL), Sorensen's test, and modified plank
  - Shoulder dysfunction was lower in athletes with increased balance and core activation for SLB and DLL
- Correlates to people with poor balance have > risk of injury

Is There a Link Between Weak Core/Stability and Injuries?

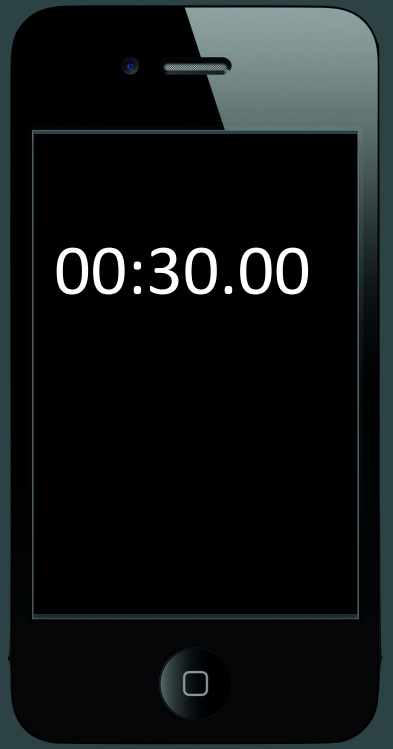
- Pitchers with less control during single leg stance
  - 3X more likely to miss more than 30 days due to injury
  - 60% were upper extremity injury
- Reduced Single leg stance time in pitchers with shoulder injury
- LE Y-Balance test
  - Significantly reduced dynamic balance in both the stance leg and lead leg in high school and college baseball players with UCL tears.



Silfies (2015)

SPORTS MEDICINE CENTER

Group Activity-Single Leg Balance

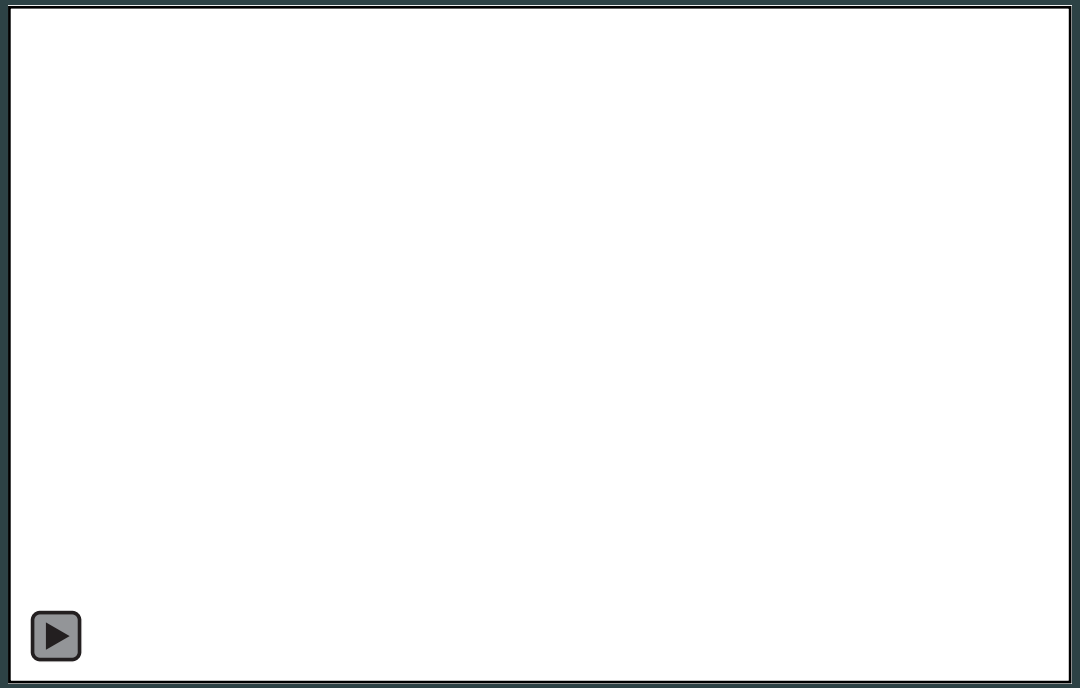


Children's Hospital Colorado

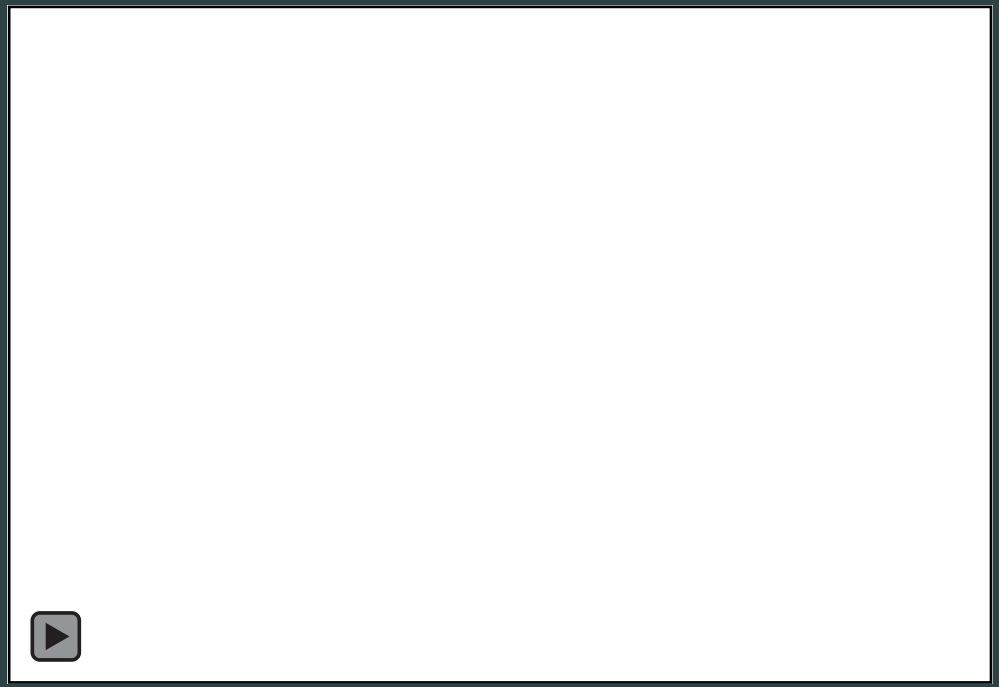
Leading With the Hips

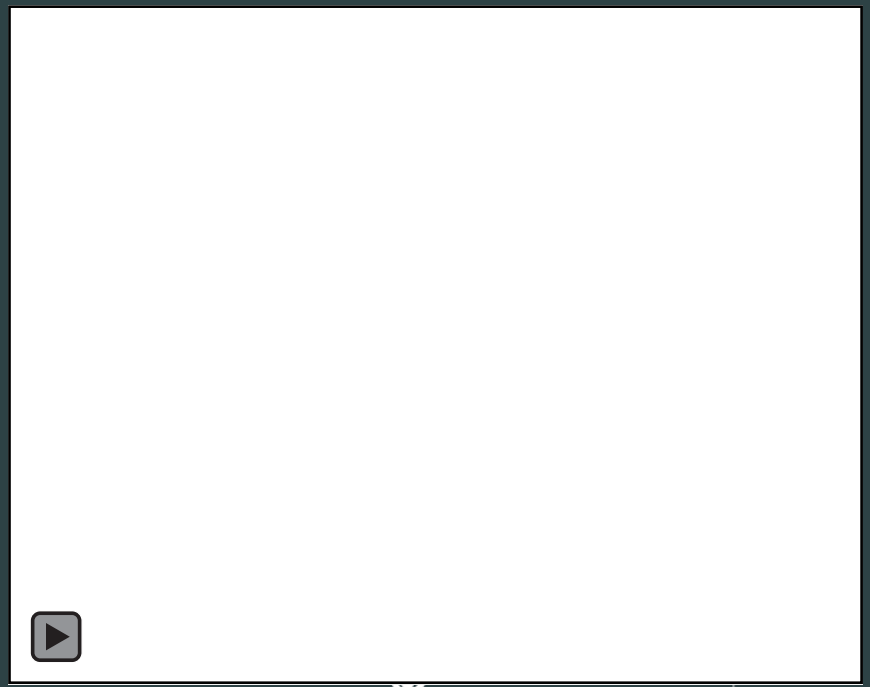
- Immediately following the SLB and pelvic stability portion in phase of pitching
- Why lead with the hips?
  - Initiates linear velocity
  - Increases stride length
  - Proper timing of the kinematic sequence
- “Inefficiency or failure of the kinetic chain can increase the kinetic requirements of the shoulder to maintain top velocity and performance.”

Proper Hip Lead - Pro



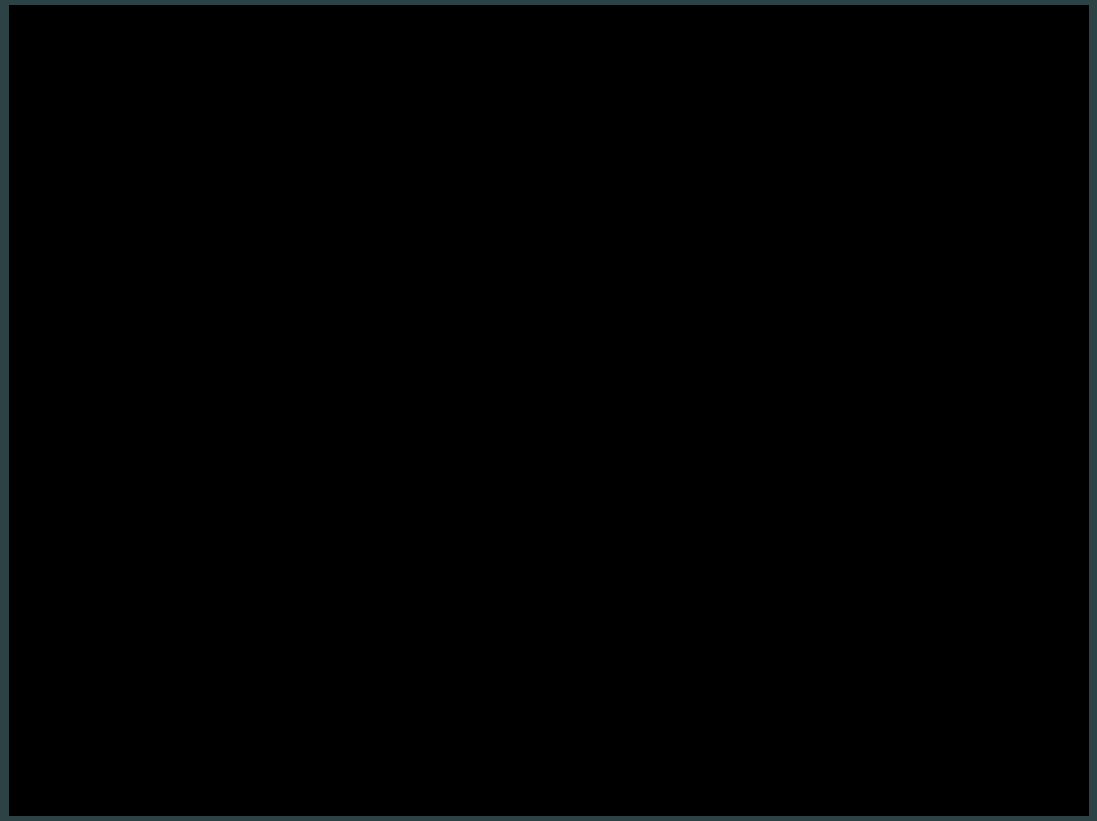
Hip Lead - Youth: The Good and The Bad





Group Activity—Hershiser Drill

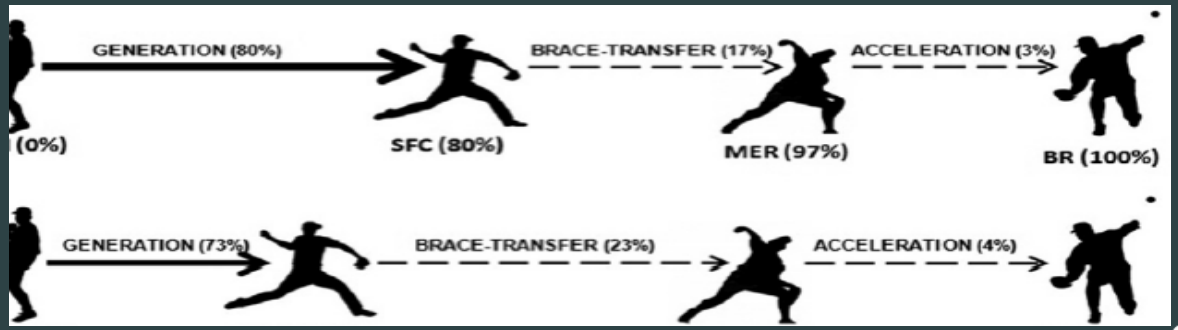
SPORTS MEDICINE CENTER



Children's Hospital Colorado

Stride Length

- Proficient baseball pitchers – stride lengths between 80% and 85% body height
- 25% lower stride length = altered total body and throwing arm linear momentum
- Longer strides reduces throwing arm momentum by intersegmental trunk effect
  - Throwing arm has greater proportion of total momentum
- Simple math: 6ft height=~5ft stride length; 4ft height=3.5ft stride length

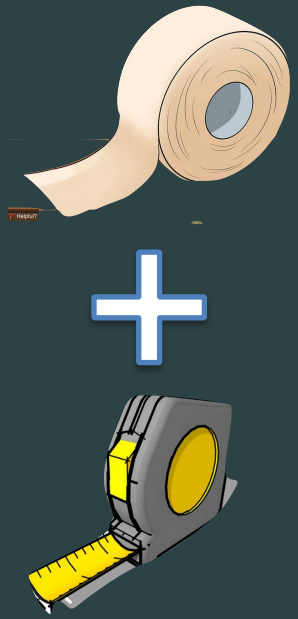


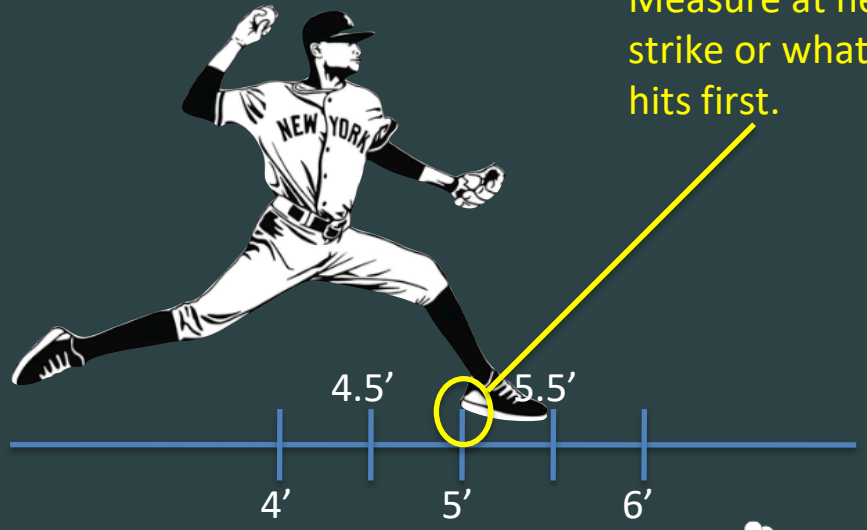
Ramsey (2014)

Youth Pitching Stride Length

- Average stride length for the population was found to be 66.0% of body height
- 3 Variables Statistically Significant Correlation with Stride Length
  - Power Production (vertical jump)
  - Pitching experience
  - Single-leg balance

Group Activity: Stride Length





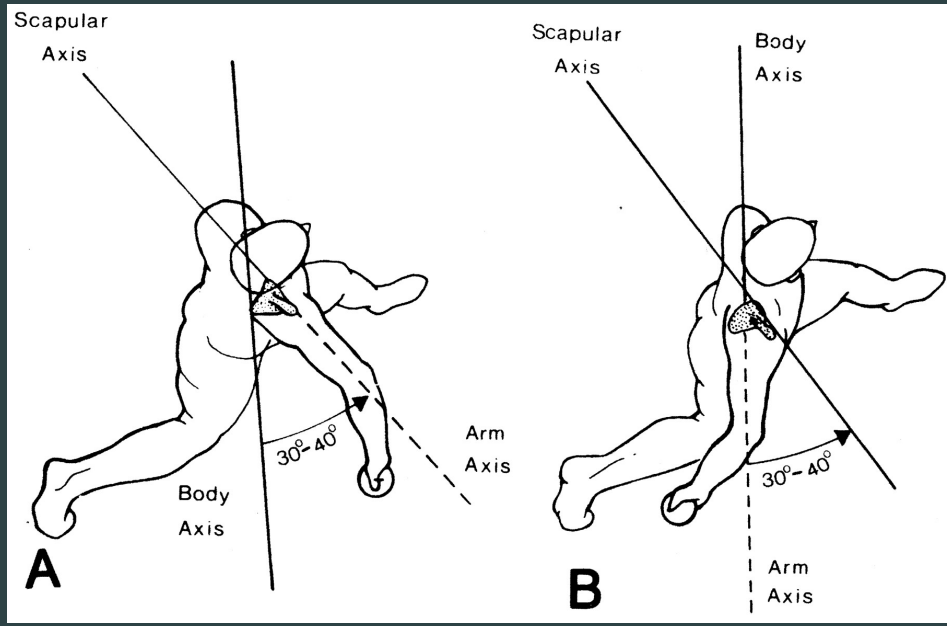
Thoracic Mobility

SPORTS MEDICINE
CENTER

Children's Hospital Colorado

Pelvic-Upper Torso Separation and Arm Stress

- Oyama et al.
  - HS baseball players
  - Improper trunk rotation sequence = greater shoulder external rotation angle and shoulder proximal forces
- Aguinaldo et al.
  - Adult pitchers who rotated their upper torso later had reduced magnitudes of elbow valgus torque



Oyama (2014), Aguinaldo (2009)

What it is supposed to look like…

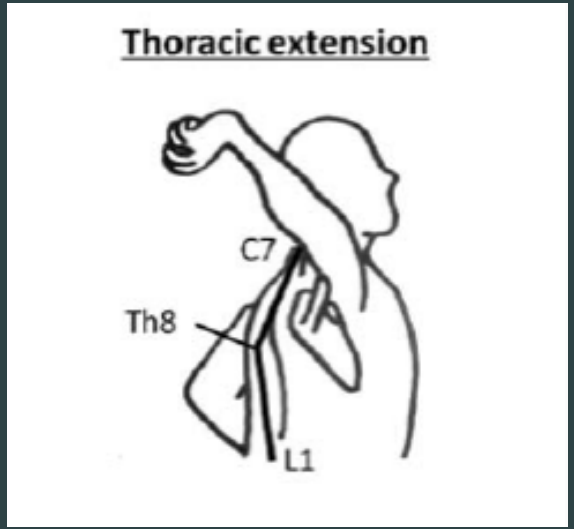
Thoracic Mobility and Pelvic Torso Separation

Miyashita et al.

- Scapular tilting and thoracic extension contribute to the maximum external rotation angle while throwing. Deficits in tilting or extension can cause the thrower to need more glenohumeral external rotation.

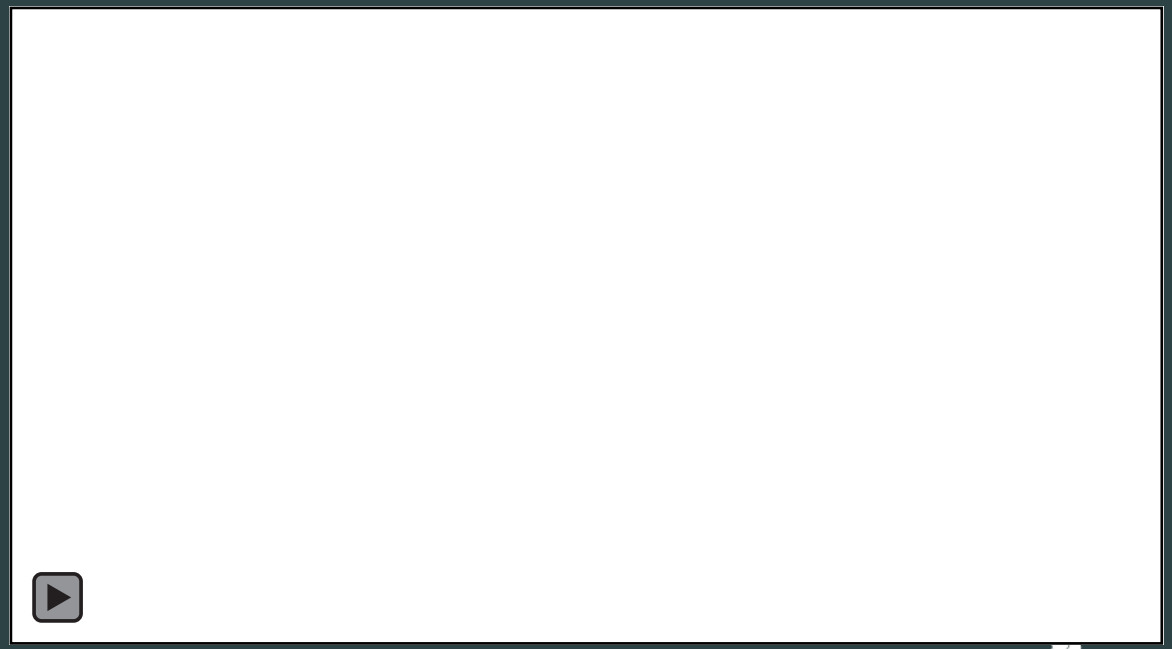
Sakata et al.

– Junior baseball players ages 6-12 years of age had a 2.5x greater risk of having a medial elbow injury with thoracic kyphosis angle of >30 degrees.

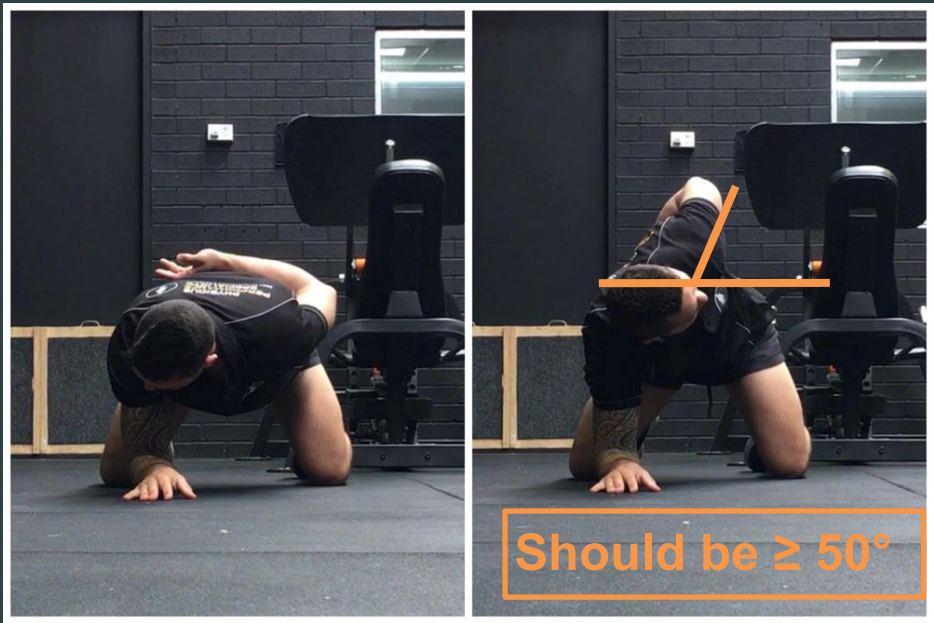


Miyashita (2010), Sakata (2016)

Good Pelvic-Torso Separation

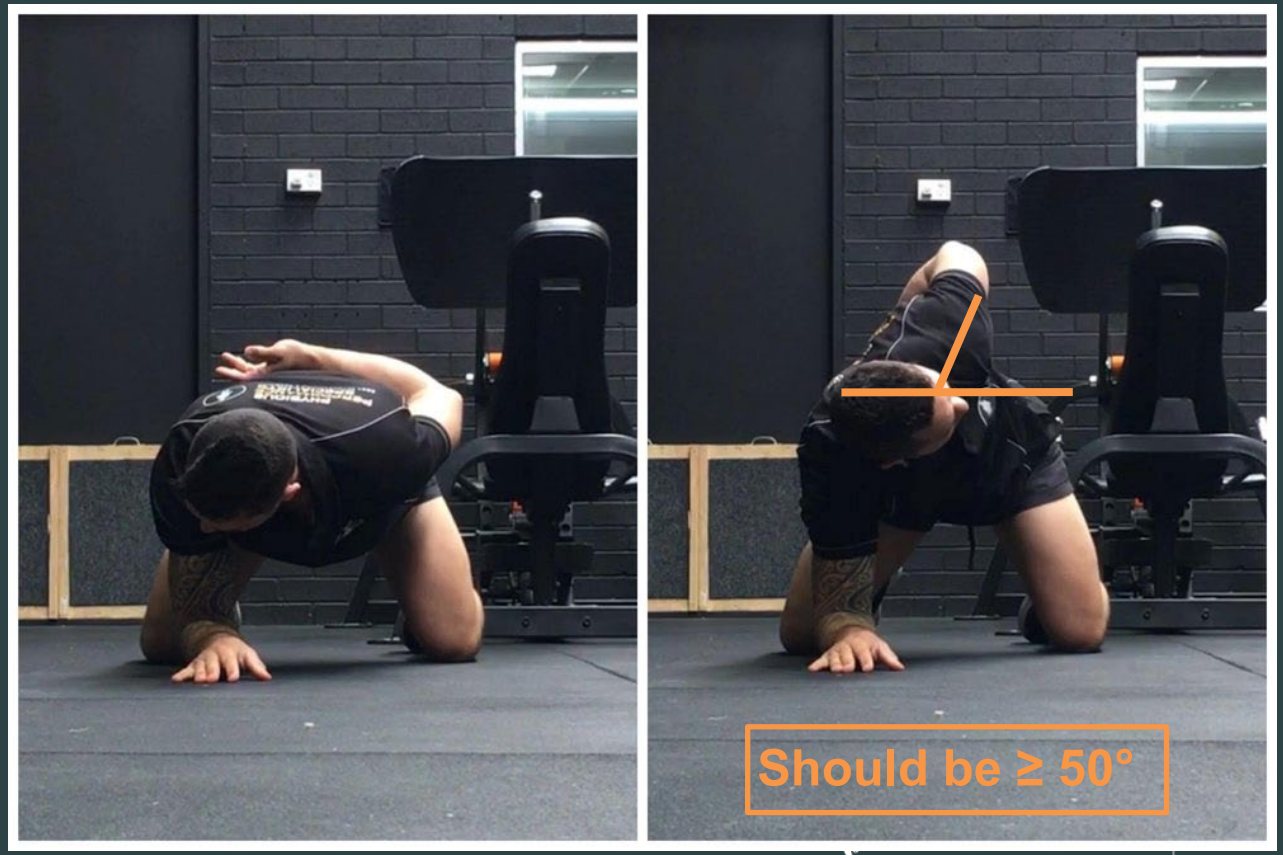


Thoracic Mobility Dysfunctions – Assess



Group Activity—Thoracic Mobility

SPORTS MEDICINE CENTER



Timing of Abduction and External Rotation

SPORTS MEDICINE CENTER
Children's Hospital Colorado

GH External Rotation

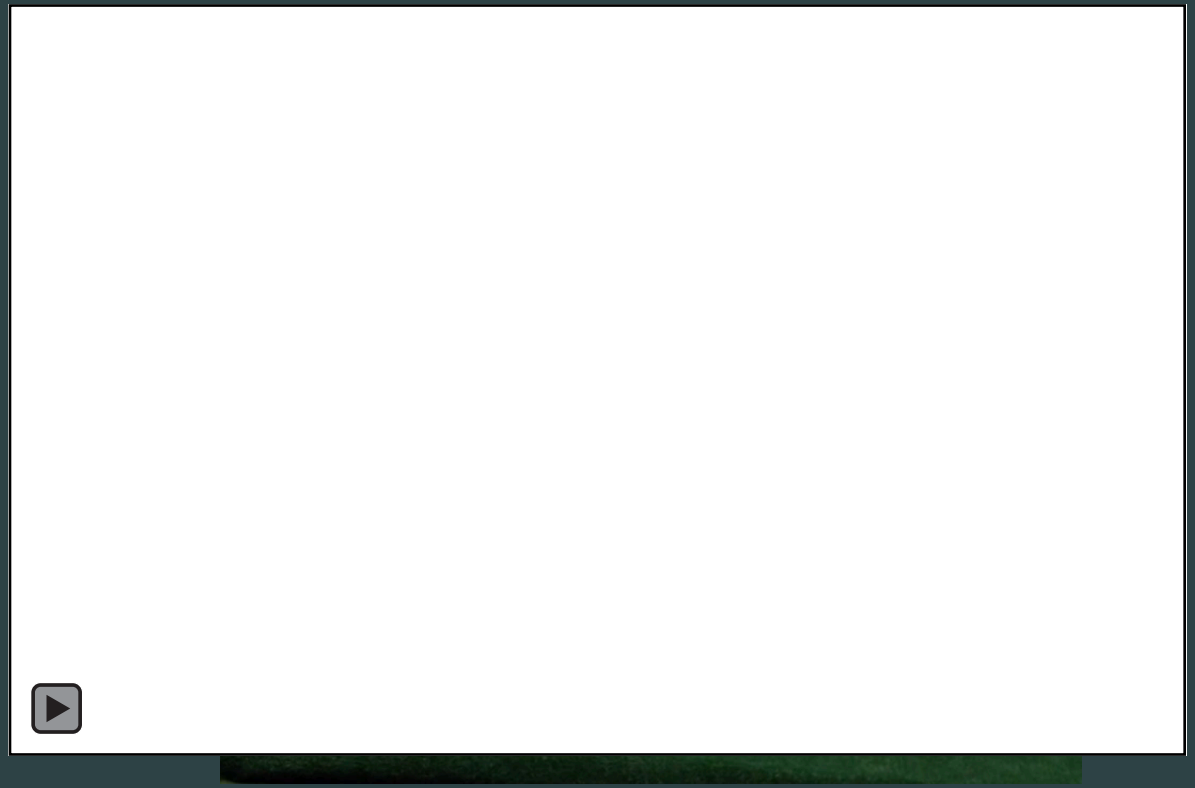
- Can reach ~170-190 degrees (Oyama, 2012)
- The timing of external rotation also depends on scapular-thoracic movement and shoulder abduction. (Calabrese, 2012)
- Too much internal rotation prior to **stride foot contact** causes pitcher to have to exert more muscular force over a longer period of time to reach maximum external rotation.
  - *Late timing of abduction and external rotation can cause "leading with the elbow" which can increase anterior shoulder force and medial sided elbow force. (Fortenbraugh, et al 2009)*

Let's

- Sh
- At
  is
  ex
- As
  pl
  int

Let's evaluate…THE NOT SO GOOD (Drew Storen)

- Not as much early abduction.
- Forearm is level with shoulders at stride foot contact.
- Shoulder internally rotates significantly before going into external rotation.
- "Inverted W"
- Tommy John surgery in 2018.



Side by side…

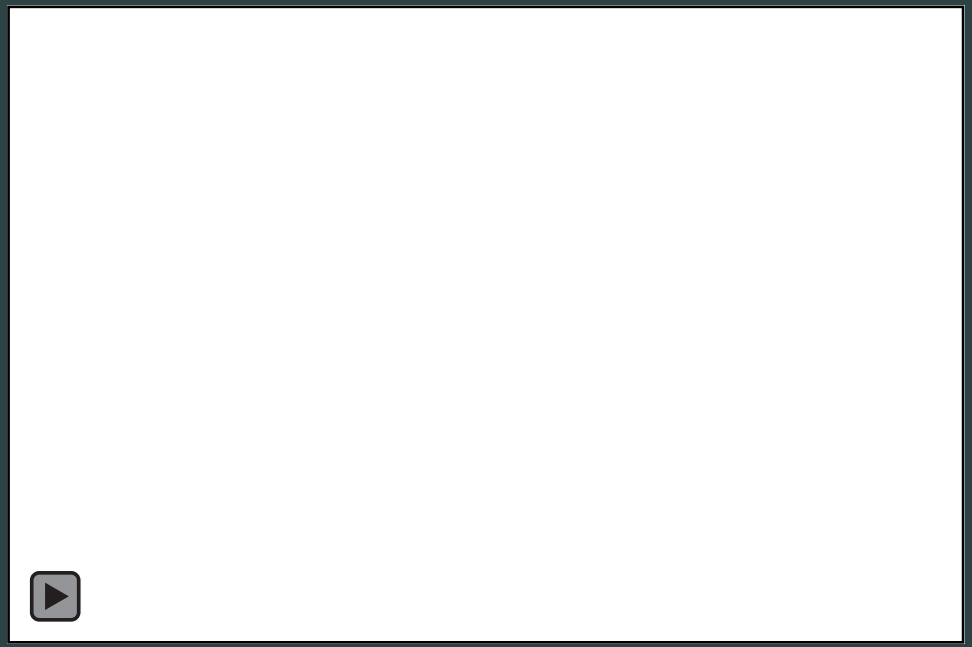
Phenoms on the IL

- All made it to the Major Leagues at a young age and all high velocity pitchers.
- At foot strike, arm is level (or below) with the shoulders.
- Shoulder should be abducted and externally rotating at this point!
- All 3 pitchers underwent UCL reconstruction within their first two years in the Major Leagues

Motion Analysis-ROM Testing

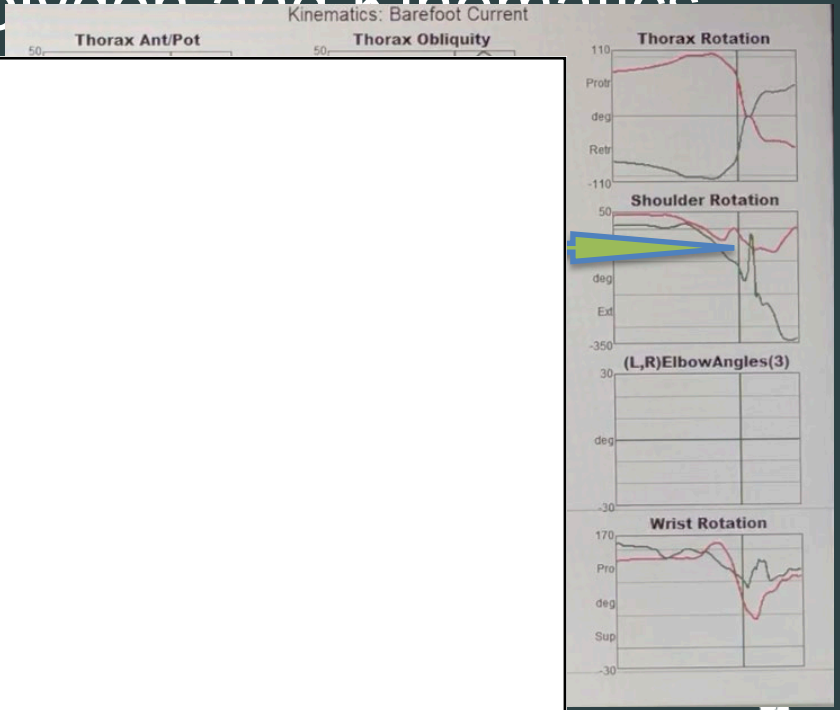
- GH Flexion
- GH Extension
- GH ER
- GH IR
- Supination
- Pronation
- GH Abduction
- Horizontal Adduction
- Elbow Flexion
- Elbow Extension

Motion Analysis-Video



- ROM Testing
- Warm up
- 10 throws (all fastballs)

Motion Analysis-Polygon and Kinematics

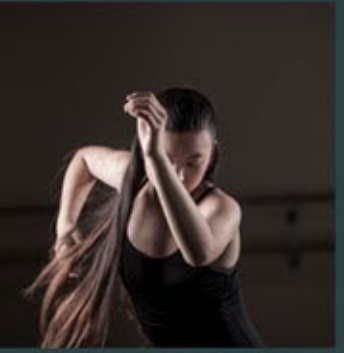


Study Overview

- Ages 8-11
- Youth baseball pitchers that have had some pitching instruction
- ~15 subjects for the pilot study
- Long range goal to follow kids through high school
- Hoping to quantify certain “faulty” pitching mechanics and their direct effect on forces applied through the medial elbow and anterior shoulder.
  - Subsequently, determine future injury risk.

Intervention Strategies

IF…	THEN
• Poor single leg stability	• Core and proprioceptive work
• Not leading with the hips	• Hershiser Drill
• Poor timing of thoracic rotation/not separating	• Work on thoracic mobility (should be ~50 degrees or more)
• Poor timing of GH abduction and/or external rotation.	• Check for scapulothoracic dysfunction
• Inadequate stride length	• Increase gluteal activation and hip mobility (internal rotators)



SPORTS MEDICINE

NUTRITION

concussion care

physical therapy

Fracture management

SIDELINE COVERAGE

Sports medicine surgeons

Tailored care

injury prevention

Return to play evaluations

CERTIFIED ATHLETIC TRAINERS

Community Education

Board-certified pediatric experts

Innovative research

SPORTS MEDICINE CENTER
Children's Hospital Colorado

References

- Seroyer ST, Nho SJ, Bach BR, Bush-Joseph CA, Nicholson GP, Romeo AA. The Kinetic Chain in Overhead Pitching: Its Potential Role for Performance Enhancement and Injury Prevention. *Sports Health*. 2010;2(2):135-46.
- Chu SK, Jayabalan P, Kibler WB, Press J. The Kinetic Chain Revisited: New Concepts on Throwing Mechanics and Injury. *PM R J*. 2016;8:S69-S77.
- Chalmers PN, Wimmer MA, Verma NN, Cole BJ, Romeo AA. The Relationship Between Pitching Mechanics and Injury: A Review of Current Concepts. *Sports Health*. 2017;9(3):216-21.
- Fortenbaugh D, Fleisig GS, Andrews JR. Baseball Pitching Biomechanics in Relation to Injury Risk and Performance. *Sports Health*. 2009;1(4):314-20.
- Chaudhari. A., McKenzie. C., Pan. X., Onate. J. (2014). *Lumboplevic Control and Days Missed Due to Injury in Professional Baseball Pitchers*. American Journal of Sports Medicine, 42, (11). PP2734-2740.
- Chu. S., Jayabalan. P., Kibler. W., & Press. J. (2016). *The Kinetic Chain Revisited: New Concepts on Throwing Mechanics and Injury*. Advanced Sports Medicine Concepts and Controversies, 8, PP: S69-S77.
- Kibler. B., Wilkes. T., & Sciascia. A. (2013). *Mechanics and Pathomechanics in the Overhead Athlete*. Clinical Sports Medicine, 32. PP:637-651.

References

- Park. S., Loebenberg. M., Rokito. A., & Zuckerman. J. (2002). *The Shoulder in Baseball Pitching*. Hospital for Joint Diseases, 61, (1,2). PP: 68-88.
- Radwan. A., Francis. J., Green. A., Kahl. E., Maciurzynski. D., Quartulli. A., Schultheiss. J., Strang. R., & Weiss. B. (2014). *Is There a Relation Between Shoulder Dysfunction and Core Instability*? Internal Journal of Sports Physical Therapy, 9, (1). PP:8-13.
- Silfies. S., Ebaugh. D., Pontillo. M., & Butowicz. C. (2015). *Critical Review of the Impact of Core Stability on Upper Extremity Athletic Injury and Performance*. Brazilian Journal of Physical Therapy, 19, (5). PP: 360-368. \
- Aguinaldo, A. L., & Chambers, H. (2009). Correlation of Throwing Mechanics With Elbow Valgus Load in Adult Baseball Pitchers. *The American Journal of Sports Medicine*, *37*(10), 2043–2048. https://doi.org/10.1177/0363546509336721
- Laudner, K., Wong, R., Onuki, T., Lynall, R., & Meister, K. (2015). The relationship between clinically measured hip rotational motion and shoulder biomechanics during the pitching motion. *Journal of Science and Medicine in Sport*, *18*(5), 581–584. https://doi.org/10.1016/j.jsams.2014.07.011
- Luera, M. J., Dowling, B., Magrini, M. A., Muddle, T. W., Colquhoun, R. J., & Jenkins, N. D. (2018). Role of Rotational Kinematics in Minimizing Elbow Varus Torques for Professional Versus High School Pitchers. *Orthopaedic Journal of Sports Medicine*, *6*(3), 232596711876078. https://doi.org/10.1177/2325967118760780

References

- Scarborough, D. M., Bassett, A. J., Mayer, L. W., & Berkson, E. M. (2018). Kinematic sequence patterns in the overhead baseball pitch. *Sports Biomechanics*, , 1–18. https://doi.org/10.1080/14763141.2018.1503321
- Seroyer, S. T., Nho, S. J., Bach, B. R., Bush-Joseph, C. A., Nicholson, G. P., & Romeo, A. A. (2010). The Kinetic Chain in Overhand Pitching: Its Potential Role for Performance Enhancement and Injury Prevention. *Sports Health: A Multidisciplinary Approach*, *2*(2), 135–146. https://doi.org/10.1177/1941738110362656
- Solomito, M. J., Garibay, E. J., Woods, J. R., Õunpuu, S., & Nissen, C. W. (2015). Lateral Trunk Lean in Pitchers Affects Both Ball Velocity and Upper Extremity Joint Moments. *The American Journal of Sports Medicine*, *43*(5), 1235–1240. https://doi.org/10.1177/0363546515574060
- Weber, A. E., Kontaxis, A., O'Brien, S. J., & Bedi, A. (2014). The Biomechanics of Throwing. *Sports Medicine and Arthroscopy Review*, *22*(2), 72–79. https://doi.org/10.1097/jsa.0000000000000019
- Ramsey DK, Crotin RL, White S. Effect of stride length on overarm throwing delivery: A linear momentum response. *Human Movement Sci.* 2015; 38:185-96.
- Fry KE, Pipkin A, Wittman K, Hetzel S, Sherry M. Youth Baseball Pitching Stride Length: Normal Values and Correlation With Field Testing. *Sports Health.* 2016;9(3):205-09.
- Saito M, Kenmoku T, Kameyama K, Murata R, Yusa T, Ochiai N, Kijima T, Takahira N, Fukushima K, Ishige N, Takaso M. Relationship Between Tightness of the Hip Joint and Elbow Pain in Adolescent Baseball Players. *The Ortho J of Sports Medicine.* 2015;2(5):1-5.

References

- Oyama S, Yu B, Blackburn JT, Padua DA, Li L, Myers JB. Improper Trunk Rotation Sequence Is Associated With Increased Maximal Shoulder External Rotation Angle and Shoulder Joint Force in High School Baseball Pitchers. *The Am J Sports Med.* 2014;42(9).
- Calabrese G,. Pitching Mechanics, Revisited. IJSPT. 2013; 8(5): 652-60.
- Oyama S, Baseball pitching kinematics, joint loads, and injury prevention. Journal of Sport and Health Science. 2012; 1: 80-91.