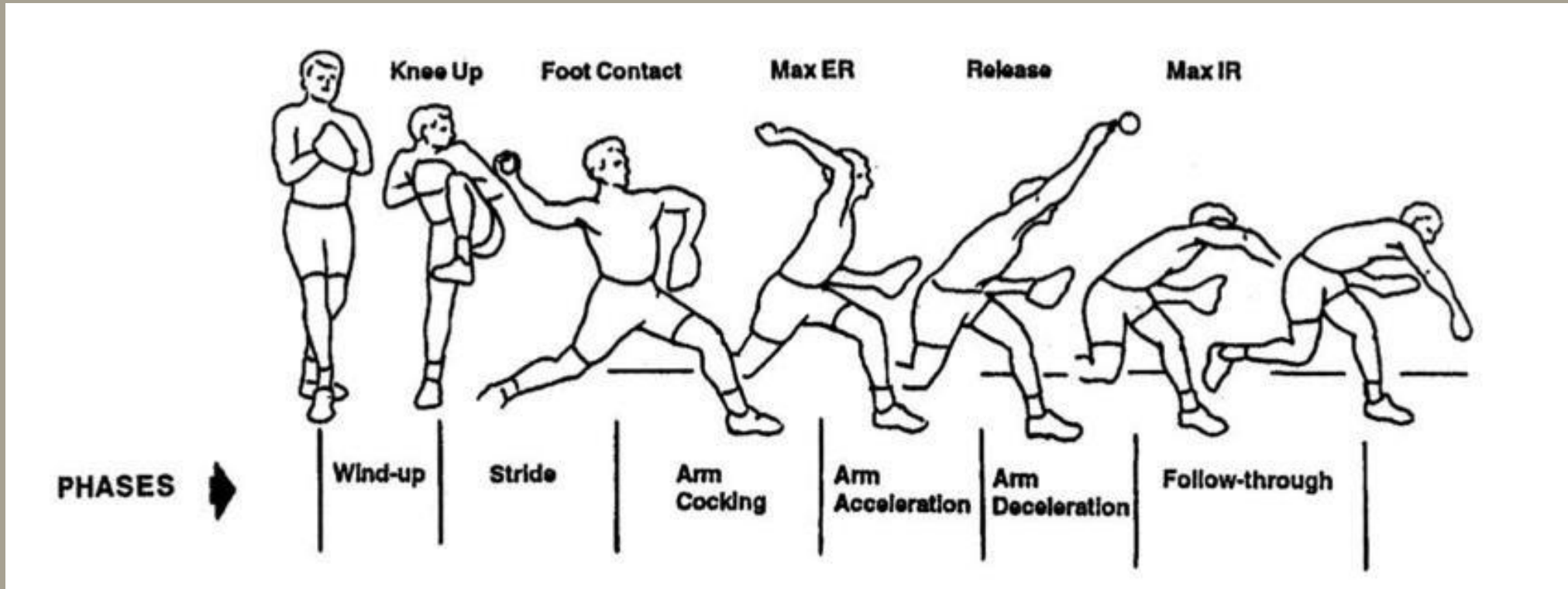


BIOMECHANICS OF BASEBALL PITCHING

MORGAN SULLIVAN

PITCHING BASICS

- Explosive and unnatural motion
- Many factors must align to create a good pitch
- Many different pitching styles and motions but all follow similar concept



PHASES OF MOTION



1. WIND-UP

- Leg raise and straight posture do work against gravity and store potential energy for upcoming lateral motion
- Arms remain stationary and at front

2. STRIDE

- Beginning of the conversion of potential energy into mechanical energy
- Abduction of the shoulder (Deltoid) muscles raises the elbows to prepare for cocking motion
- Ends with foot plant landing softly, not on the heel





3. COCKING PHASE

- Maximal external rotation of the shoulder (Infraspinatus and teres minor muscles stabilize humerus rotation)
- Foot plant begins action of the 'kinetic chain'



- Kinetic Chain: Foot plant, Trunk Rotation, Shoulder Rotation, Elbow translation, Wrist Translation
- Extensor (triceps) muscles allow for rapid forearm extension
- Internal angular velocity at the shoulder: ~ 7600 deg/sec
- Internal angular velocity at the elbow: ~ 2500 deg/sec
- Force on the Ulnar Collateral Ligament can reach 60N

4. ACCELERATION



5. ARM DECELERATION

- Post-release deceleration of arm, supraspinatus muscle contracts to decelerate internal rotation
- Pitching muscles begin to relax



6. FOLLOW THROUGH

- Natural momentum-guided motion
- Back leg raises to stabilize position

Front View

Muscles of the Rotator Cuff

Back View

Subscapularis

Supraspinatus

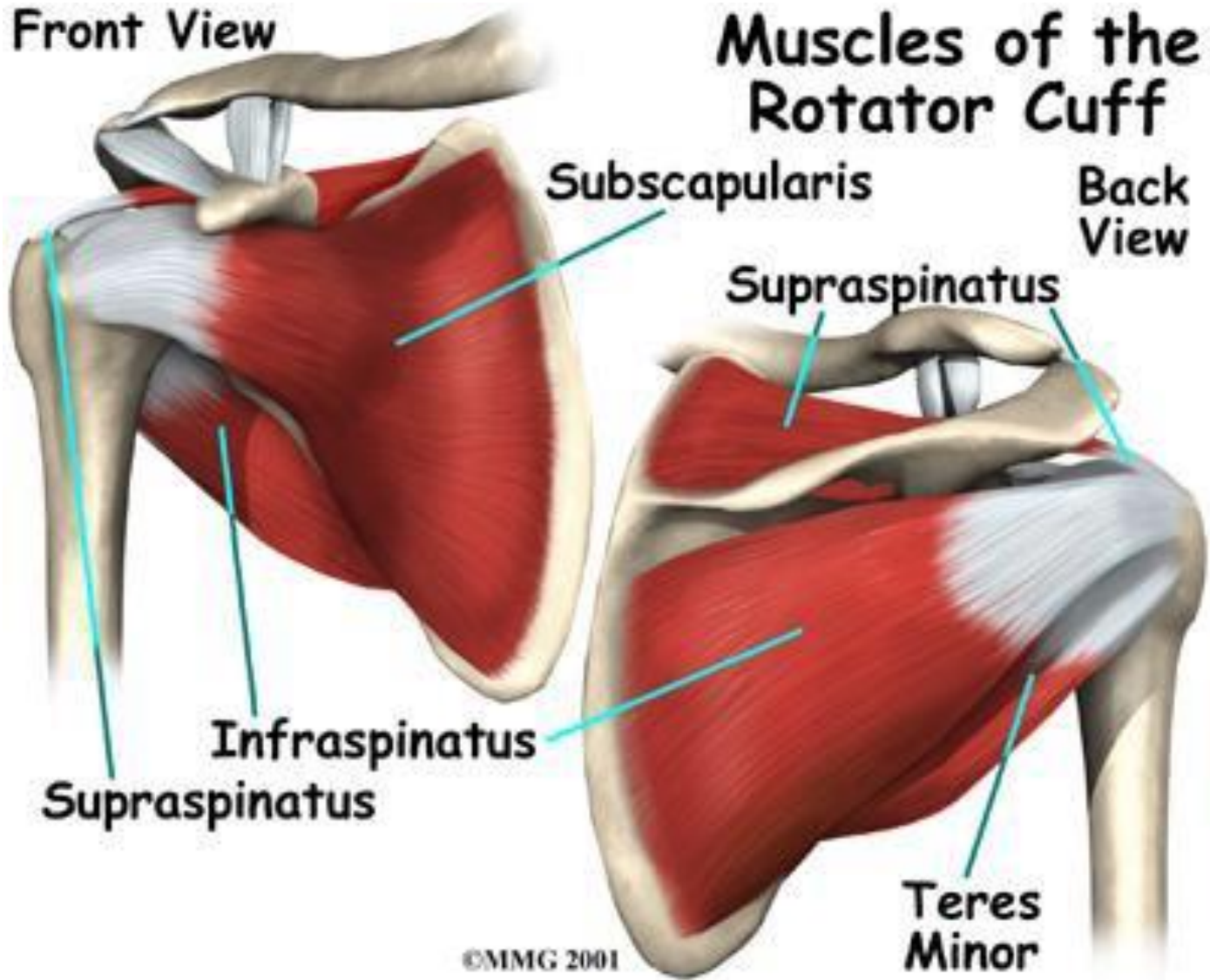
Infraspinatus

Supraspinatus

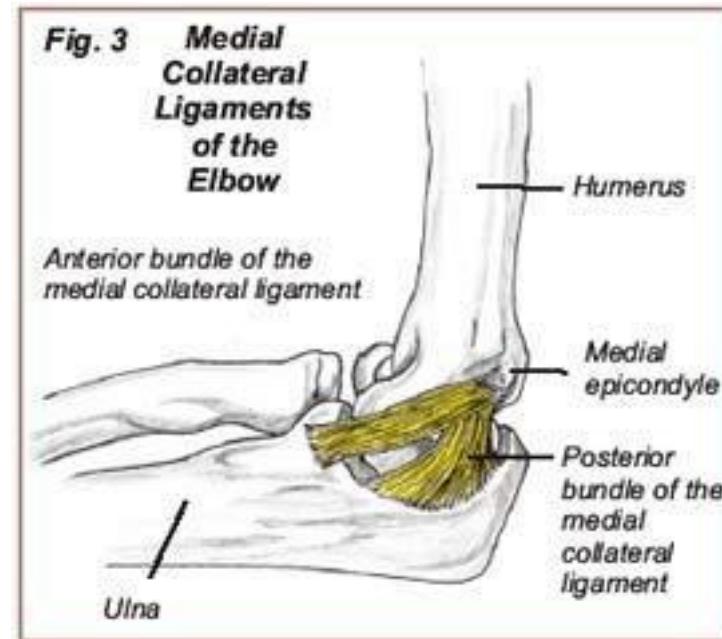
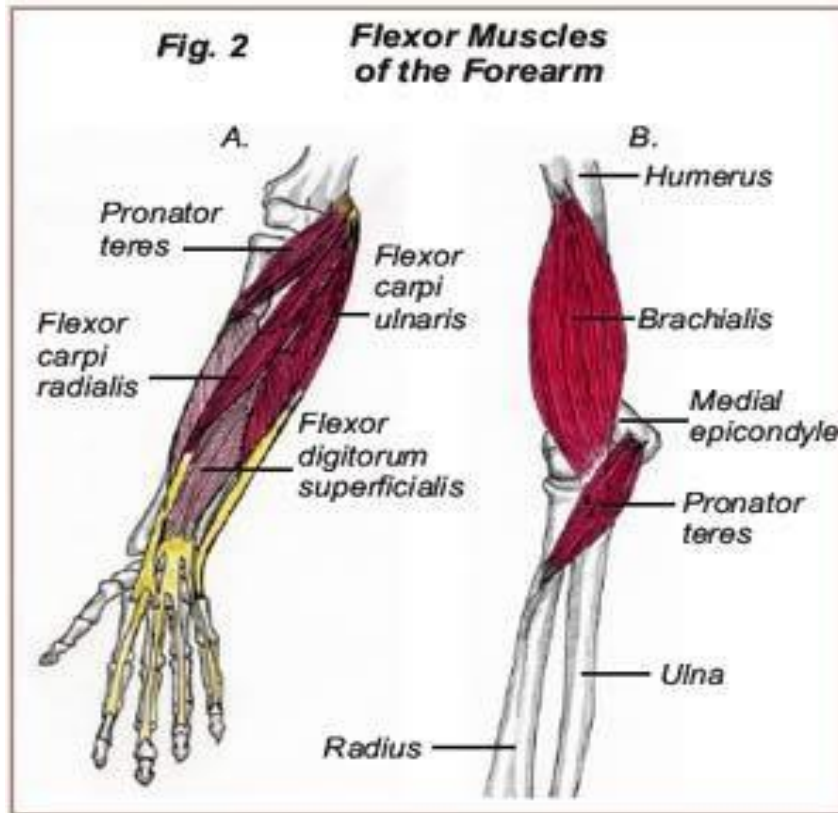
Teres Minor

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IMPORTANT
PITCHING
MUSCLES



PITCHING ANATOMY



PITCH COMPARISON

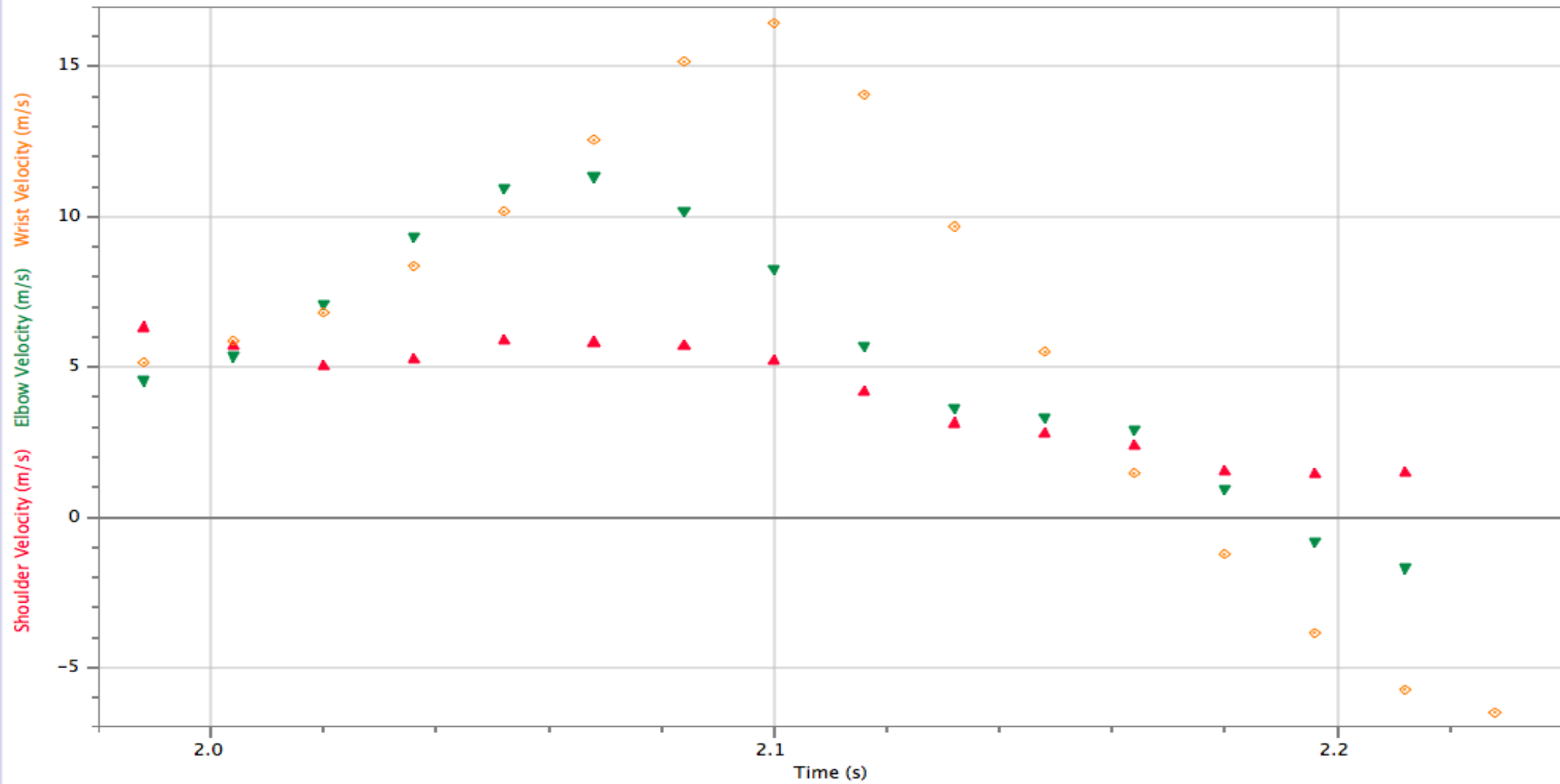
Fastball

Thrown for speed, the fastball is the most common pitch and sacrifices lateral motion for precision and speed

Curveball

A generally slower pitch that sacrifices speed for a drastic change in position. Typical curveball pitching motion involves wrist flexion immediately prior to ball release

Fastball Arm Velocity



FASTBALL ARM VELOCITIES

$$\text{Force of chain on ball} = ma = (4.96\text{kg} + .149\text{kg})(36\text{m/s}^2) = 185.5\text{N}$$

$$\text{KE} = \frac{1}{2}mv^2 = \frac{1}{2}(.149\text{kg} + 4.96\text{kg})(14.6\text{m/s})^2 = 545 \text{ Joules}$$

$$U = mgh = (.149\text{kg})(9.8\text{m/s}^2)(1.62\text{m}) = 2.4 \text{ Joules}$$

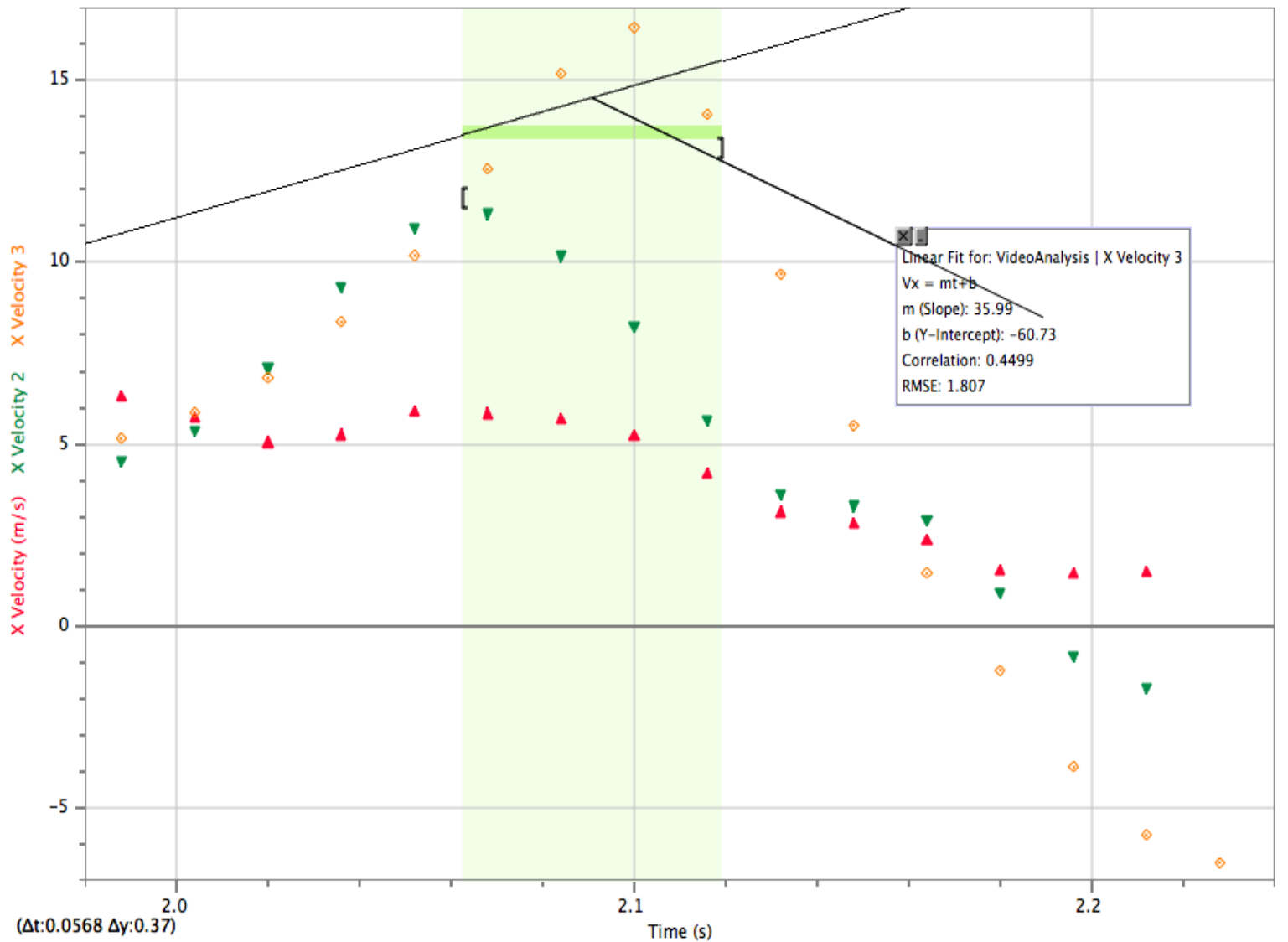
$$\text{Work} = \Delta\text{KE} + \Delta U = (545\text{J}) + (2.4\text{J}) = 547.4 \text{ Joules}$$

$$\text{Momentum prior to release} = mv = (4.96\text{kg} + .149\text{kg})(14.6\text{m/s}) = 74.6 \text{ N}\cdot\text{s}$$

$$\text{Momentum of ball after release} = mv = (.149\text{kg})(36.1\text{m/s}) = 5.4 \text{ N}\cdot\text{s}$$

Conservation of momentum states that Ben should be moving at around .84m/s after throw. Logger Pro calculated 1.13m/s so, not far off

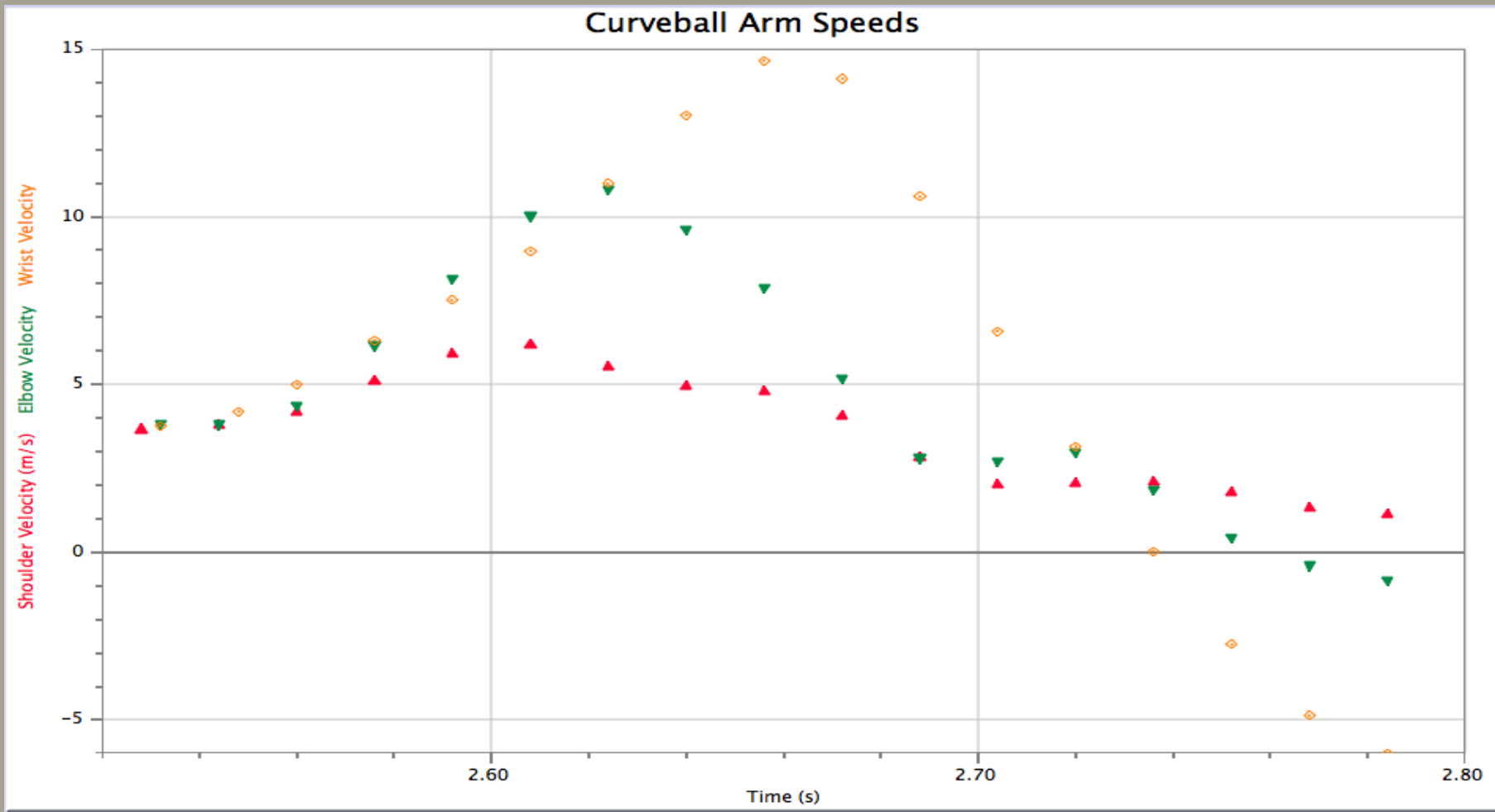
CALCULATIONS



FASTBALL ACCELERATIONS

- Assume: Force is always acting perpendicular to the moment arm (which it is not)
- Arm length: $\sim .7\text{m}$
- Arm mass: $\sim 6\%$ of body weight, so, $(82.6\text{kg})(.06) = 4.96\text{kg}$
- Acceleration from cocking to release: 36 m/s^2
- $T = F \times r = (4.96\text{kg})(36\text{m/s}^2)(.53\text{m}) = 94.6 \text{ Nm}$

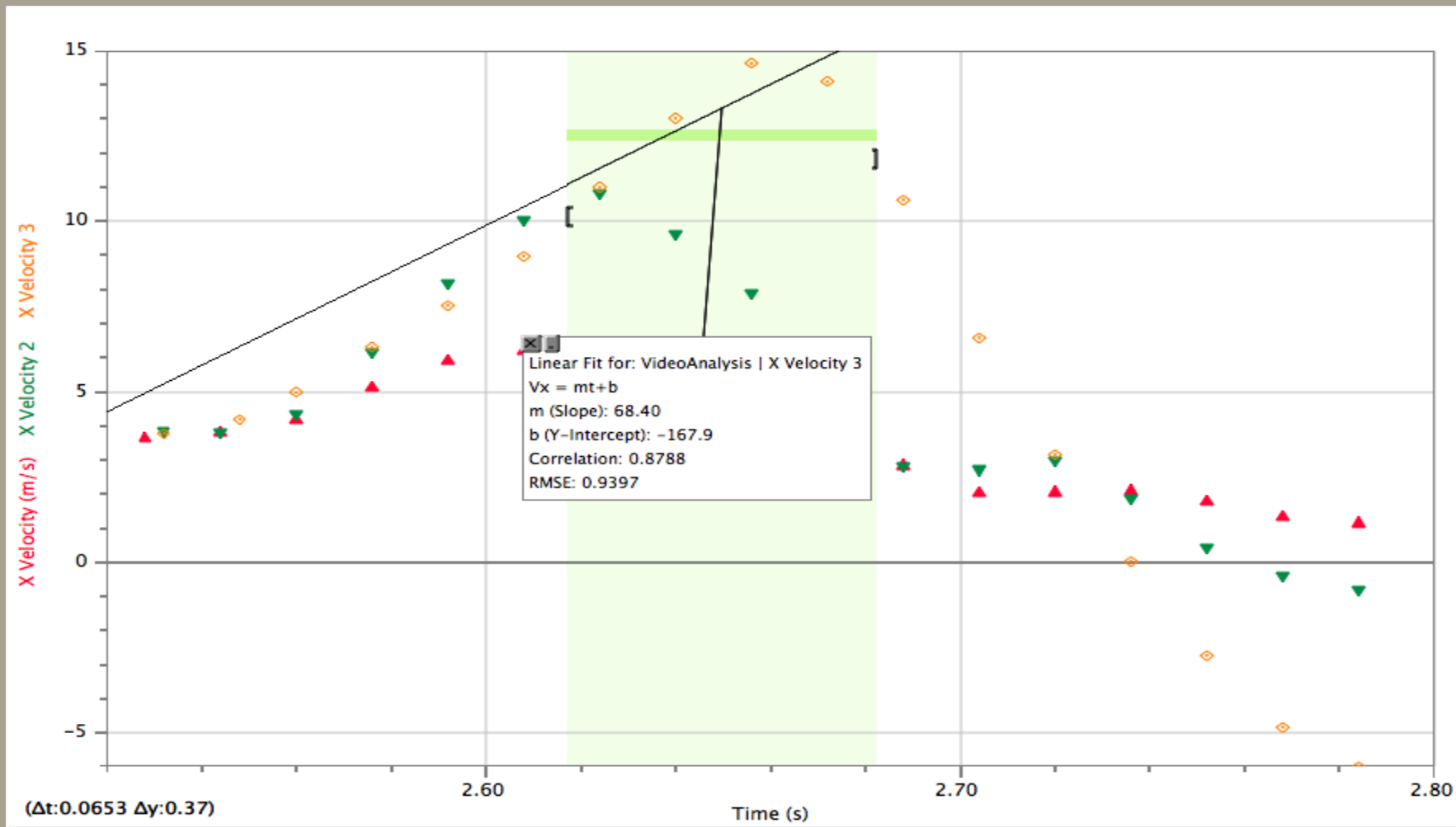
CALCULATIONS (CONT.)



CURVEBALL ARM VELOCITIES

CALCULATIONS

- Force of chain on ball = $(4.96 + .149\text{kg})(68.4\text{m/s}^2) = 352.5\text{N}$
- $\text{KE} = \frac{1}{2} mv^2 = (1/2)(4.96\text{kg} + .149\text{kg})(12.1\text{m/s})^2 = 374$
Joules
- $U = 2.4$ Joules
- $\text{Work} = \Delta\text{KE} + \Delta U = (374\text{J}) + (2.4\text{J}) = 376.4$ Joules
- Momentum prior to release = $mv = (4.96\text{kg} + .149\text{kg})(12.1\text{m/s}) =$
- $61.8 \text{ N}\cdot\text{s}$
- Momentum of ball after release = $mv = (.149\text{kg})(25\text{m/s}) = 3.7 \text{ N}\cdot\text{s}$
- So: Ben's velocity after should be $.70\text{m/s}$, Logger Pro calculated
- $.86\text{m/s}$ - again pretty close



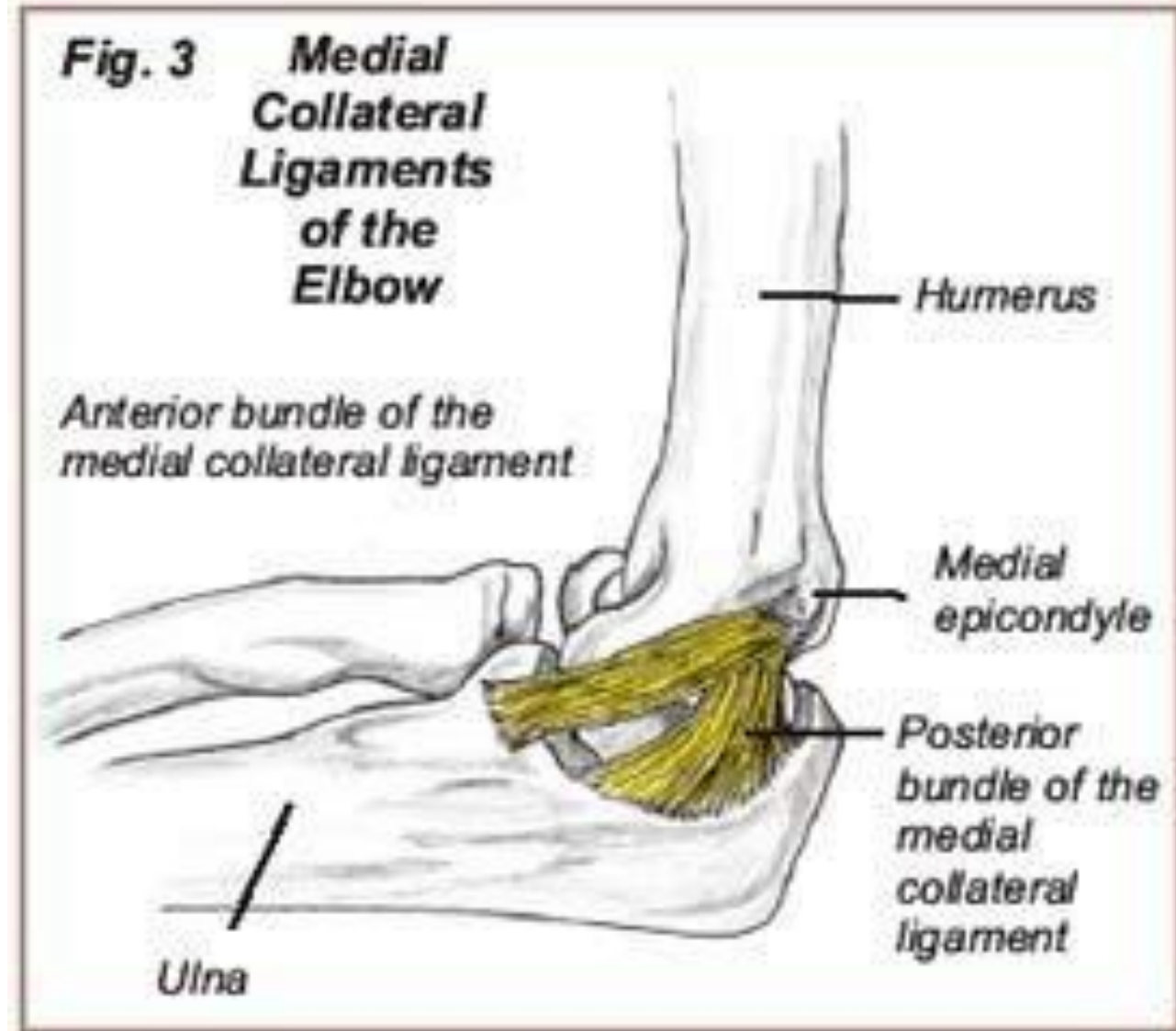
CURVEBALL ACCELERATION

CALCULATIONS (CONT.)

- Same assumption as before; force is always perpendicular to the moment arm
- Acceleration from cocking to release in curve: 68.4m/s^2
- $T = F \times r = (4.96\text{kg})(68.4\text{m/s}^2)(.6\text{m}) = 203.6 \text{ Nm}$
- Moment-arm assumption really comes into play in this
- case

COMMON INJURIES: UCL

- Due to the unnatural motion of pitching, injury is exceedingly common.
- A very common injury involves damage to the UCL, which can reach its ultimate tensile strength
- Over many throws, the UCL can
- become frayed or torn
- Tommy John surgery



COMMON INJURIES: ROTATOR CUFF

- During cocking and deceleration, extreme stress is placed on the muscles of the rotator cuff
- Rotator cuff injury usually involves injuries in the tendons of the supraspinatus or infraspinatus muscles, which stabilize the glenohumeral joint during deceleration



LIMITATIONS

The majority of the momentum that goes into a pitch comes from the rotation of the trunk

By studying the linear movement of the shoulder, elbow and wrist, only the final portion of the kinetic chain is analyzed

2D analysis is limiting

Future analysis might use motion capture to look at the rotational kinematics of the trunk during pitching, as well as analyzing the rotation of the arm in more depth

REFERENCES

- Blake, Chris. "The Kinetic Chain: Strength and Conditioning of the Baseball Athlete." New England Musculoskeletal Institute at the UConn Health Center. University of Connecticut Health Center. Web. 16 Apr. 2011.
<http://nemsi.uchc.edu/clinical_services/orthopaedic/sportsmedicine/baseball_training/index.html>.
- Dubin, Joshua. "Medial Epicondylitis." Dubin Chiropractic. Web. 16 Apr. 2011.
<<http://www.dubinchiro.com/features/pitcher1.html>>.
- Fleisig, G. S., J. R. Andrews, C. J. Dillman, and R. F. Escamilla. "Kinetics of Baseball Pitching with Implications About Injury Mechanisms." *The American Journal of Sports Medicine* 23.2 (1995): 233-39. Print.
- Fleisig, G. S. "Kinetic Comparison Among the Fastball, Curveball, Change-up, and Slider in Collegiate Baseball Pitchers." *American Journal of Sports Medicine* 34.3 (2005): 423-30. Print.
- Hung, George K., and Jani Macari. Pallis. *Biomedical Engineering Principles in Sports*. New York: Kluwer Academic/Plenum, 2004. Print.
- Nissen, C. W., M. Westwell, S. Ounpuu, M. Patel, M. Solomito, and J. Tate. "A Biomechanical Comparison of the Fastball and Curveball in Adolescent Baseball Pitchers." *The American Journal of Sports Medicine* 37.8 (2009): 1492-498. Print.
- "Rotator Cuff Injury, Symptoms and Treatment." *The Virtual Sports Injury Clinic - Sports Injuries, Symptoms, Diagnosis and Treatment*. Web. 16 Apr. 2011.
<<http://www.sportsinjuryclinic.net/cybertherapist/back/shoulder/rotatorcuff.htm>>.



