

Biomechanical Analysis of Motion of Professional Baseball Pitchers

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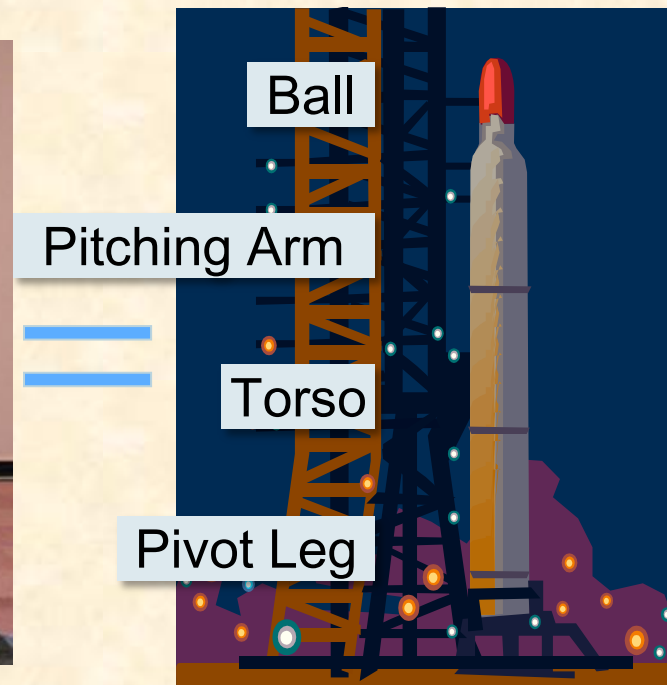
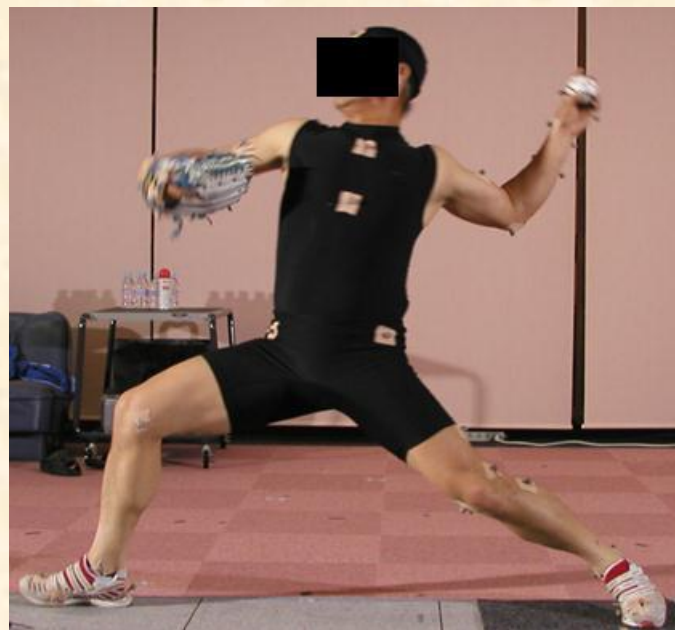
Theory of pitching motion



From Wikipedia

Roger Clemens
MLB career in 1984-2007

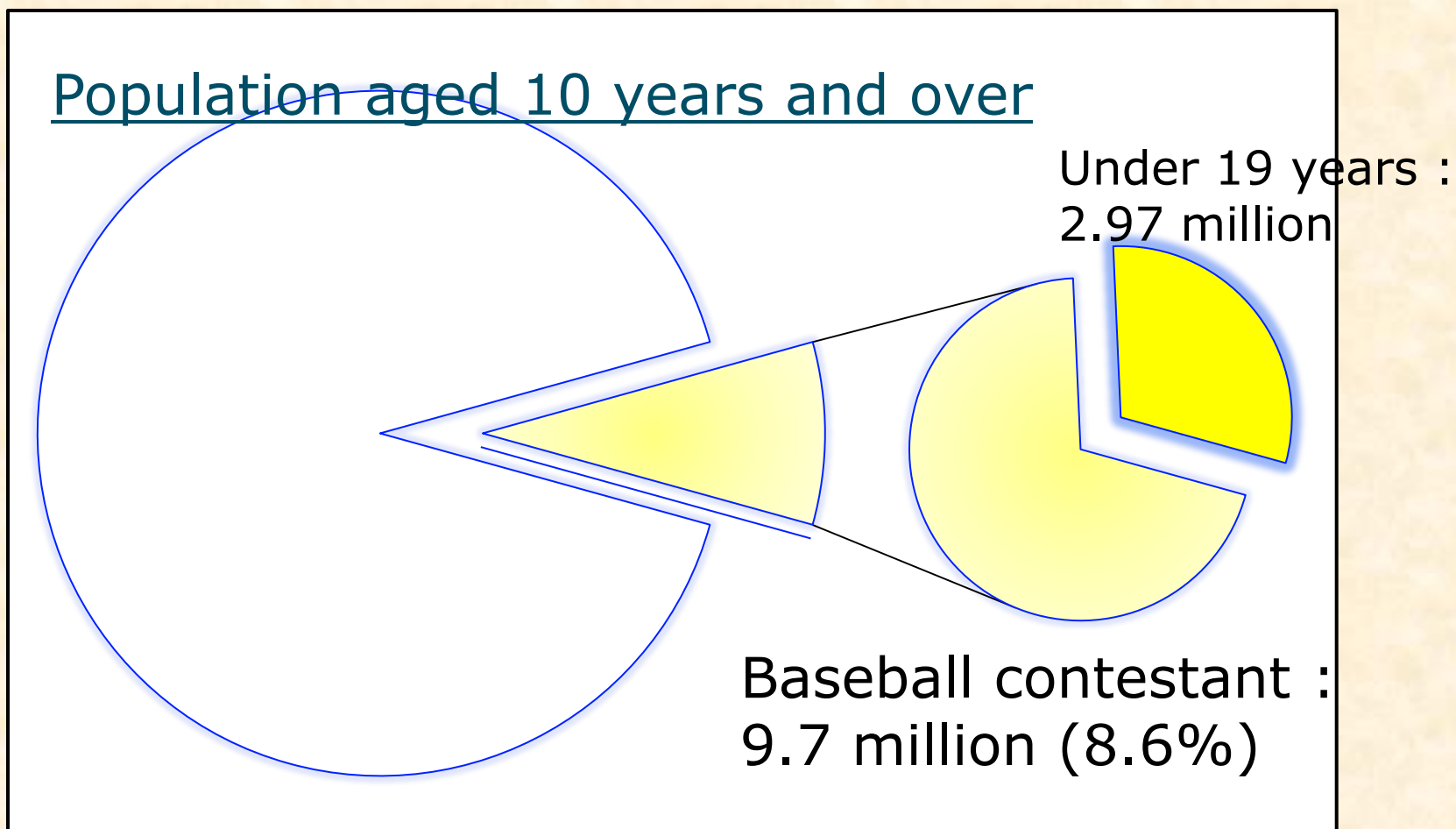
"The Rocket"



"Three stage rocket system" mechanism

Background

- Many baseball players in Japan



The Census in 2005, Japan

Background

■ Necessity to keep long baseball careers



- Healthcare and growth in daily life
- Development of baseball player resources
- Stimulation of social activity
- Increase in purchasing power for baseball equipment

Problem: Many pitchers are injured.

Aim

- To clarify how to keep playing baseball for pitchers during their long lives
 1. Biomechanical analysis of a professional baseball pitcher who has long career
 2. Quantification of the pitching motion using biomechanical energetics
 3. Comparisons between the veteran pitcher and a rookie pitcher

Subjects and trials

- Two active professional pitchers



Subject A (lefty)

27 years career

1.76 m / 84.6 kg

Ball speed 121km/h



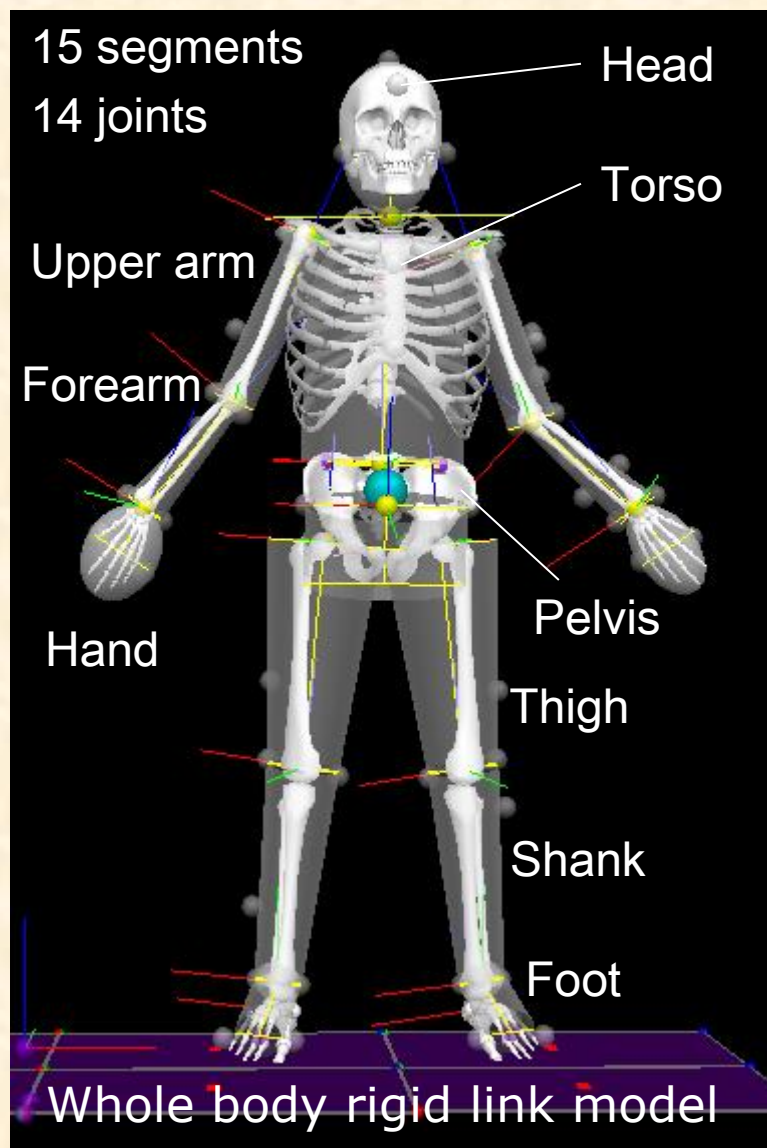
Subject B (righty)

2 years career

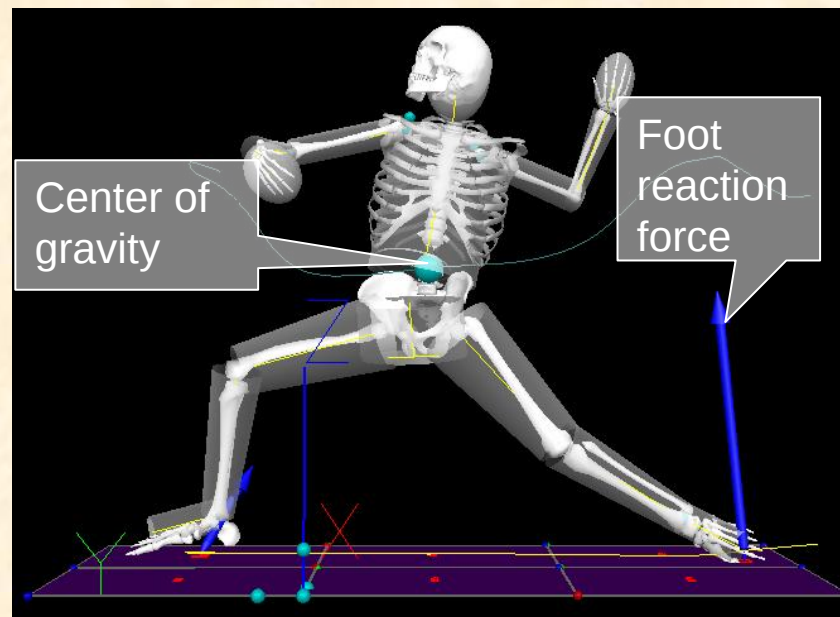
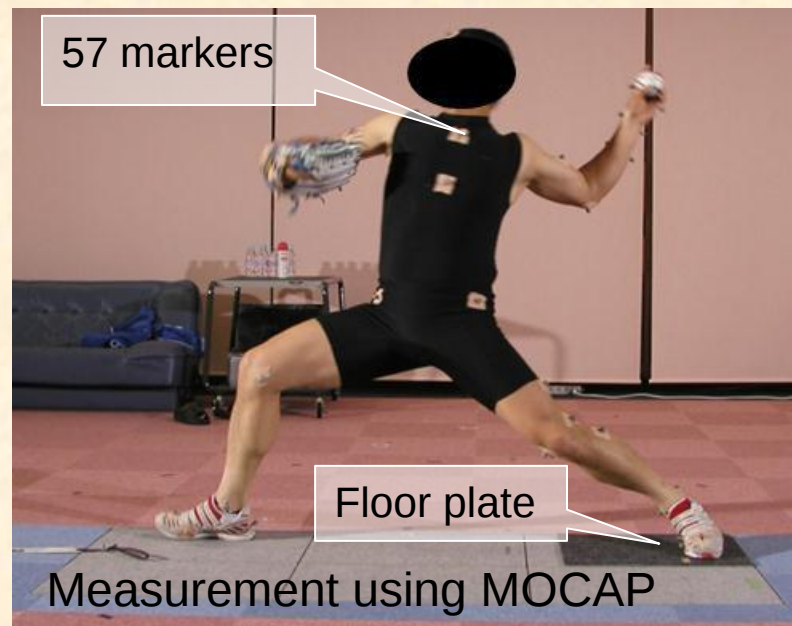
1.82 m / 84.1 kg

Ball speed 133km/h

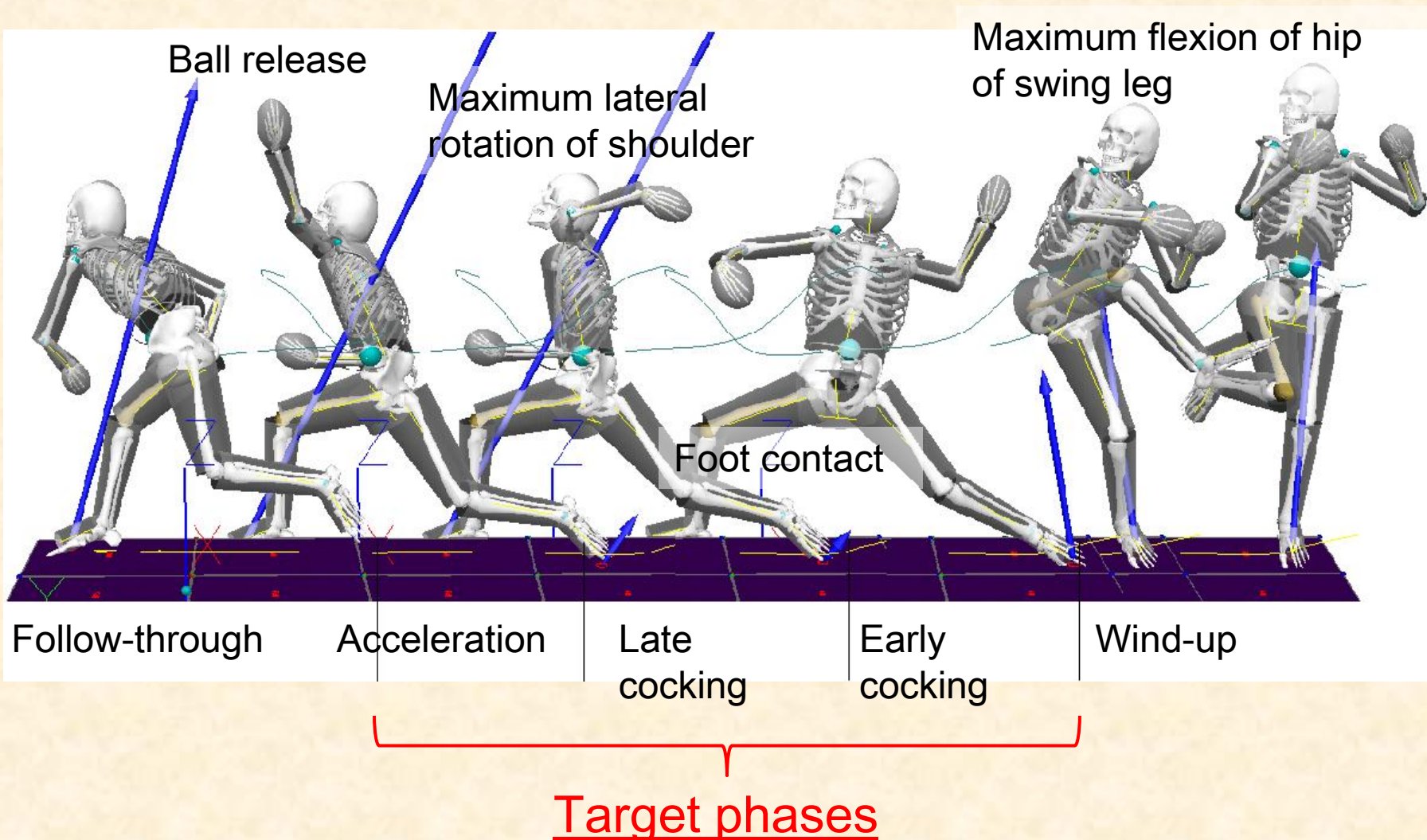
Model Analysis



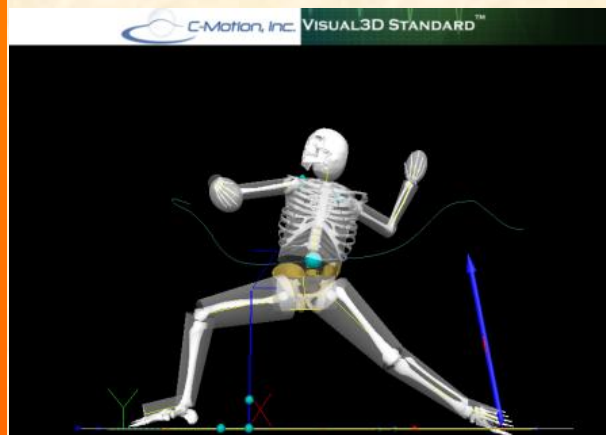
Visual3D (c-motion Inc.)



Phase of pitching motion

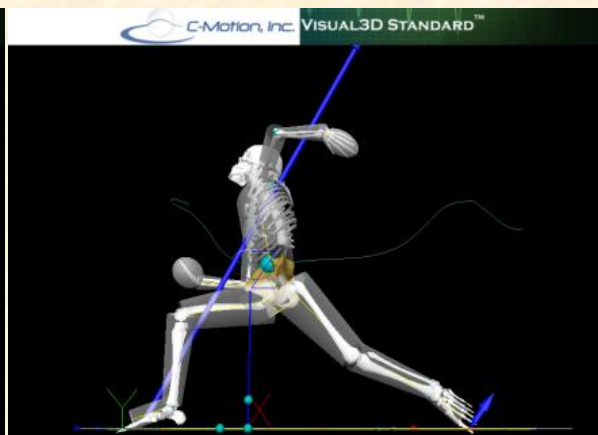


Mechanism of pitching motion



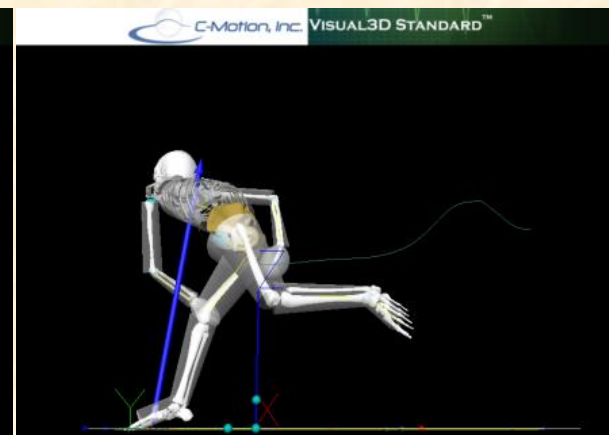
Pivot leg

- Extension of leg joints
- Hip abduction
- Hip medial rotation



Pelvis/Torso

- Waist twist and lateral bending, as shoulder moves forward and upward



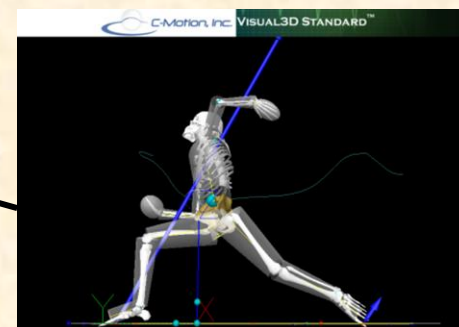
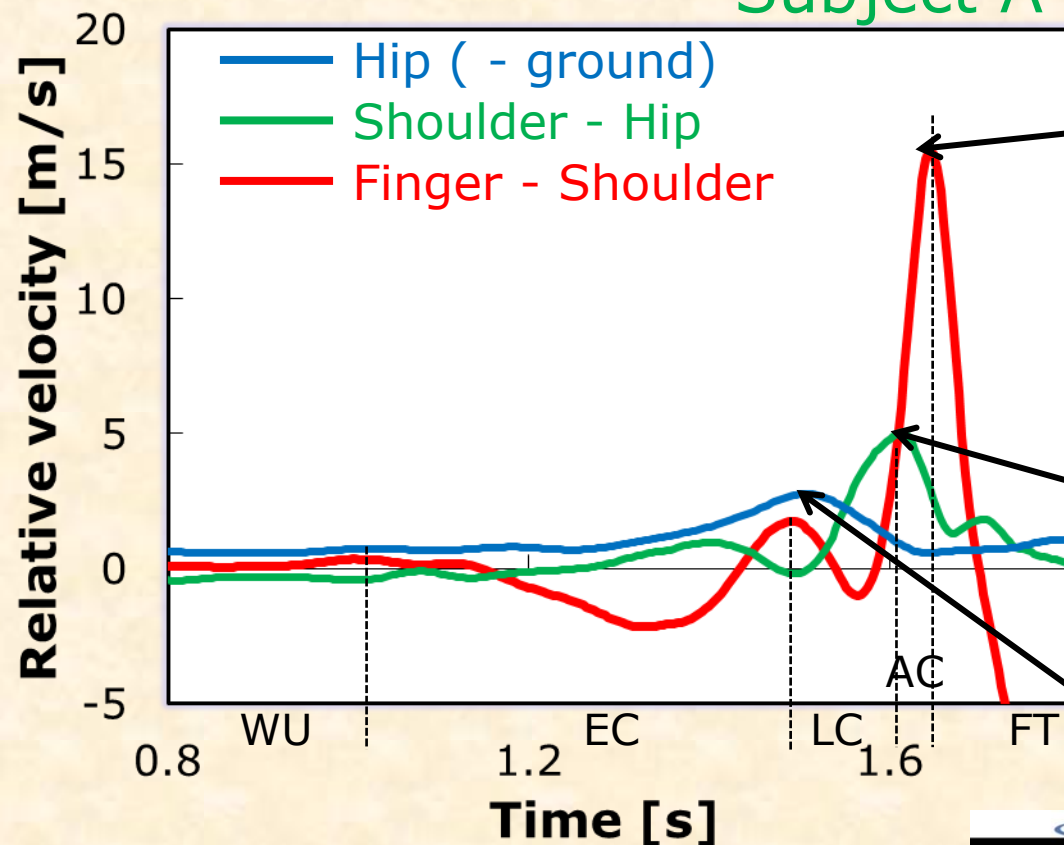
Pitching arm

- Shoulder adduction and medial rotation
- Elbow extension
- Forearm medial rotation
- Ball release

**Three stage rocket system
mechanism**

Relative velocity of each joints

Subject A



Definition

- Upper joint velocity relative to lower joint velocity
- Parallel to ground

Aim

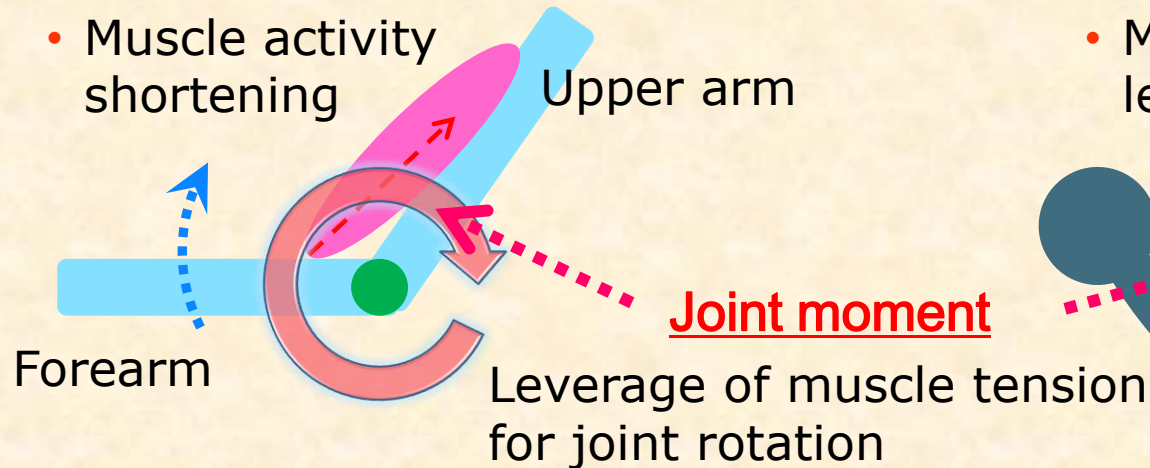
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Mechanical modeling of muscle activity

■ Isotonic muscle activity modeling

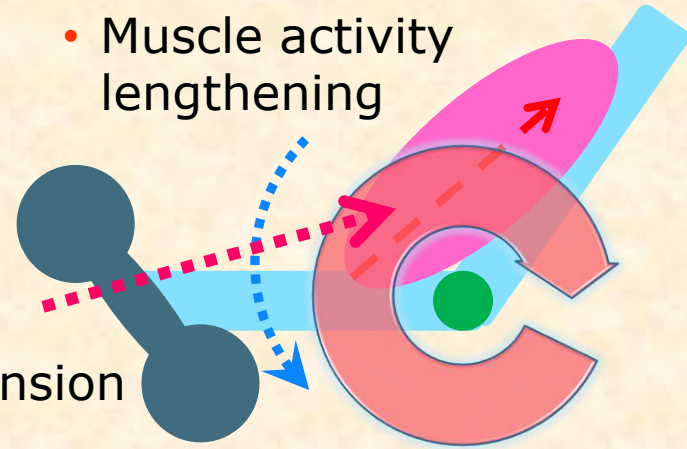
Concentric contraction

- Muscle activity shortening



Eccentric contraction

- Muscle activity lengthening



■ Joint power

$$= \text{Joint moment} \times \text{Joint angular velocity}$$



∴

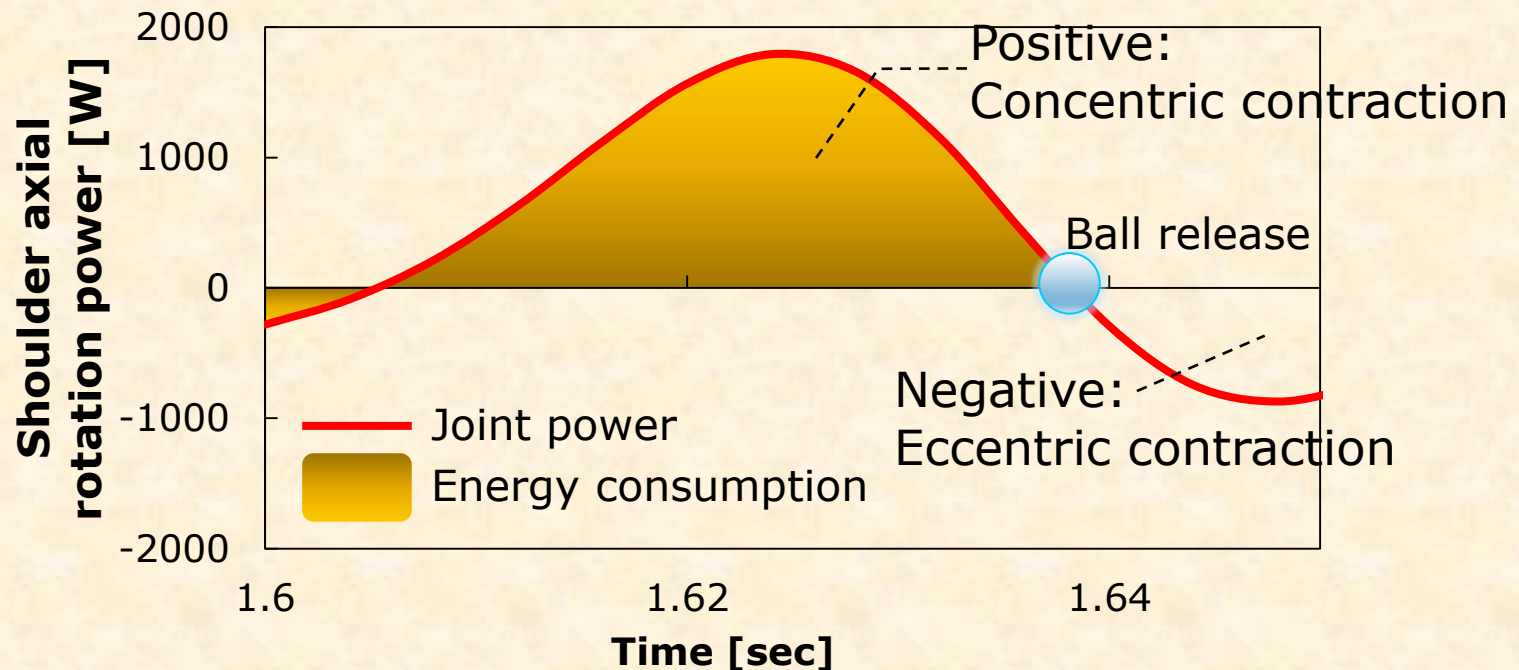


$$\text{Horsepower} = \text{Torque} \times \text{Engine revolution}$$

Biomechanical energetics

■ Joint energy consumption

- e.g. Joint power of axial rotation of pitching arm



Positive: Energy emission for accelerating motion

Negative: **Energy absorption** for decelerating motion

No regeneration = No contribution for ball speed

Aim

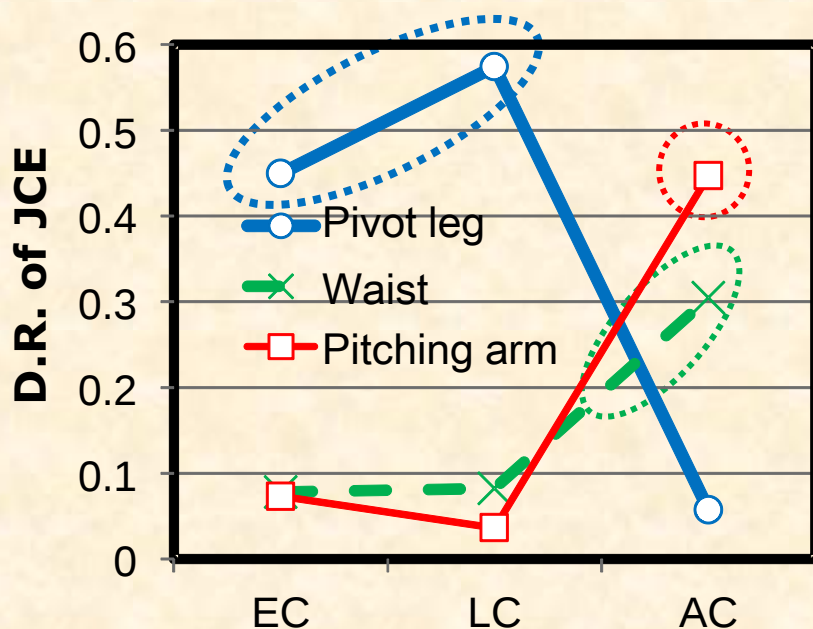
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Quantification of pitching mechanism

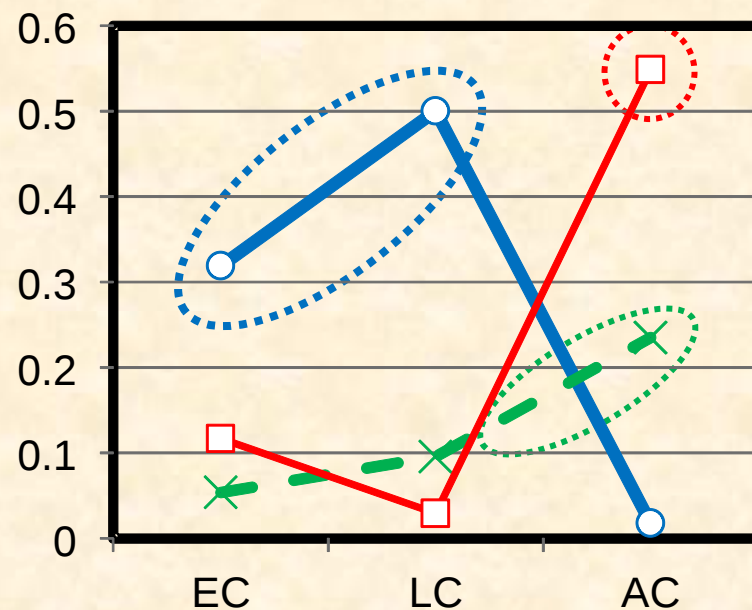
■ Distribution ratio of joint concentric energy

$$= \frac{\text{Sum of joint concentric energy of each part}}{\text{Sum of joint concentric energy of whole body}}$$

Index of muscle activity for accelerating motion



Subject A



Subject B

Subject A protected his arm from overuse.

Pitching Efficiency

- Evaluation of ball speed and whole body energy consumption

$$\text{Pitching Efficiency} = \frac{\text{Kinetic energy of ball}}{\text{Energy consumption of whole body}}$$

Short term: Capability of complete games

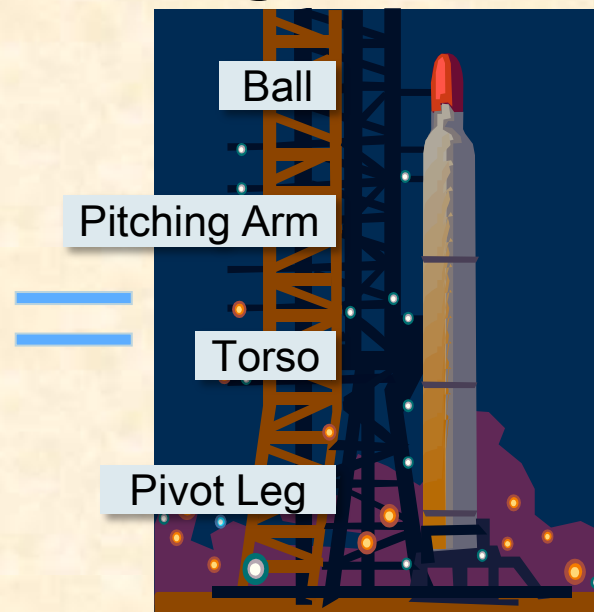
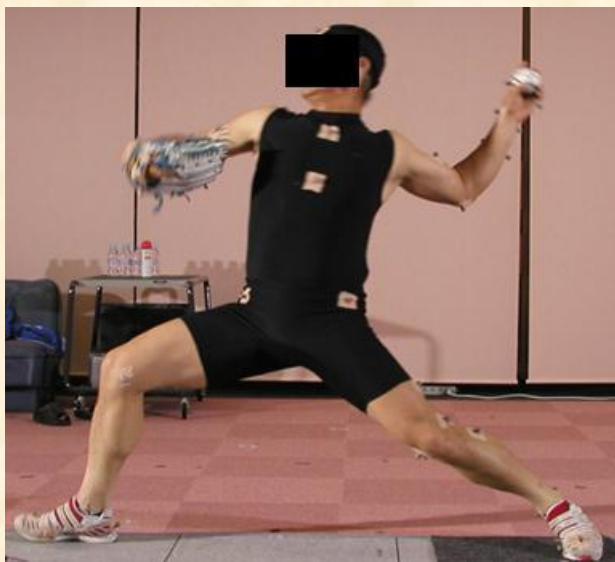
Long term: Capability of long career of pitcher

	Subject A	Subject B
Ball Speed	33.6 m/s 121 km/h	36.9 m/s 132 km/h
Kinetic energy of ball	79.1 J	95.5 J
Energy consumption	918.0 J	1237.1 J
Pitching Efficiency	0.086	0.077
Innings pitched / Years	3336.2/29=115	295.0/4=74

Subject A had high capability of long career.

Conclusion

- To clarify how to keep playing baseball for pitchers during their long lives



1. Pitching mechanism is like “3-stage rocket system”
2. Two energetic indices are defined
3. Using pivot leg and waist contribute to pitch effectively from results of 2 energetic indices

Acknowledge

- This research received cooperation from Ryutaro Himeno, RIKEN, Japan.



- Special thanks to 2 pitchers, K.K. and F.K. Yokohama Bay Stars for participating in this measurement.

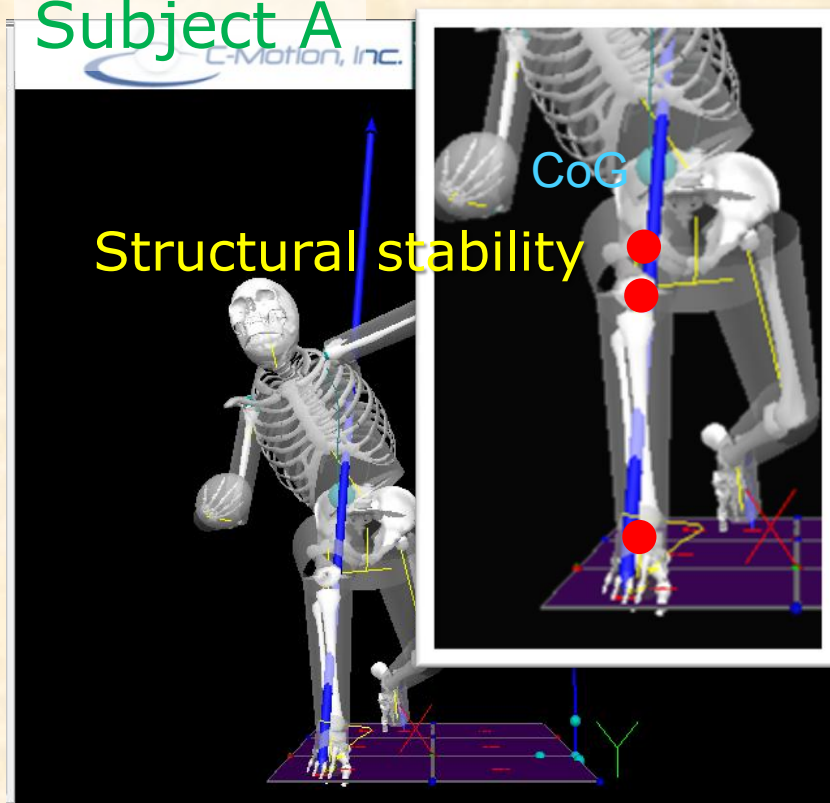
Thank you for your kind attention!

How to improve the motion of subject B ?

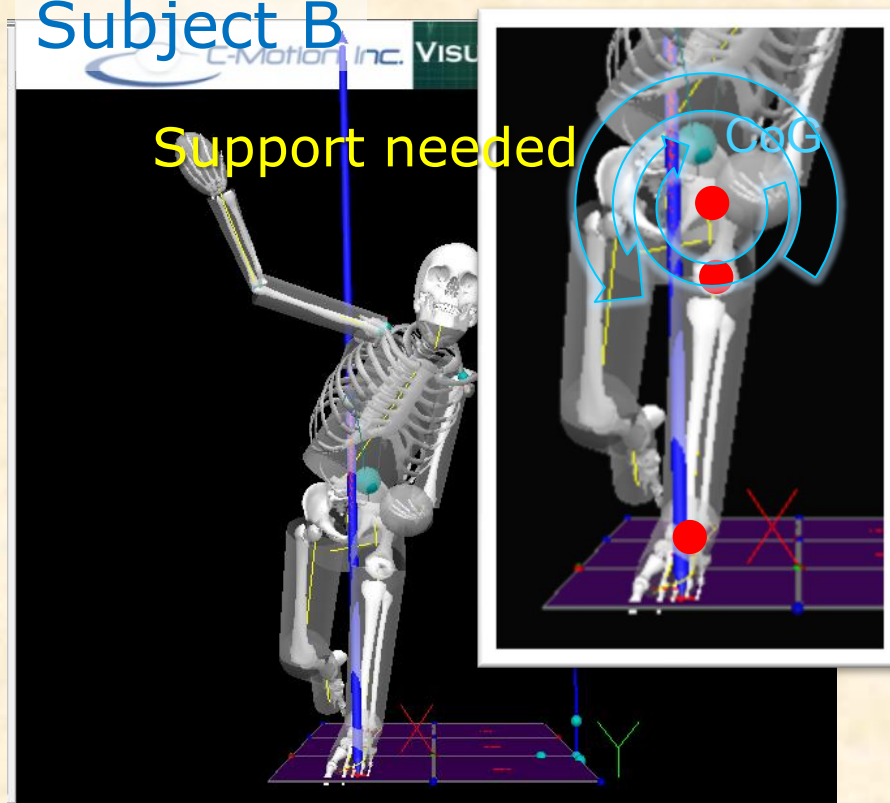
■ Back to the motion data...

— e.g. ball release

Subject A



Subject B



Training or equipment
to support hip inner rotation muscle