Impact of Stride Length on Pelvis Energy Flow in High School and Collegiate Baseball Pitchers: A Retrospective Analysis

D. Taylor La Salle, M.S.

SABR

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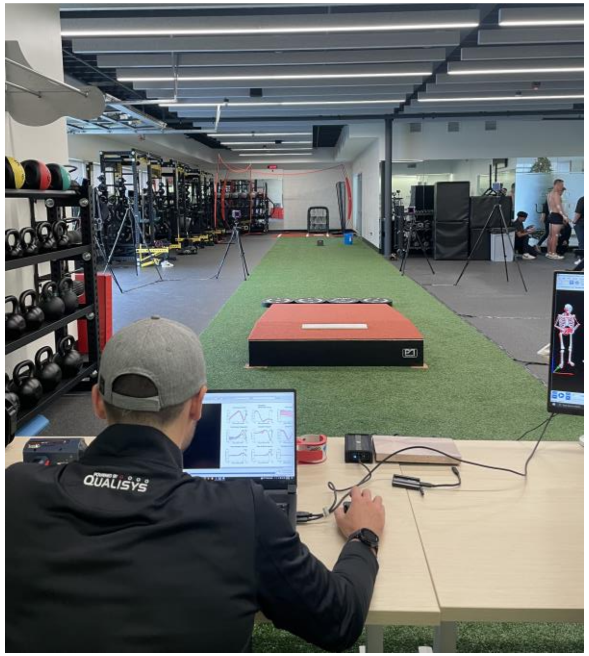

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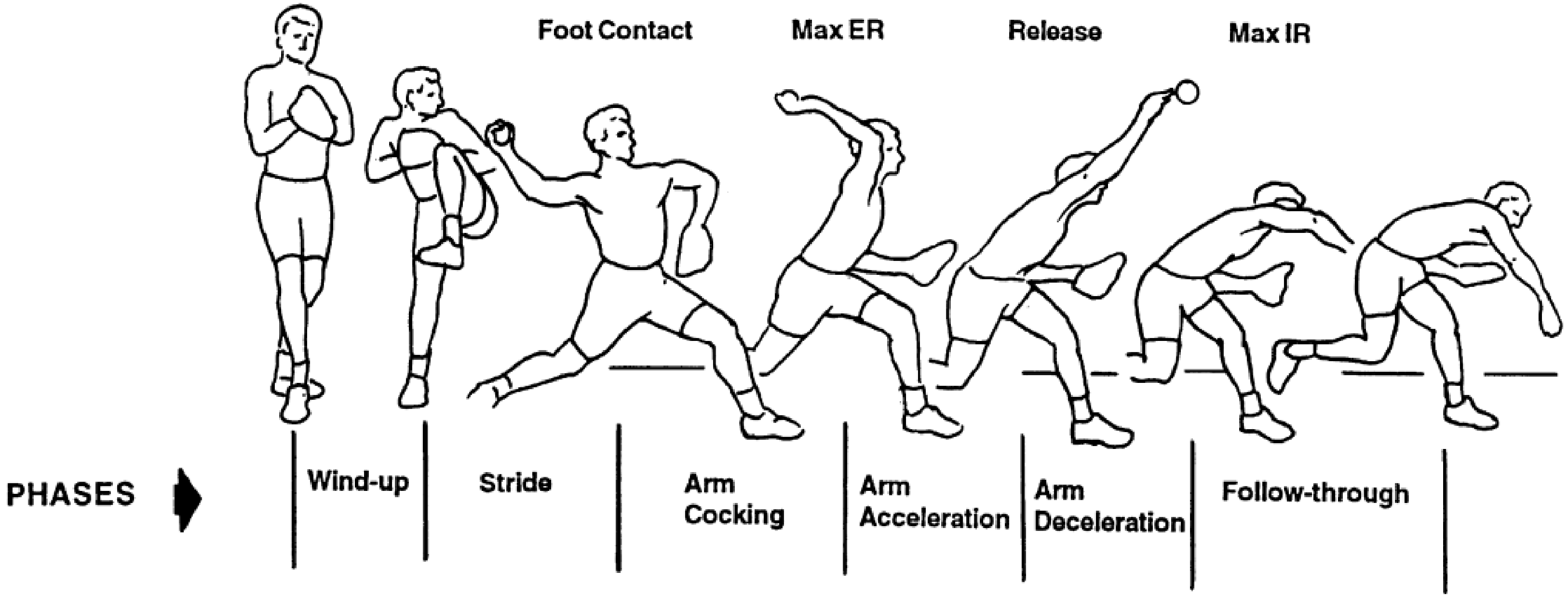
Overview

- Pitching Biomechanics
- Research by Ryan Crotin, Ph.D. and Daniel Ramsey, Ph.D.
- Why Stride Length?
- Retrospective Energy Flow Analysis
- Conclusion

Pitching Biomechanics



Fleisig G. et al. (1996)

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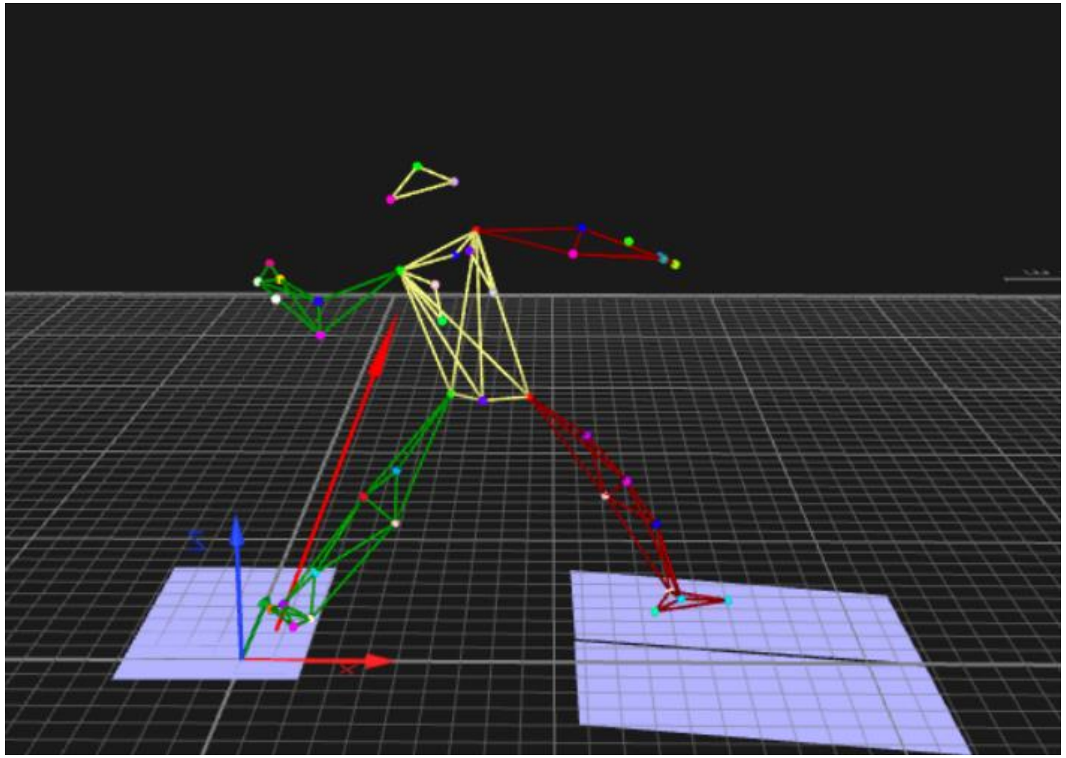
Pitching Biomechanics



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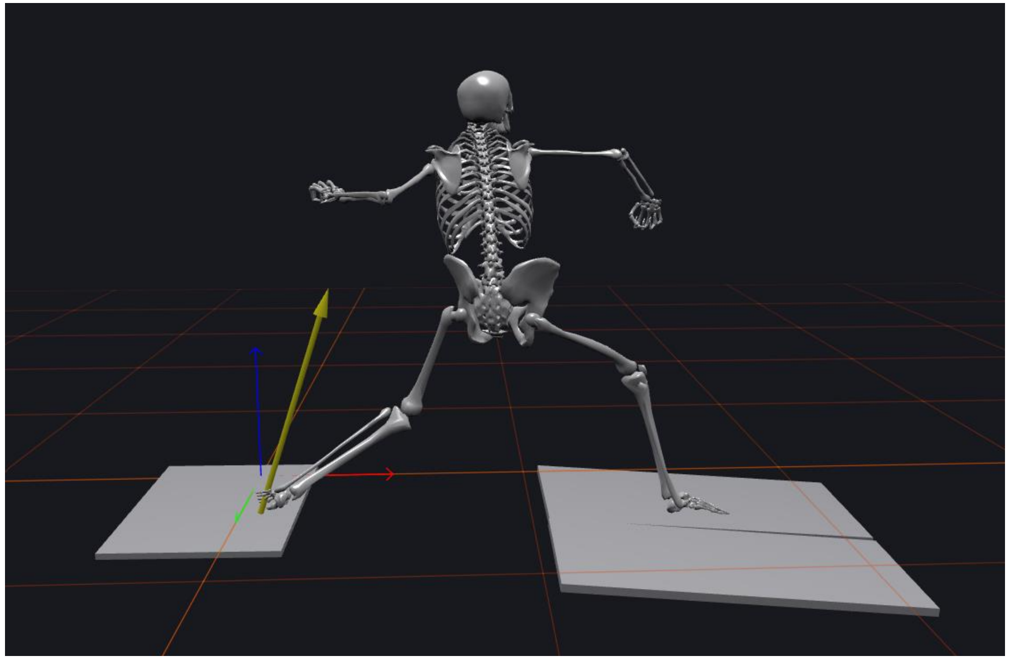
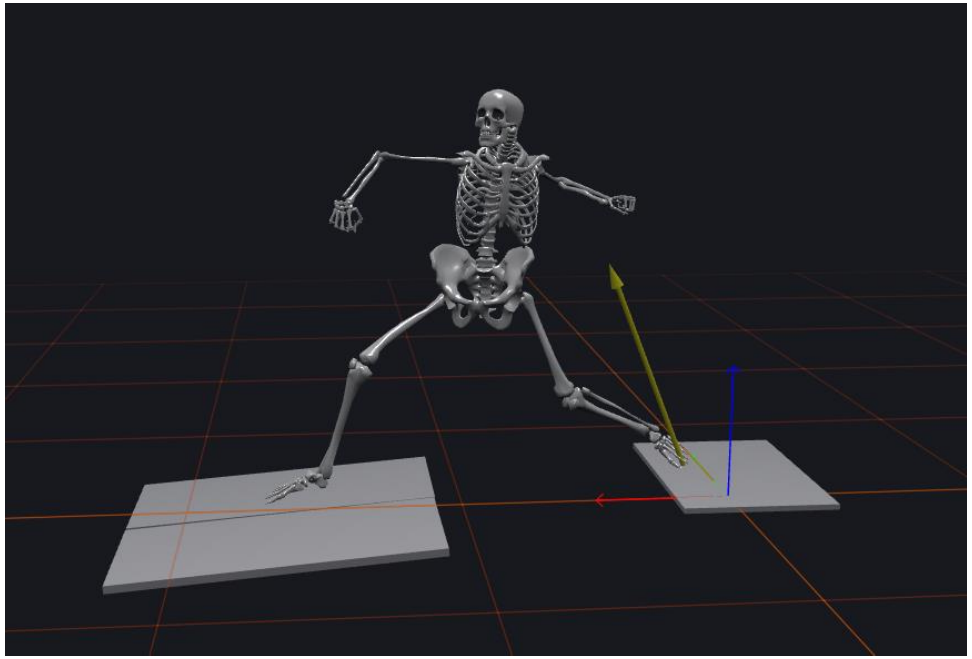
Pitching Biomechanics





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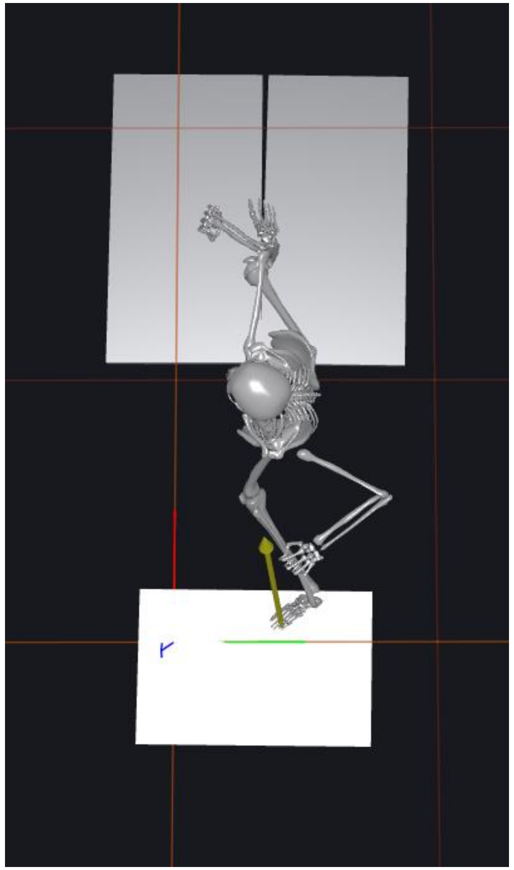

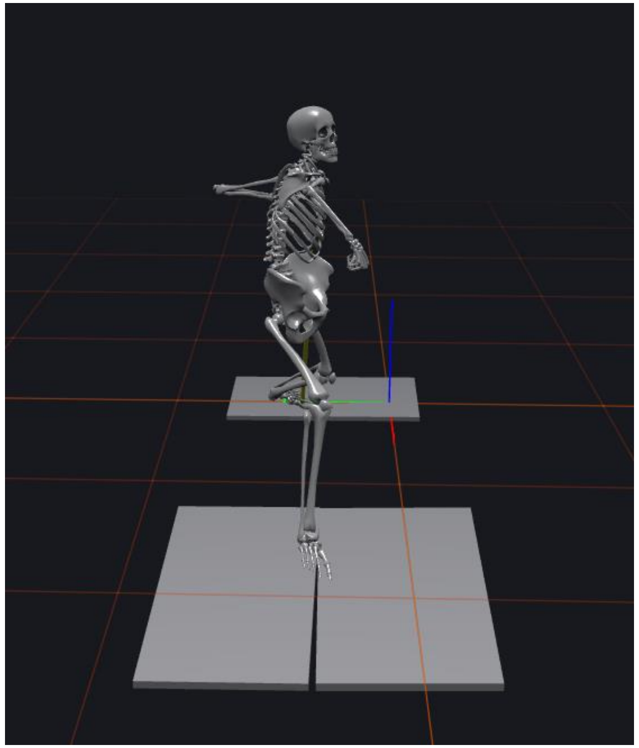

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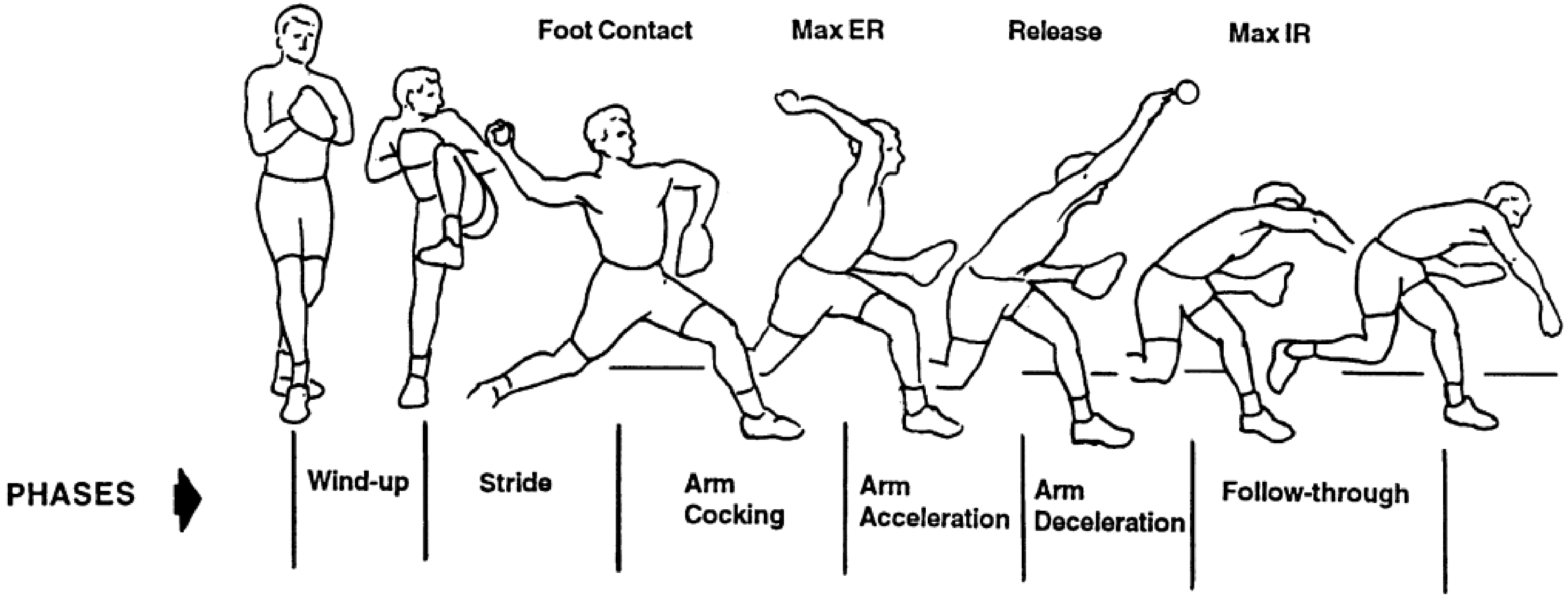
Events and Phases of Pitching



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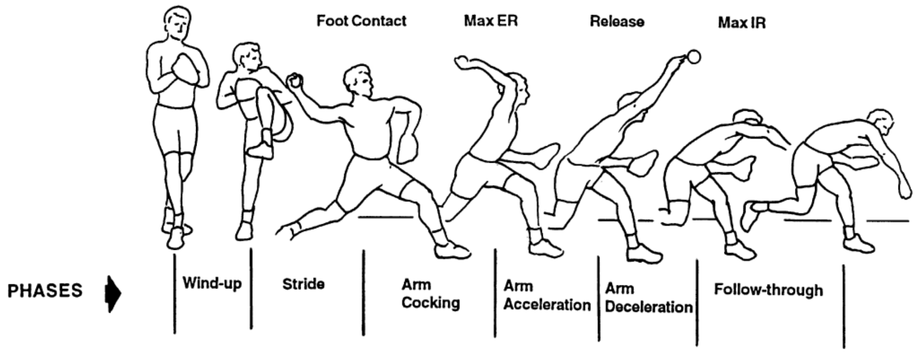
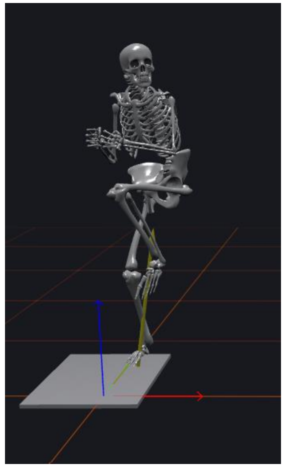
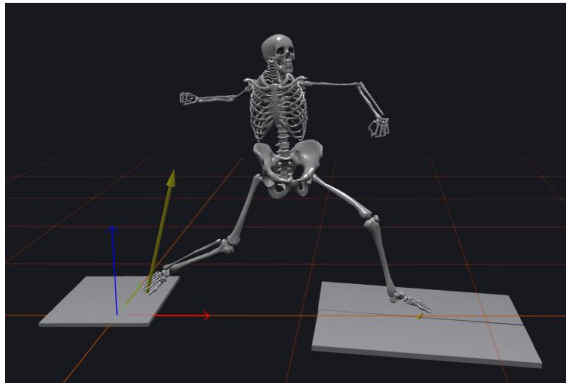
Events and Phases of Pitching

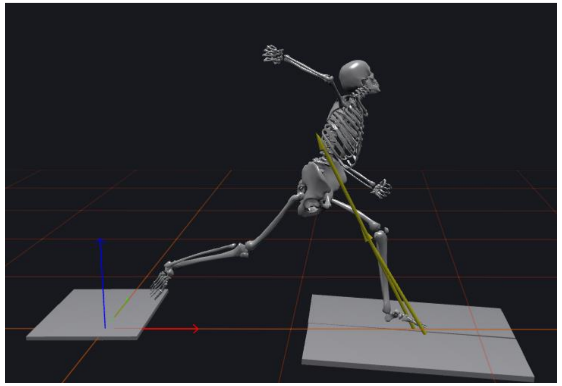




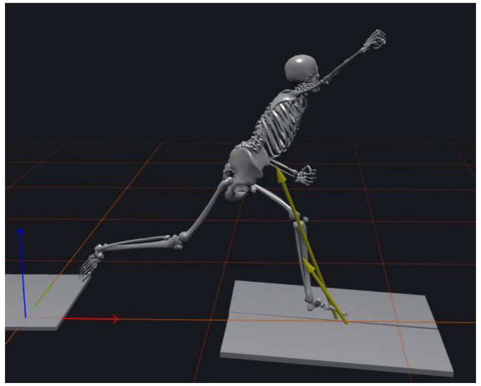
Max Knee Height



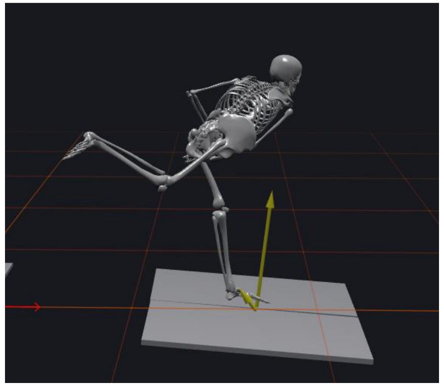
Stride Foot Contact



Max External Rotation

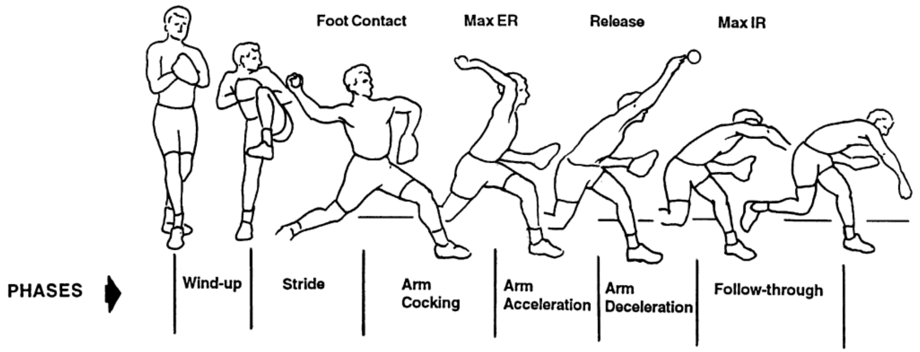


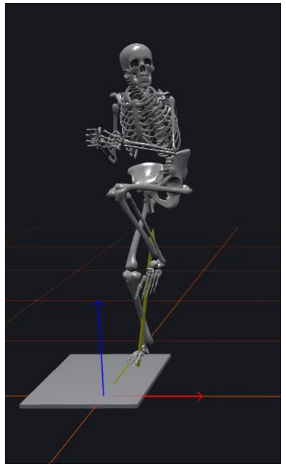
Ball Release



Max Internal Rotation

Events and Phases of Pitching





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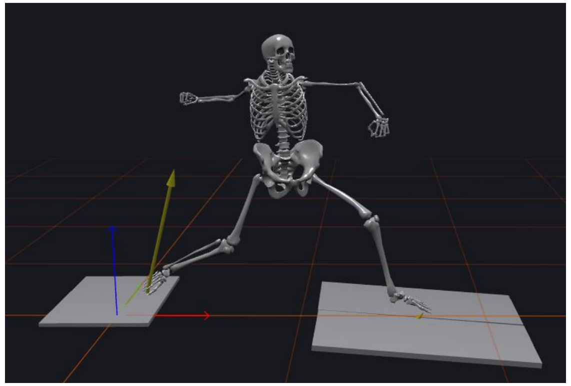
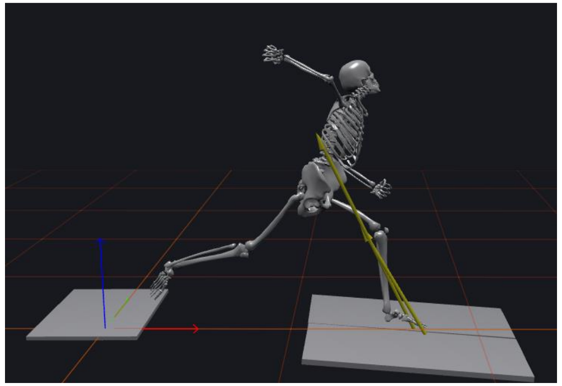
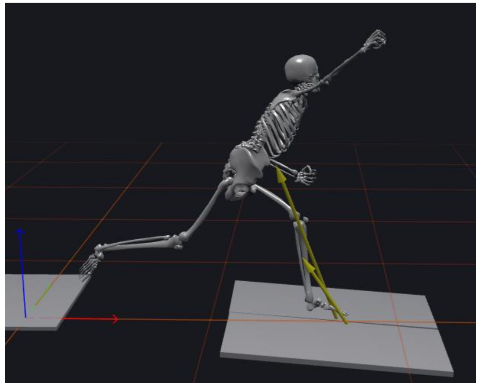


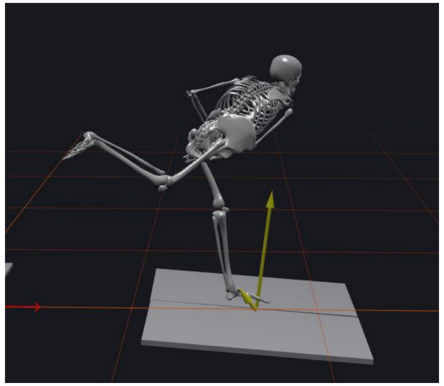
Stride Foot Contact



Max External Rotation



Ball Release



Max Internal Rotation

Ryan Crotin, Ph.D.

Daniel Ramsey. Ph.D.

- Crotin, R. L., Kozlowski, K., Horvath, P., & Ramsey, D. K. (2014). Altered stride length in response to increasing exertion among baseball pitchers. Medicine and Science in Sports and Exercise, 46(3), 565–571.
- Ramsey, D. K., Crotin, R. L., & White, S. (2014). Effect of stride length on overarm throwing delivery: A linear momentum response. Human Movement Science, 38, 185–196.
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- Ramsey D.K., Crotin R.L. Effect of stride length on overarm throwing delivery: Part II: An angular momentum response. Hum Mov Sci. 2016 Apr;46:30-8
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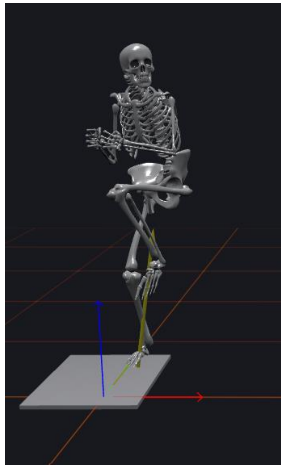
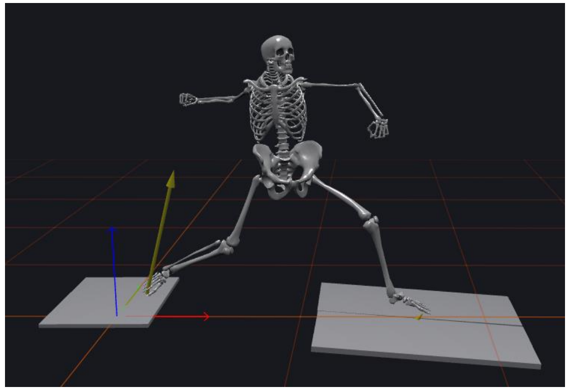
Stride Length?

Measurable at Stride Foot Contact

- Pitching rubber to the heel of the stride leg
- Pitching rubber to the ankle joint of the stride leg
- Between ankle joint centers of both legs
- Between heel of both legs





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Stride Length?

Stride Length (% Body Height) has been correlated to ball velocity

Youth and Adolescent Pitchers

Tocci et al., 2017

Sgroi et al., 2015

Collegiate pitchers

Yanagisawa & Taniguchi, 2020

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Stride Length?

"Stride lengths of 80% BH or greater may aid professional pitchers in achieving higher ball velocity"

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SPORTS MEDICINE AND BIOMECHANICS

Check for updates

The association of stride length to ball velocity and elbow varus torque in professional pitchers

Joseph E. Manzi[a], Brittany Dowling[b], Joshua S. Dines[c], Zhaorui Wang[a], Kyle N. Kunze[c], Ryan Thacher[c], Kathryn L. McElheny[c] and James B. Carr[d]

[a]Weill Cornell Medical College, New York, NY, US; [b]Sports Performance Center, Midwest Orthopaedics at Rush, Oak Brook, IL, US; [c]Sports Medicine Institute West Side, Sports Medicine Institute Hospital for Special Surgery, New York, NY, US; [d]Sports Medicine Institute Florida, Sports Medicine Institute Hospital for Special Surgery Florida, West Palm Beach, FL, US

ABSTRACT

Professional basebal pitchers (n =315) were divided into quartiles based on increasing stride length and random intercept linear mixed-effect models were used to correlate stride length with ball velocity, pelvis and trunk rotation at foot contact, and throwing arm kinetics. Average stride length among all pitchers was 78.3±5.3%body height (%BH). For every 10% increase in stride length, ball velocity increased by 0.9 m/s (B =0.089, β =0.25, p <0.001) and trunk rotation initiation occurred 4.23 ms earlier (B =–0.42, β = –0.14, p <0.001). When divided into quartiles pelvis rotation was less towards home plate in Q1 compared to Q3 and Q4 (70.0±10.7° vs. 60.9±8.9° and 58.6±9.1°, p <0.001). No significant differences in shoulder internal rotation torque (p =0.173) or elbow varus torque (p =0.072) were noted between quartiles. Professional baseball pitchers who reached stride lengths of 80%BH or greater achieved faster ball velocity without an increase in elbow varus torque. This may, be a byproduct of rotating the pelvis for a greater proportion of the pitching motion and thereby more effectively utilising the lower extremities in the kinetic chain. Encouraging players to achieve this threshold of stride length may enhance ball velocity outcomes.

ARTICLE HISTORY
Accepted 25 June 2021

KEYWORDS
Pitch speed; elbow varus torque; trunk rotation; kinetic chain

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Stride Length?

Stride Length not associated with ball velocity

Professional Pitchers
Dun et al., 2007

College Pitchers
Solomito et al., 2020

Youth Pitchers (~15 years old)
Van Trigt et al., 2018

INCONCLUSIVE

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Methods

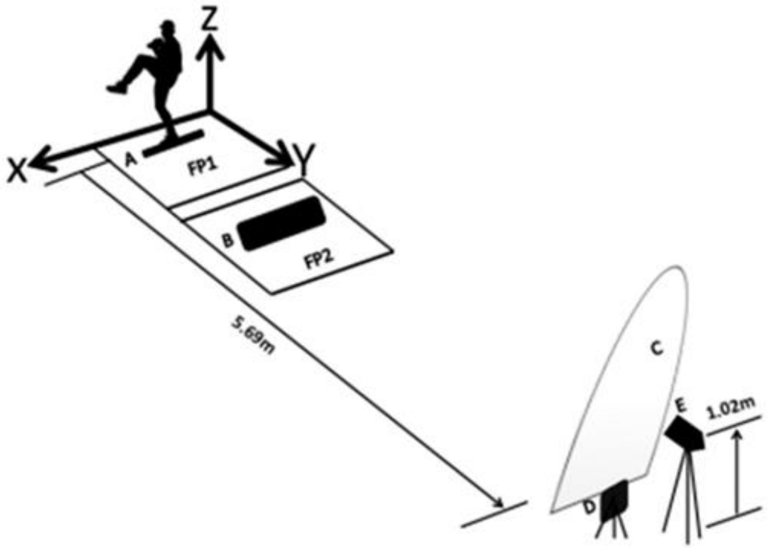
Ryan Crotin, Ph.D.

Daniel Ramsey. Ph.D.

Randomized Crossover Design

Two Simulated Games

- +25% Normal Stride Length
- -25% Normal Stride Length
- Fastball from first 20 Pitches



OVERSTRIDE (76% BH) ⟷ **1.40 m**

DESIRED STRIDE (67% BH) ⟷ **1.24 m**

UNDERSTRIDE (52% BH) ⟷ **0.95 m**

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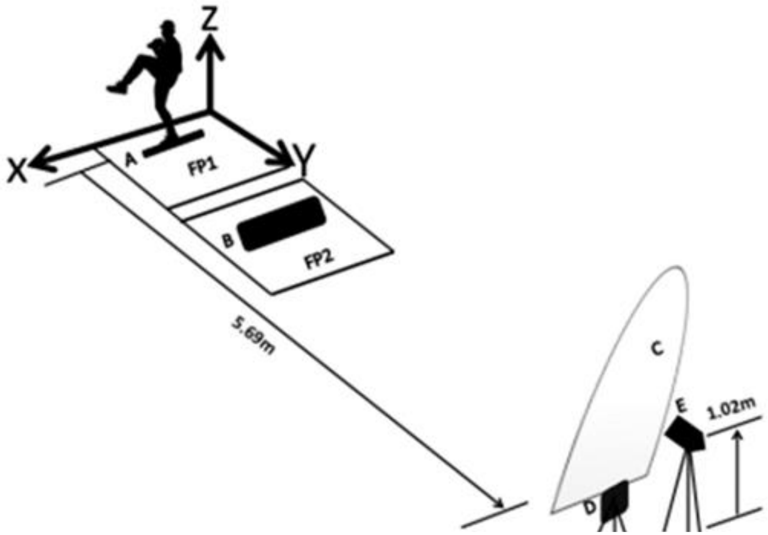
Subjects

Ryan Crotin, Ph.D.

Daniel Ramsey. Ph.D.

- Healthy Collegiate and High School Pitchers
- Age = 18.63 ± 1.67yr
- Height = 1.84 ± 0.054m
- Mass = 82.14 ± 0.054kg



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Key Findings


Ryan Crotin, Ph.D.


Daniel Ramsey. Ph.D.

- Ball velocity was maintained

  125.5 km/h (± 7.78) 123.5 km/h (± 8.15)

- US (-25%) = improper timing of pelvic/hip rotation
- US (-25%) ↑ lateral trunk tilt
- US (-25%) ↓ forward momentum

OVERSTRIDE (76% BH) ⟷	1.40 m
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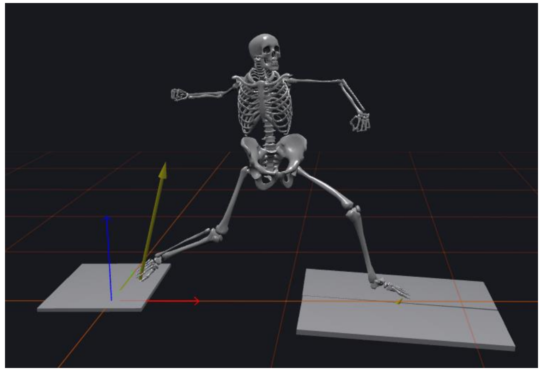
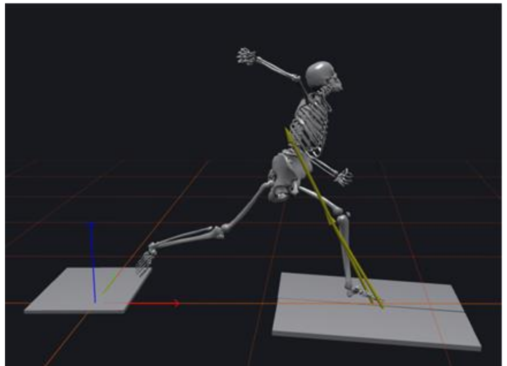
Energy

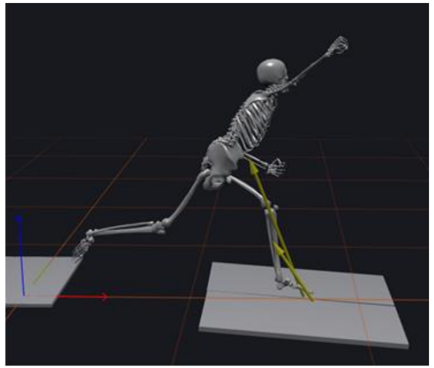
Ground Reaction Force

- Drive Leg = greater amount of force in **OS (+25%)** vs US (-25%)



- Stride Leg = greater amount of braking force in **OS (+25%)** vs US (-25%)





Energy Flow Analysis

39th International Society of Biomechanics in Sport Conference, Canberra, Australia (Online): Sept 3-6, 2021

LOWER BODY CONTRIBUTIONS TO PELVIS ENERGY FLOW AND PITCH VELOCITY IN COLLEGIATE BASEBALL PLAYERS

Arnel Aguinaldo,[1] Kristen Nicholson[2]

Kinesiology, Point Loma Nazarene University, San Diego, CA[1]
Orthopaedic Surgery, Wake Forest School of Medicine, Winston Salem, NC[2]

The aims of this study were to examine the generation, absorption, and transfer of energy through the pelvis at the drive hip, stride hip, and lumbosacral joints and to determine predictors of ball speed during baseball pitching. Motion capture and ground reaction force (GRF) data from 20 collegiate pitchers were analysed using energy flow and LASSO regression analyses. Energy was transferred from the drive leg to the pelvis during the stride phase while energy was transferred from the pelvis to the stride leg and trunk during arm-cocking. Drive leg GRF, impulse, and stride hip generation contribute to pitch velocity.

KEYWORDS: mechanical energy, segmental power, kinetics, overarm throwing.

INTRODUCTION: The pitching motion in baseball is a complex activity that is performed with an open kinetic chain through which mechanical energy purportedly flows in a proximal-to-distal fashion to accelerate the throwing arm (Aguinaldo & Escamilla, 2019). Optimal timing of segmental rotations, specifically pelvic and trunk rotations, has been shown to maximize efficiency of the pitching motion (Aguinaldo, Buttermore, & Chambers, 2007). While previous research have primarily focused on the biomechanics of the upper body segments during pitching (Chalmers et al., 2017), the drive (back) and stride (front) legs play important roles in

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Energy Flow Analysis

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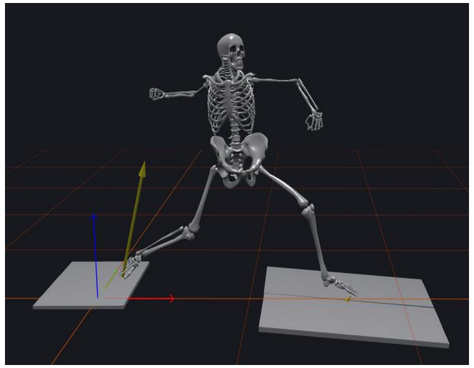
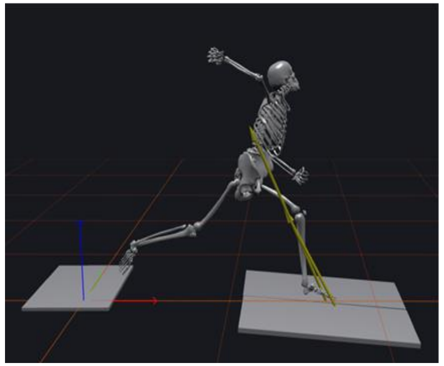
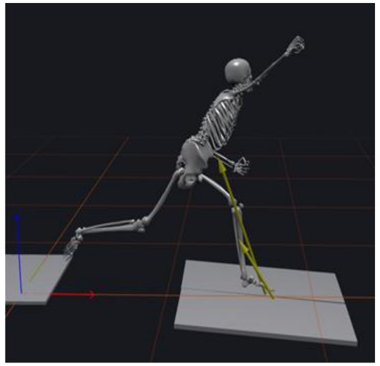
"Energy through the kinetic chain flows from the drive leg to the pelvis during the stride phase and from the pelvis to the stride leg and trunk during the arm-cocking phase."







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Energy Contribution of Hips

RESEARCH ARTICLE

Upper body contributions to power generation during rapid, overhand throwing in humans

Neil T. Roach[1,2,*] and Daniel E. Lieberman[2]

ABSTRACT

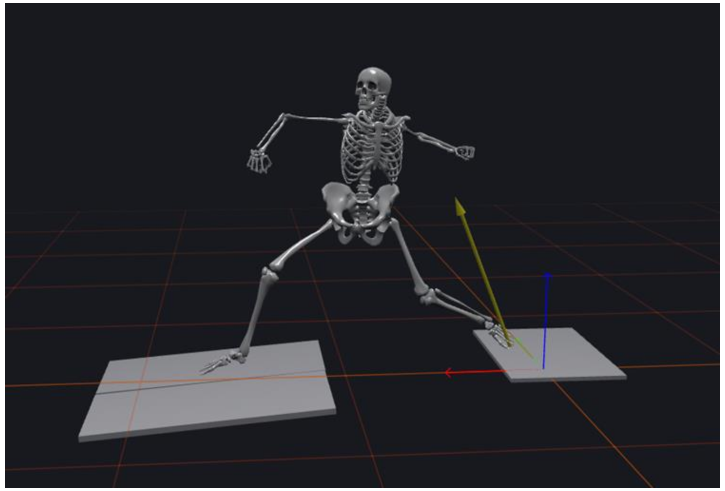
High-speed and accurate throwing is a distinctive human behavior. Achieving fast projectile speeds during throwing requires a combination of elastic energy storage at the shoulder, as well as the transfer of kinetic energy from proximal body segments to distal segments. However, the biomechanical bases of these mechanisms are not completely understood. We used inverse dynamics analyses of kinematic data from 20 baseball players fitted with four different braces that inhibit specific motions to test a model of power generation at key joints during the throwing motion. We found that most of the work produced during throwing is generated at the hips, and much of this work (combined with smaller contributions from the pectoralis major) is used to load elastic elements in the shoulder and power the rapid acceleration of the projectile. Despite rapid angular velocities at the elbow and wrist, the restrictions confirm that much of the power generated to produce these distal movements comes from larger proximal segments, such as the shoulder and torso. Wrist hyperextension enhances performance only modestly. Together, our data also suggest that heavy reliance on elastic energy storage may help explain some common throwing injuries and can provide further insight into the evolution of the upper body and when our ancestors first developed the ability to produce high-speed throws.

2001; Pappas et al., 1985; Putnam, 1993). Previous work has shown that large angular velocities of torso rotation, shoulder internal rotation, elbow extension and wrist flexion all occur at the moment of release and significantly contribute to projectile speed (Fig. 1) (Fleisig et al., 1995; Fleisig et al., 1996; Hirashima et al., 2007; Pappas et al., 1985). This study focuses on how these large angular velocities are produced in the upper body.

Angular movements are produced when torques act across joints, generating mechanical work and power. Muscles are the source of most torques and are thus key contributors to joint power production and angular velocity. As expected, electromyography (EMG) patterns of muscle activity during throwing show sequential activation of muscles mirroring the progression of the throwing motion (Hirashima et al., 2002). However, muscle activation patterns alone cannot fully explain how throwing power is generated. For example, an individual with a paralyzed triceps brachii can still achieve rapid elbow extension during throwing, indicating that the triceps does not power rapid elbow extension on its own (Roberts, 1971). In addition, although EMG recordings of shoulder internal rotator muscles indicate high activity during internal rotation (DiGiovine et al., 1992; Gowan et al., 1987), experimental data on shoulder power show that these muscles only

The hips provide most of the necessary energy for torso rotation produced during throwing

The hips are important energy generators for the acceleration of the trunk and throwing arm



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What happens when you alter stride length?


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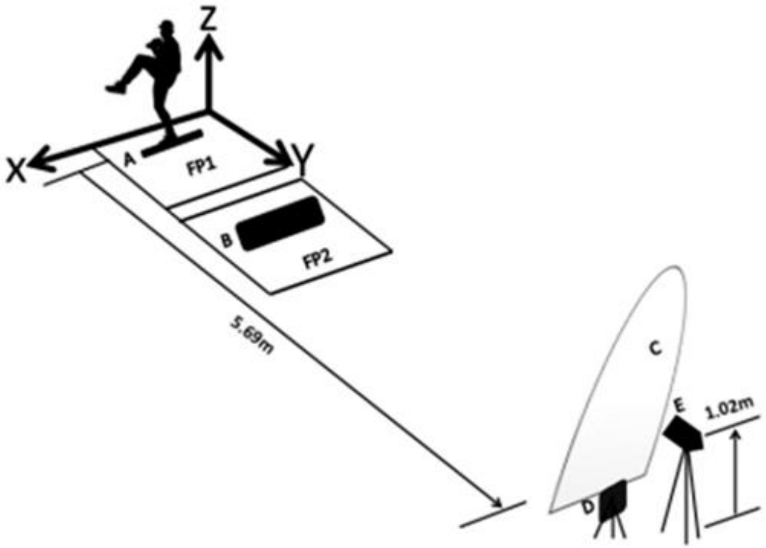
Daniel Ramsey. Ph.D.



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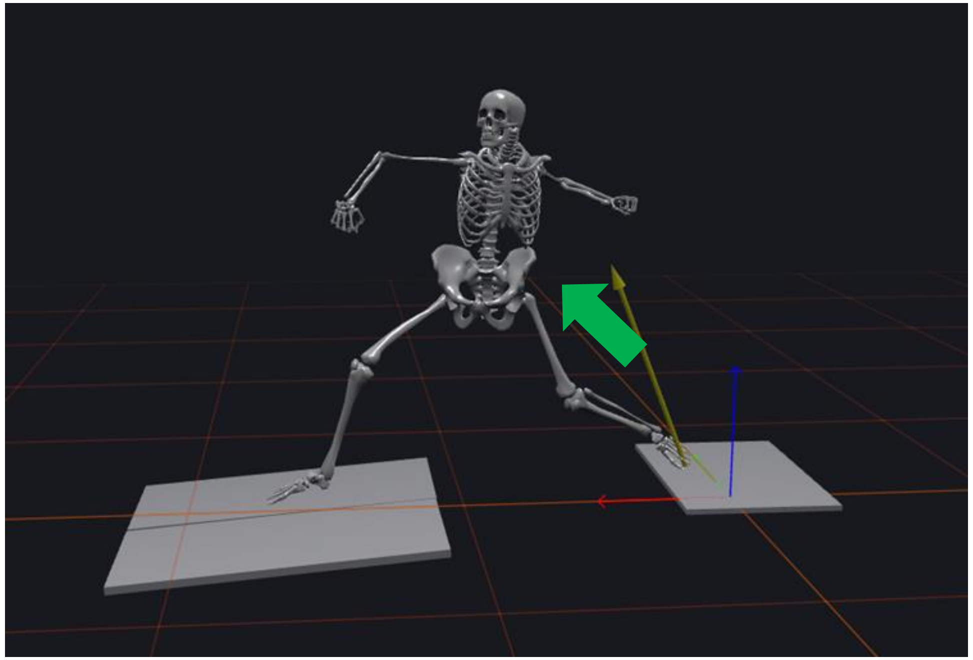
Energy Flow Analysis

During Stride Phase

- Greater energy absorption at the back hip in **OS (+25%)** vs US (-25%)

- “Maintaining the Load”

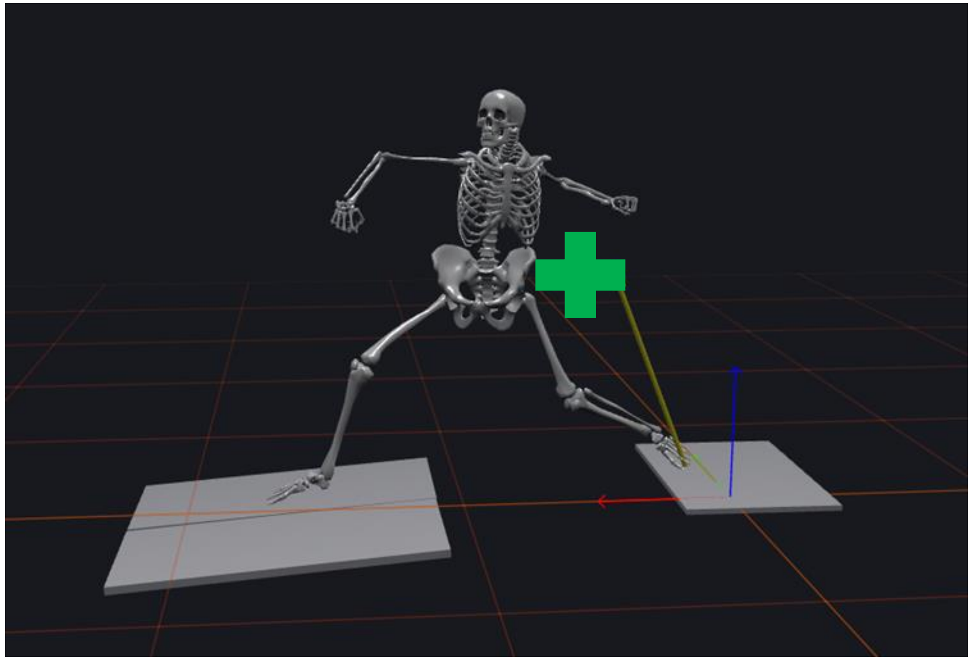


Energy Flow Analysis

During Stride Phase

- Greater energy generation at the back hip in OS (+25%) vs **US (-25%)**

- "Quick Burst"



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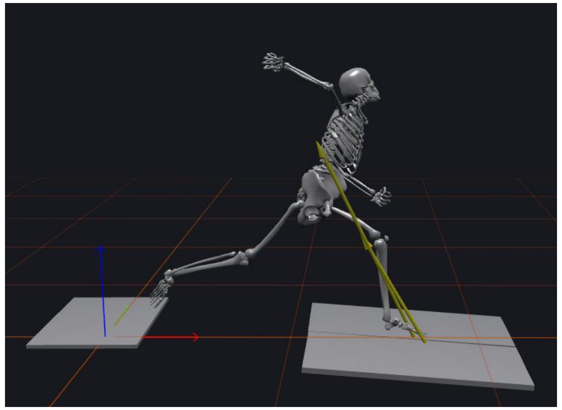
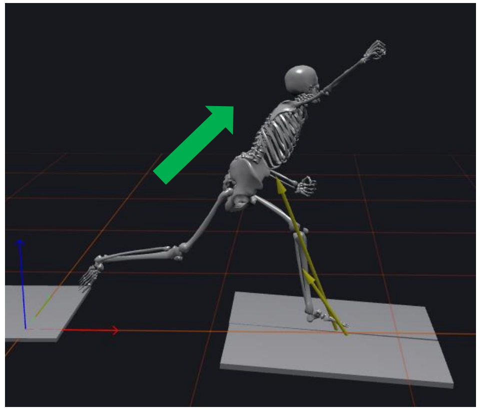
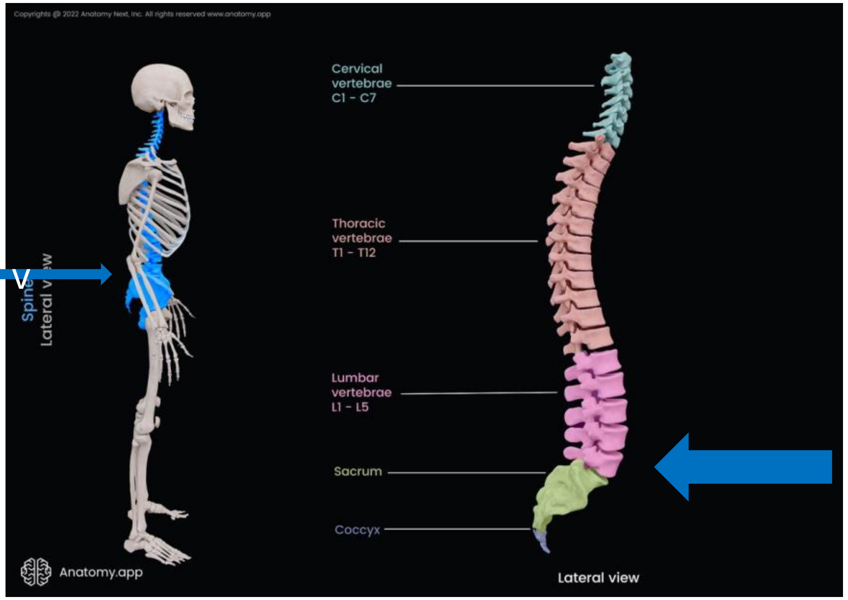
Energy Flow Analysis

During Arm Acceleration

- Greater energy transfer at the L5S1 joint in **OS (+25%)** vs US (-25%)



Lumbosacral Joint

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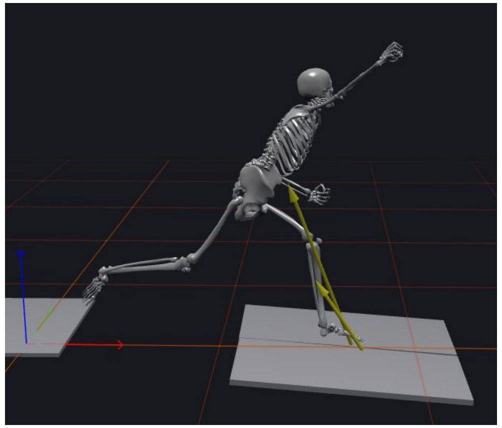
Energy Flow Conclusion

Keys to improving performance

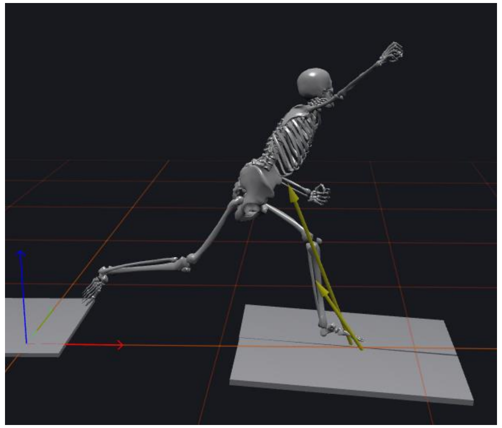
Increase Stride Length?

- Lead Leg Breaking Force Increases
- Hip Strength and Stability
- Transfer of Energy from Pelvis to Trunk



Energy Flow Conclusion

Pitchers looking to increase stride length may need to improve strength in hip and core to maintain proper pitching mechanics and improve performance




THANK YOU
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