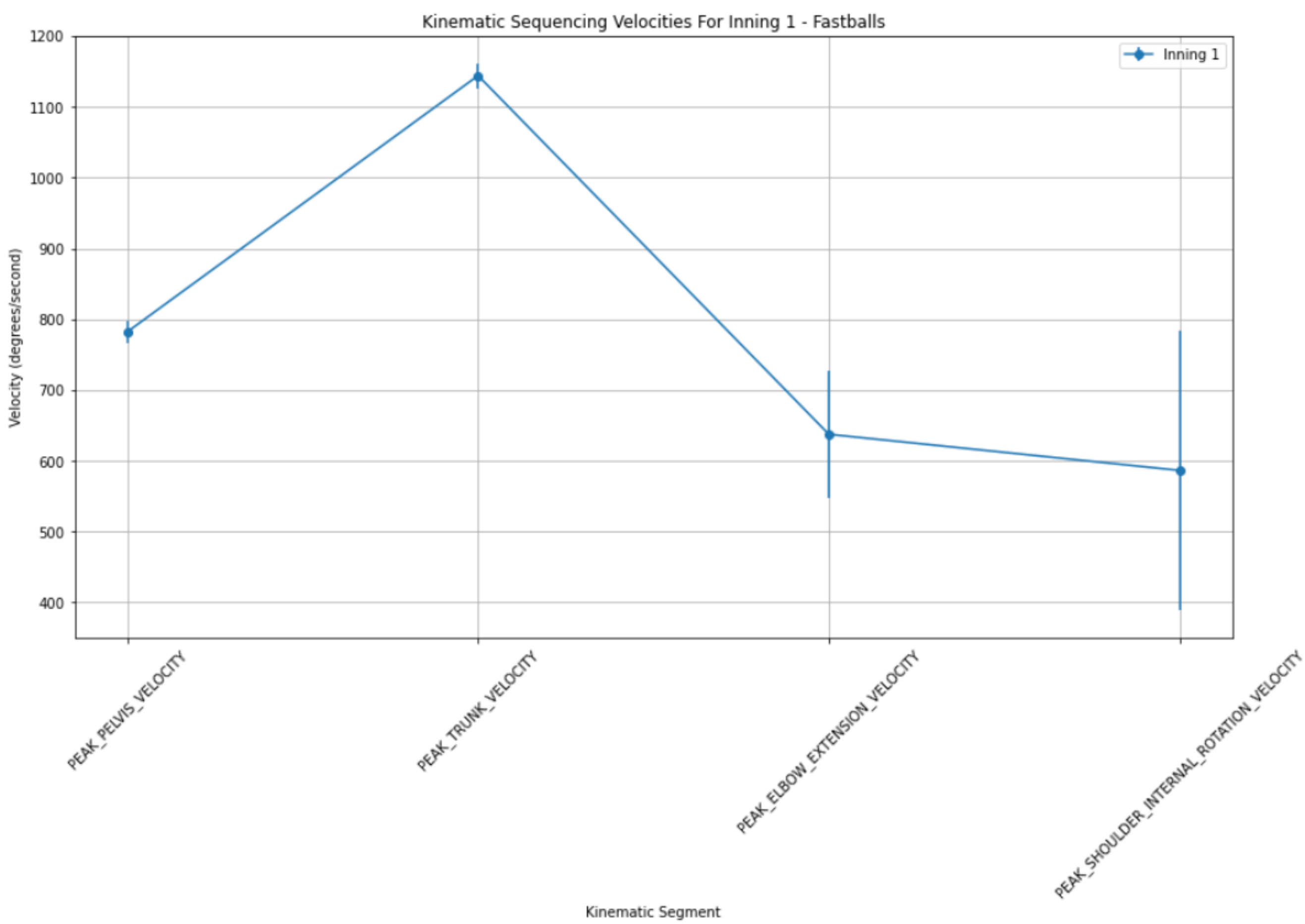
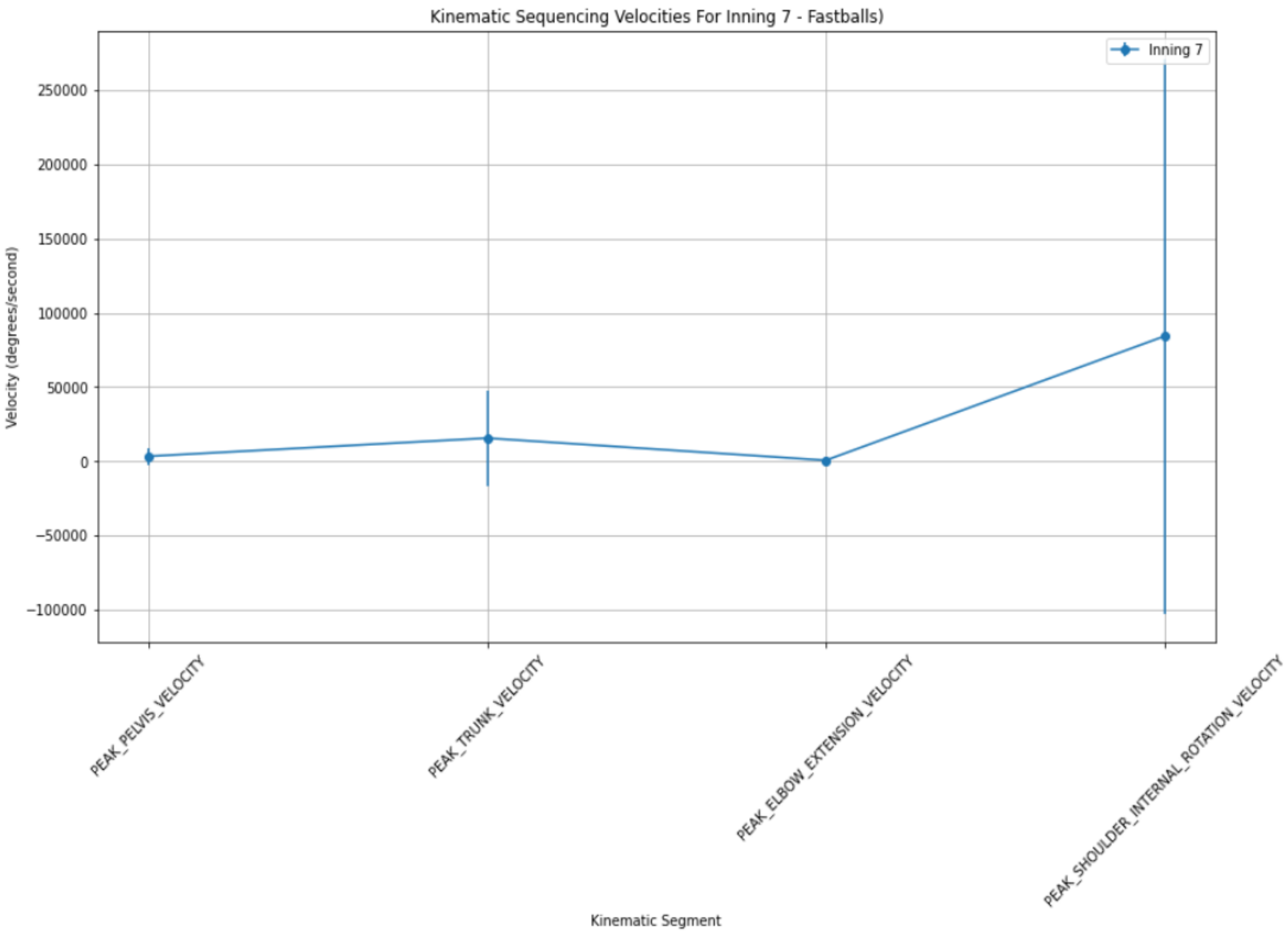
Texas Rangers Biomechanics Exercise – EBENEZER OLUBAYODE SUBMISSION

2. Plot the kinematic sequencing velocities (listed above) for only fastballs using their averages and +/- 1 SD. Provide 2 plots, one for each inning. The data is normalized from peak leg lift to the follow thru





3. Using your answers from Question #1, is there a statistical difference between the first and last inning of work that would raise any red flags for this pitcher for any signals / metrics or anything else? Explain why or why not.

There are some key changes I noticed between the first and seventh innings for this pitcher that actually raises concerns, particularly with fastballs. There is a drop in release-speed from (95.5 to 93.6) mph and the 64-degree reduction in shoulder external rotation which suggest fatigue or mechanical breakdown and can potentially lead to increase stress and injury risk. Elbow varus torque also fluctuated more in the seventh inning which raises red flags about possible elbow-injuries (like UCL-tears).

For fastball, the data shows a link between decreased release-speed and reduced elbow-torque. A 1.9 mph drop in speed led to an 11.98 Nm reduction in torque, signaling fatigue-related mechanical issues. Torque dropped from (126.21 to 114.23)Nm which actually points to inefficiencies.

Also, curveballs itself experienced a similar drop in release-speed (82.26 to 80.97) mph, but its std remained consistent (0.56 to 0.59) which means more stable mechanics. Curveballs appear less affected by fatigue, maintaining consistent shoulder mechanics, likely because they rely more on spin and control than velocity.

Therefore, I would say, decrease in fastball release-speed and mechanical variability, particularly in shoulder and elbow metrics, raises red flags which means that fatigue could heighten injury-risk for fastballs, while curveball mechanics remain more stable.

4. Are there any other metrics / signals from this data set that you would use / create that you feel would be valuable and why?

In addition to the existing metrics, I would introduce two valuable metrics from the dataset: Front Knee Flexion and Foot Position (FOOTPOS_IN).

Studies like Solomito et al. (2015) explain that inadequate knee flexion disrupts energy transfer from the lower to upper body, leading to overcompensation by the shoulder and elbow, which increases injury risk. A 10-degree increase in knee flexion at ball release can reduce elbow varus torque by 2.1 Nm, significantly lowering the risk of injuries like UCL tears. By tracking FRONTKNEE_X from foot plant (FP) to ball release (BR), we can identify pitchers at risk due to inefficient lower-body mechanics.

Also, research from Slowik et al. (2021) and Fortenbaugh et al. (2009) shows that improper foot positioning, such as overly open or closed strides, can increase upper-body stress. By considering FOOTPOS_IN metric, we can monitor stride length and orientation to avoid kinetic chain inefficiencies thereby improving performance and reducing injury risks.

Together, these metrics would really help in lower body-focused approach to pitching mechanics which will enables teams to detect mechanical inefficiencies early and help pitchers avoid injury while optimizing performance.

5. Are there any metrics that you would target for development of this pitcher? Using published research; explain why the metrics selected may improve this pitcher's performance and / or injury risk.

This pitcher relies on fastballs and curveballs, but fatigue affects mechanics later in games, leading to a drop in release speed and reduced shoulder external rotation, signaling breakdowns. Targeting these metrics can help this pitcher.

Shoulder External Rotation-(SER): The pitcher's drop from -178.67 to -141.37 degrees suggests fatigue. Wilk et al. (2015) found that a (5-10) degree decrease in SER can lead to mechanical breakdown, decreased velocity, and increased injury risks, particularly rotator cuff injuries (Murray et al., 2001). Fatigue is linked to reduced muscle activation, affecting rotation strength Gandhi et al.(2012). Reduced external rotation also increases injury risk Camp et al.,(2017).

Strengthening the rotator cuff and improving mechanics will help maintain velocity and reduce injuries.

Elbow Varus Torque: The 9.5% torque drop raises UCL concerns. Higher velocities correlate with increased torque (Slowik et al., 2019), but fatigue reduces torque and velocity, potentially protecting against injury. Anz et al.,(2010) noted that torque variability raises UCL injury risk. Strengthening elbow stabilizers will help.

Trunk Rotational Velocity: An increase in trunk velocity suggests fatigue compensation, stressing the shoulder and elbow Escamilla et al.,(2007). Core strengthening can reduce compensatory movements.

By targeting these metrics, the pitcher can improve performance and reduce injury risks.

6. Is there anything in the data that stands out to you that you would like to investigate further? What else could be done using information like this given more time and resources / potential research avenues?

The correlation between decreased release speed and potential injury risk, which aligns with previous research, stood out clearly. For Pitcher A, there's an obvious relationship between decreased release speed, shoulder external rotation, and elbow varus torque, which can lead to a mechanical breakdown that could lead to injury. I would like to see how other metrics like elbow torque and shoulder external rotation can contribute to injury risk, particularly when velocity stays constant as this would help in uncovering factors beyond just speed changes.

I would start by investigating whether pitchers throwing with high intent (putting more effort in) experience different torque and shoulder mechanics compared to those throwing at the same speed but with less effort. Then, I'd explore whether different higher torque at the same velocity increase injury risk, identifying if pitchers with different torque levels face similar risks. Finally, I'd apply these insights to Pitcher A, focusing on how fatigue, indicated by reductions in shoulder external rotation and elbow varus torque, affects performance and injury risk, and explore mechanical tweaks to help mitigate those risks.

7. Please choose one hitter or pitcher to break down mechanically. Include the videos used, and brief summary of strengths / opportunities and / or areas you would like more information.

Mechanical Breakdown of the Pitcher in this Video: https://www.youtube.com/shorts/YhdmE-XktHU

Wind-Up:

He maintains good balance, but his knee doesn't flex high enough as he brings his arm back-and-up. Improving knee-drive could generate more momentum from his lower body.

Arm-Cocking:

He takes the ball out of the glove well, lifting his arm into internal rotation and maintaining chest rotation without excessive scapular pinch. However, the ball isn't brought close enough to the center of rotation, limiting torque. More torque could be generated by reducing reliance on early external rotation-(ER).

Late-Cocking & Early-Acceleration:

As his load leg moves forward and his front foot lands, his shoulder stays turned back past the midline. His elbow rises smoothly to maximum ER, staying in front of the scapular plane, which reduces shoulder stress.

Late-Acceleration & Deceleration:

His elbow descends effectively during deceleration, reducing UCL-strain. However, his chest remains too far back which limits energy-transfer and affects velocity. A better chest-positioning would help him direct more force toward the target.

Leg-&-Hip-Position:

His front hip drops early, causing hip-hike at the end of his throw. His weak quads and valgus-knee position reduce force transfer. Improving hip-mobility and quad-strength will improve leg-drive and stability.

To improve performance and reduce injury-risk, he should develop his core-strength, chest-positioning and hip-stability.

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