PRESENTER
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Background

Why Does This Study Matter? The issue of recurring injuries and its impact on teams and players. Specifically considering injuries to MLB (baseball pitchers in general), most studies focus on;
1. Frequency of injury,
2. Performance post-injury,
3. Injury detection, and
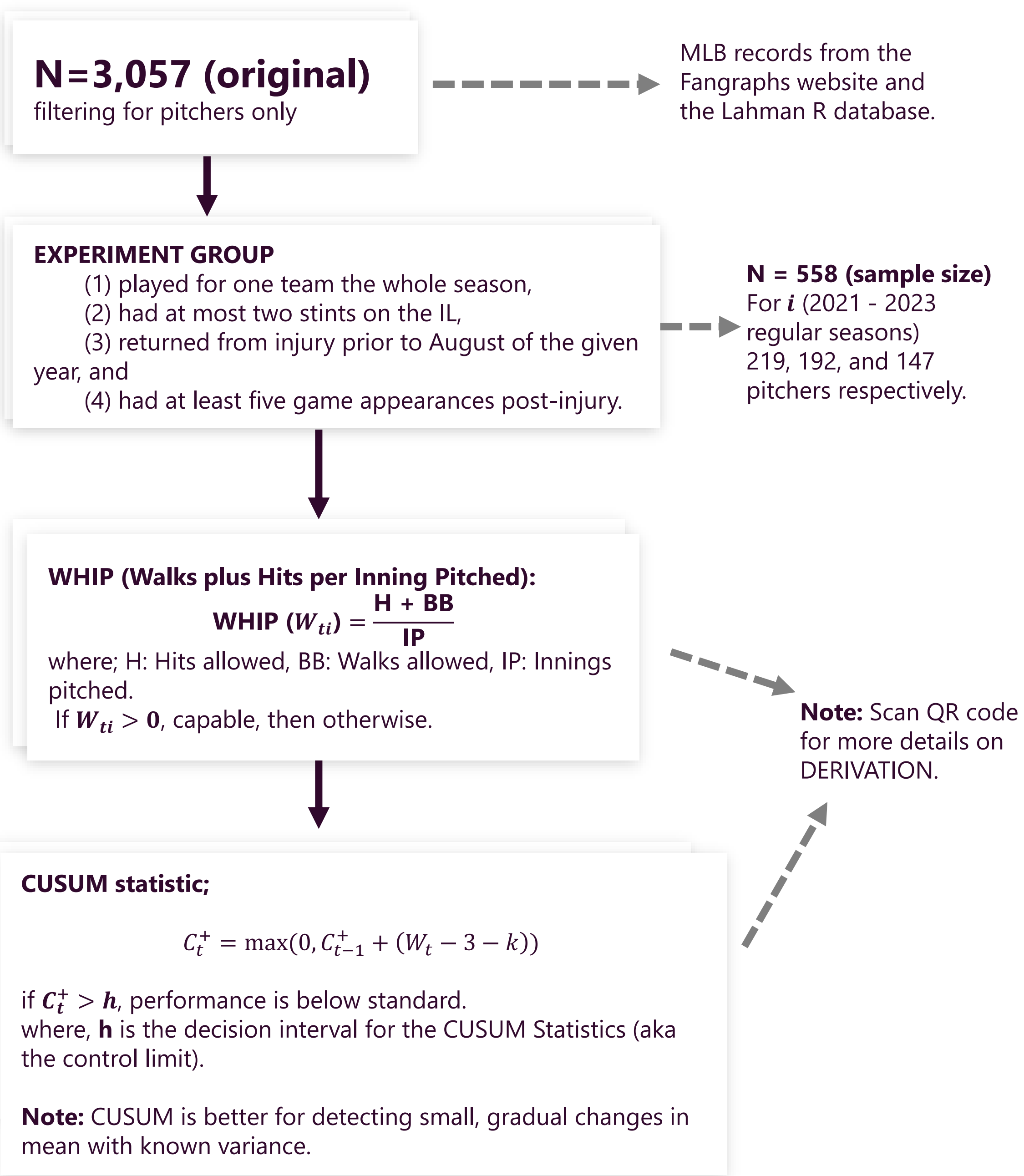4. Strategies for injury prevention.

Current Challenges

Monitoring methods rely on _retrospective analysis_ rather than _real-time_ tracking.
This suggests that traditional approaches:
1. Analyze past injuries instead of detecting risks in real time.
2. May not be proactive in preventing injuries.
3. Could delay intervention, making it difficult to prevent re-injury before it occurs.

Problem Statement

This work aims to develop a proactive system using CUSUM control charts to detect early signs of injury risk in MLB pitchers. By identifying gradual performance declines, the system will allow teams to intervene before injuries occur, reducing re-injury rates and improving player longevity. The goal is to find the optimal CUSUM threshold (h) for early injury detection, minimizing injury-related costs, improving player health, and ultimately saving team resources.

Methods

N=3,057 (original)
filtering for pitchers only

→ MLB records from the Fangraphs website and the Lahman R database.

EXPERIMENT GROUP
(1) played for one team the whole season,
(2) had at most two stints on the IL,
(3) returned from injury prior to August of the given year, and
(4) had at least five game appearances post-injury.

→ **N = 558 (sample size)**
For i (2021 - 2023 regular seasons)
219, 192, and 147 pitchers respectively.

WHIP (Walks plus Hits per Inning Pitched):
$$WHIP\ (W_{ti}) = \frac{H + BB}{IP}$$
where; H: Hits allowed, BB: Walks allowed, IP: Innings pitched.
If $W_{ti} > 0$, capable, then otherwise.

Note: Scan QR code for more details on DERIVATION.

CUSUM statistic;
$$C_t^+ = \max(0, C_{t-1}^+ + (W_t - 3 - k))$$
if $C_t^+ > h$, performance is below standard.
where, **h** is the decision interval for the CUSUM Statistics (aka the control limit).

Note: CUSUM is better for detecting small, gradual changes in mean with known variance.

How Reliable is this Approach?

Results
• Injury Detection Range: h=1 to h=20 sensitivity and specificity for early injury prediction are presented.
• Game Appearances Before Injury, Game Appearances Before Signal, and Game Saved are presented in the plot for h=1 to h=20.
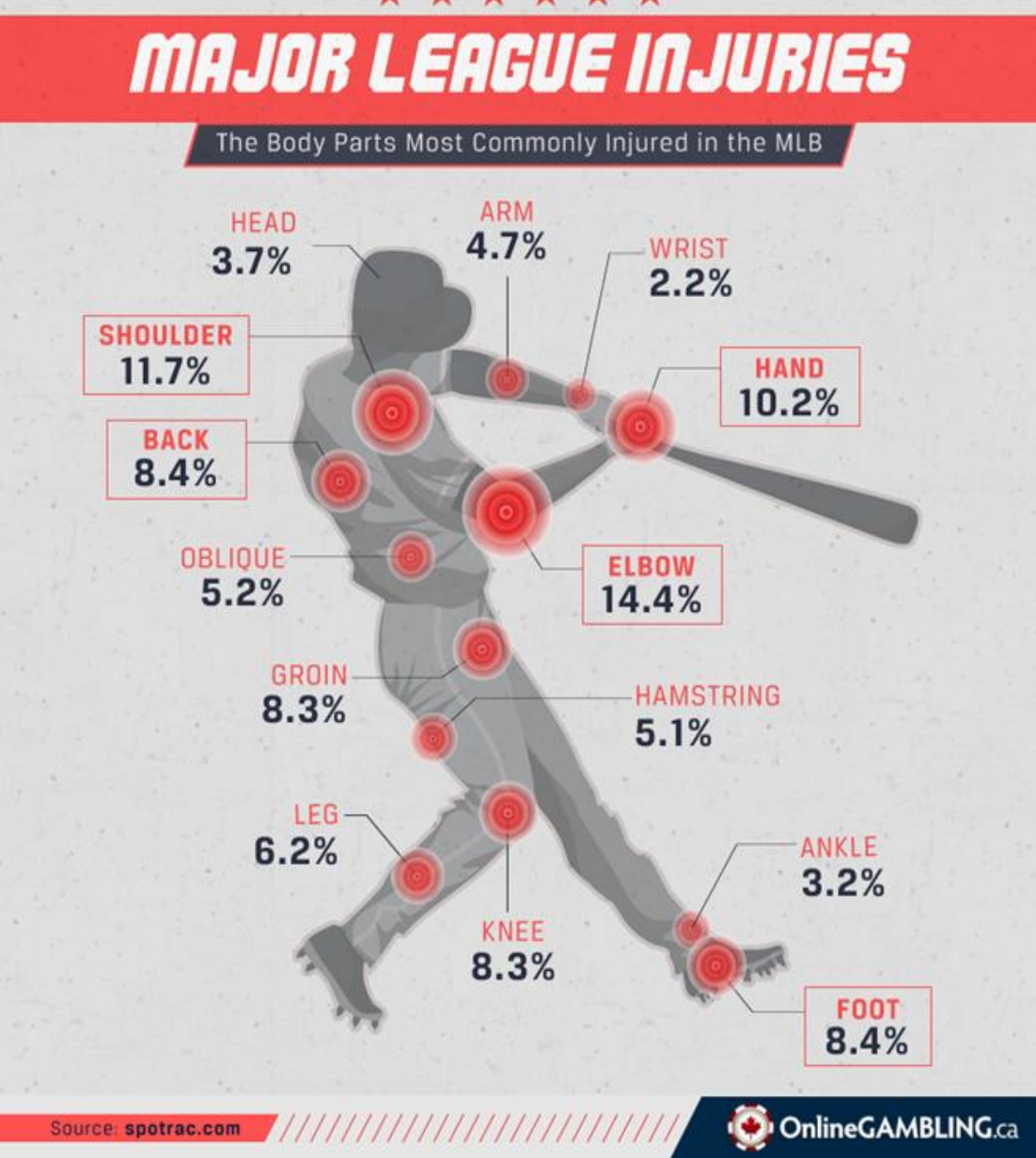**Note: Game Saved=** Average Appearances Before Injury − Average Appearances Before Signal

Analysis & Recommendation
For Effective Monitoring: Using the h range of 7–12 provides a balanced approach for injury prediction. This is **a tradeoff between sensitivity and specificity**, where increasing the decision interval (h) to be more specific also decreases the sensitivity.

Why: The cost of misclassifying a struggling pitcher as injured is low (e.g., imaging by a doctor between games).

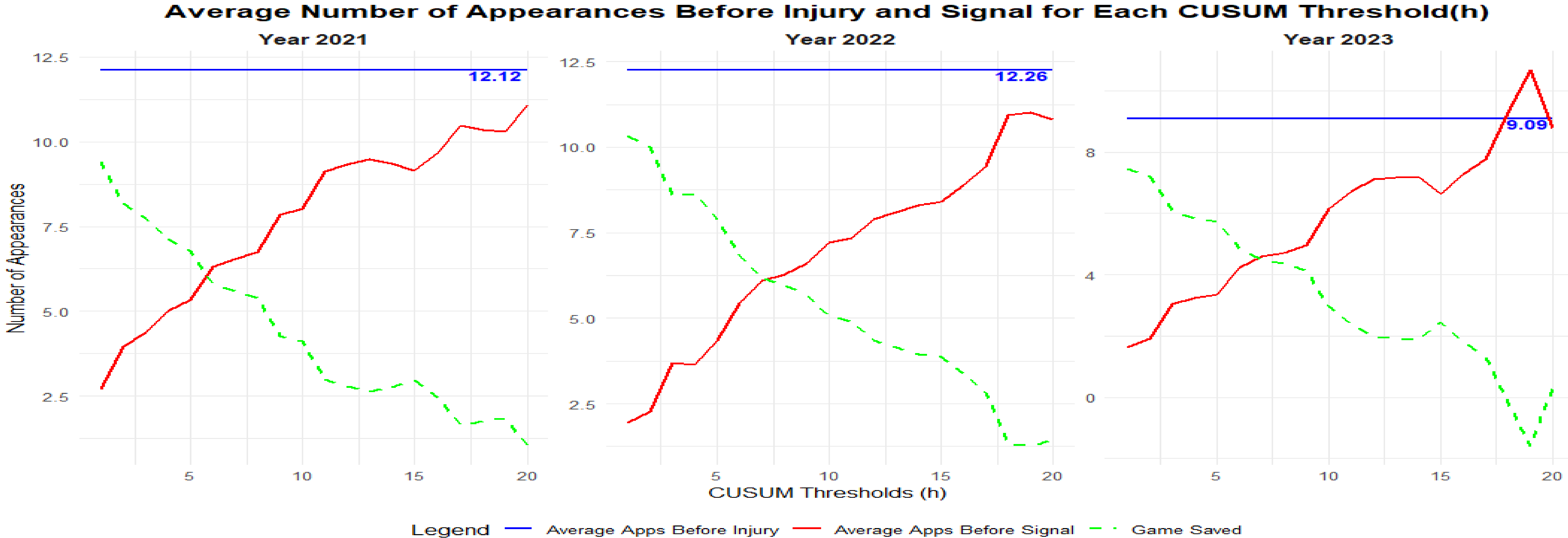**Strengths:** This approach to the solution is clear, with easy implementation.

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MAJOR LEAGUE INJURIES
The Body Parts Most Commonly Injured in the MLB

HEAD 3.7%
ARM 4.7%
WRIST 2.2%
SHOULDER 11.7%
HAND 10.2%
BACK 8.4%
OBLIQUE 5.2%
ELBOW 14.4%
GROIN 8.3%
HAMSTRING 5.1%
LEG 6.2%
KNEE 8.3%
ANKLE 3.2%
FOOT 8.4%

How well does this approach predict re-injury risk?

A Quality Monitoring Approach to Evaluating Re-Injury Likelihood to MLB Pitchers

Average Number of Appearances Before Injury and Signal for Each CUSUM Threshold(h)

Year 2021 — 12.12
Year 2022 — 12.26
Year 2023 — 9.09

Legend: Average Apps Before Injury | Average Apps Before Signal | Game Saved

CUSUM Thresholds for Detecting Injuries
How different h-values affect detection rates.

Sensitivity vs Specificity for CUSUM Thresholds (1-20)
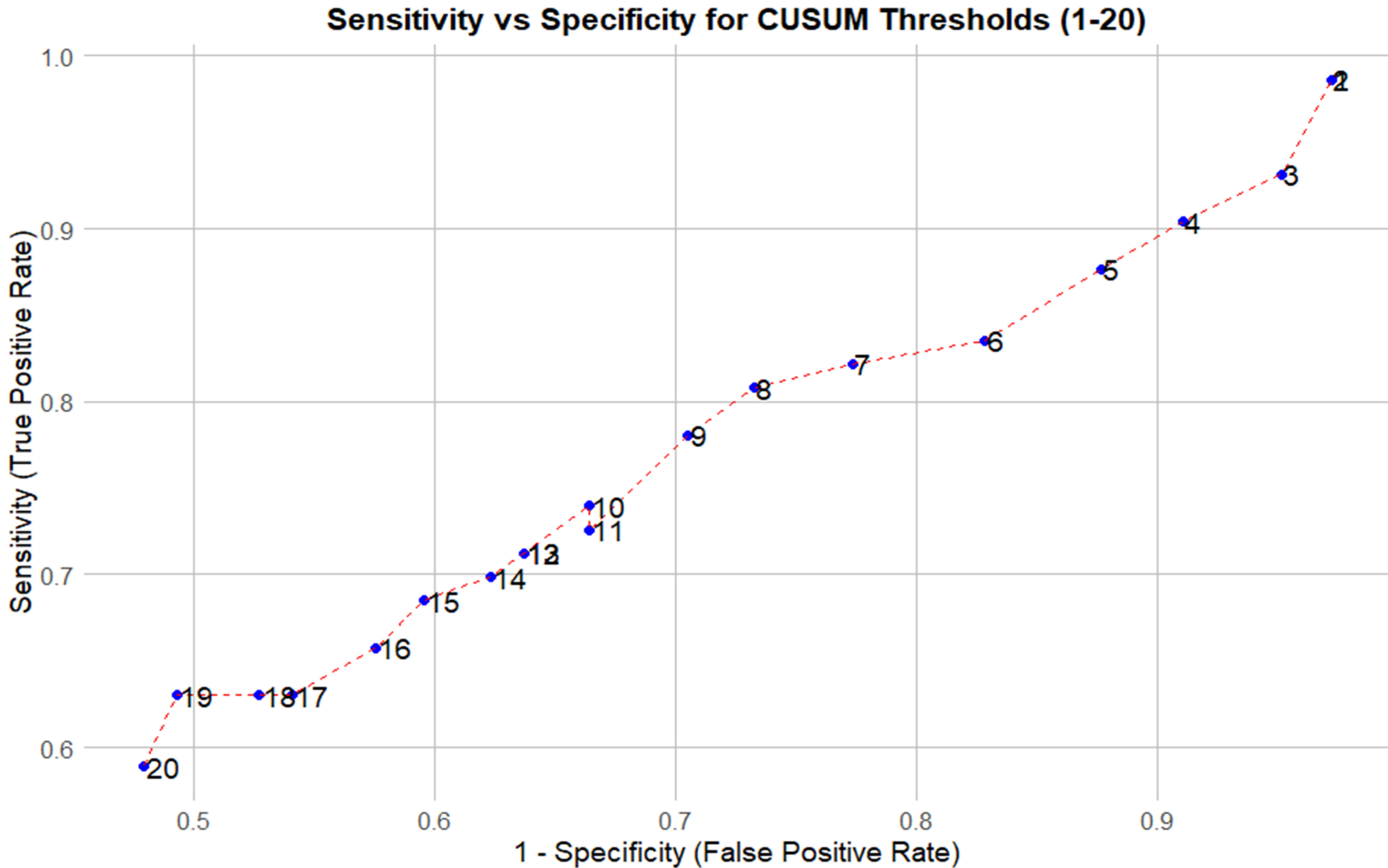
Case Study 1
A pitcher flagged by CUSUM before re-injury.

CUSUM Chart for Adam Wainwright
2023 Regular Season
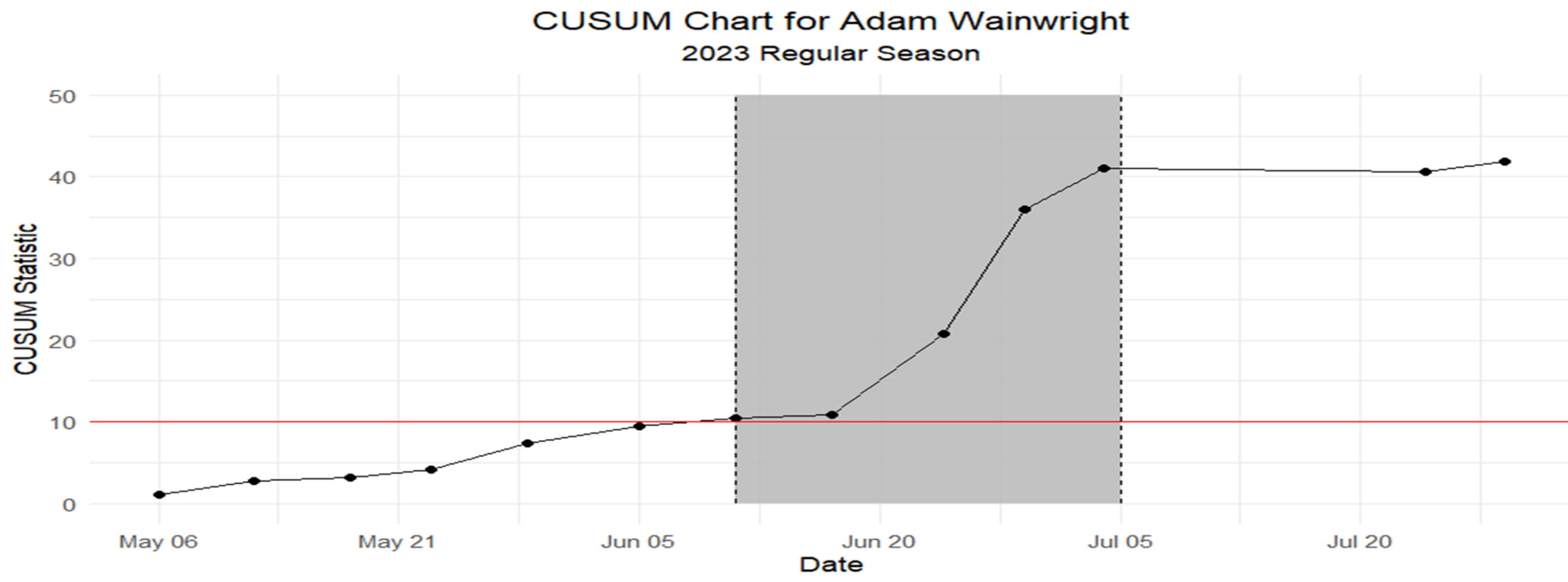
Case Study 2
A pitcher Never flagged by CUSUM After re-injury.

CUSUM Chart for Adbert Alzolay
2021 Regular Season