

## 🏃 100m Sprint Analysis - Paris 2024 Olympics

This project analyzes elite sprinters from the **Paris 2024 Olympic 100m Final** using 2D skeleton-based pose data. Using biomechanical features derived from pose estimation, it calculates per-athlete metrics such as **step length**, **step frequency**, **ground contact time**, **air time**, and **speed**.

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### 📌 Overview

The project:

- Uses midhip-to-ankle Z-axis distance to detect leg peak extension.
- Classifies air vs. contact phases per leg using threshold-based logic.
- Computes physical performance metrics and visualizes key events.
- Compares metrics across **8 elite athletes**.

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### 🛠 Methodology

#### 💡 1. Pose Data Preprocessing

- Input: CSV with 3D coordinates for 33 landmarks.
- Missing values are linearly interpolated.
- Outliers are being corrected

#### 📈 2. Smoothing & Peak Detection

- Midhip-ankle Z-distance used to detect leg extension peaks:  
```  
diff1 = |midhip\_z - right\_ankle\_z|  
diff2 = |midhip\_z - left\_ankle\_z|  
```
- Normalized and smoothed using **Savitzky-Golay Filter**.
- Peaks where smoothed difference exceeds a threshold are labeled as **leg contact initiation**.

#### 🧠 3. Classification of Contact vs. Air

- Frames after peak until drop below threshold → **Contact phase**
- Intervals between opposite leg's contact → **Air phase**
- Both legs 0 → Air
- One leg 1 → Contact
- Both legs 1 → Double contact (start of run)

#### 📏 4. Metric Computation

- **Step Length**: Distance between ankles during max air frame.
- **Step Rate**: Time between alternate leg contact events.
- **Air/Contact Times**: Counted in frames then scaled using FPS.
- **Speed**: `step length × step rate`

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## Athletes Analyzed

1. Noah Lyles
  2. Kishane Thompson
  3. Fred Kerley
  4. Akani Simbine
  5. Marcell Jacobs
  6. Letsile Tebogo
  7. Kenny Bednarek
  8. Oblique Seville
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## Evaluation Metrics (Threshold Classification Accuracy)

Athlete	Accuracy L	Accuracy R	Precision L	Precision R	Recall L	Recall R
Noah Lyles	94.0	95.2	93.70	95.97	94.44	94.44
Kishane Thompson	94.8	93.6	95.20	92.13	94.44	95.12
Fred Kerley	94.8	94.0	93.65	94.21	95.93	93.44
Akani Simbine	94.0	96.0	91.60	96.75	96.77	95.20
Marcell Jacobs	92.4	94.0	92.97	91.47	92.25	96.72
Letsile Tebogo	94.0	96.8	96.67	95.08	91.34	98.31
Kenny Bednarek	96.0	92.8	96.85	92.13	95.35	93.60
Oblique Seville	91.2	94.0	91.41	92.25	91.41	95.97

L - Left Leg

R - Right Leg

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## Athlete Performance Summary

Athlete	Avg Step Length (m)	Avg Contact Time (s)	Avg Air Time (s)	Step Frequency (Hz)
Noah Lyles	2.083	0.130	0.088	4.810
Kishane Thompson	2.034	0.126	0.081	4.851
Fred Kerley	2.521	0.133	0.094	4.815
Akani Simbine	2.161	0.133	0.079	5.936
Marcell Jacobs	2.126	0.120	0.092	4.790
Letsile Tebogo	2.184	0.120	0.098	4.654
Kenny Bednarek	2.273	0.130	0.080	4.825
Oblique Seville	1.825	0.130	0.074	5.291

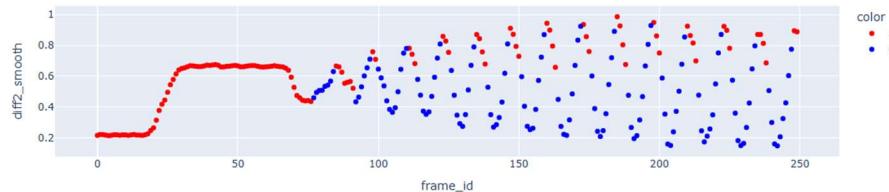
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## Visual Outputs

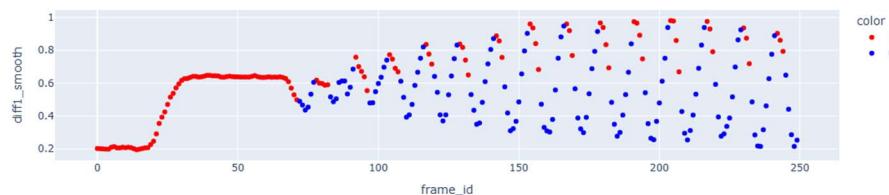
### - Color-coded leg state plots (air/contact)

1 (red color) indicates when the leg is in contact with the ground  
 0 (blue color) indicates when the leg is in air

Midhip Z vs Left Ankle Z Diff

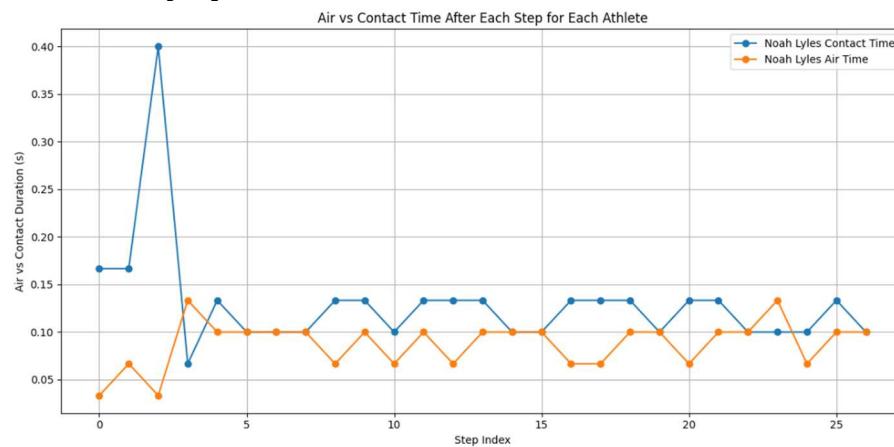


Midhip Z vs Right Ankle Z Diff

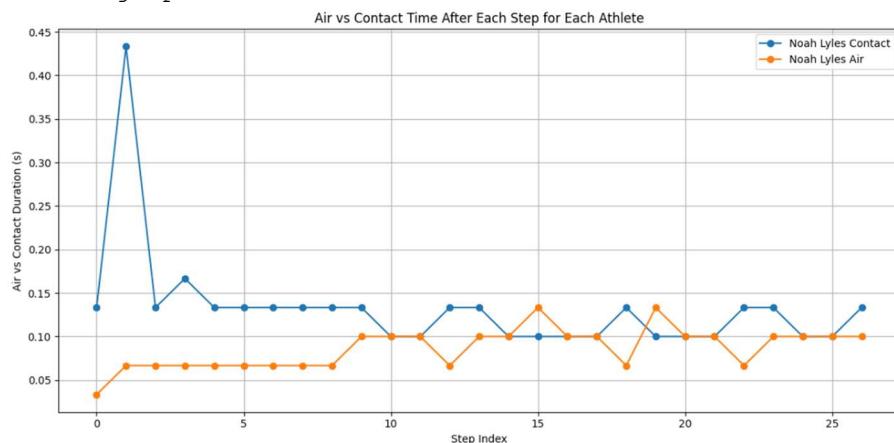


### - Air time vs contact time graphs

Predicted graph

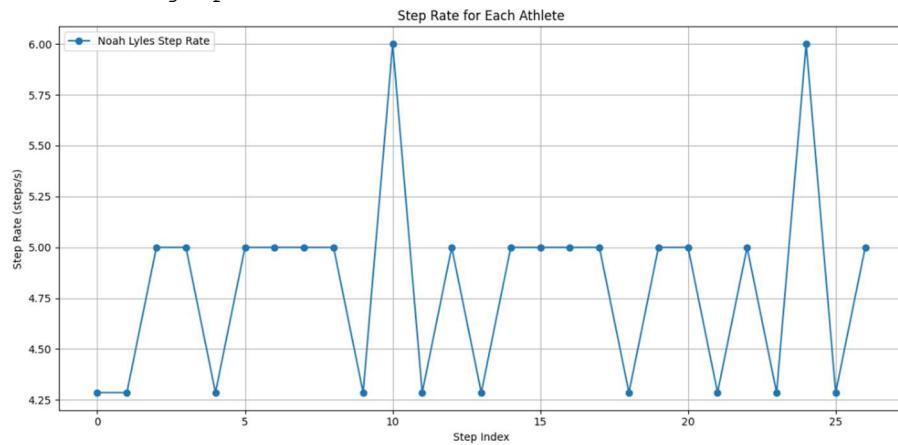


Actual graph

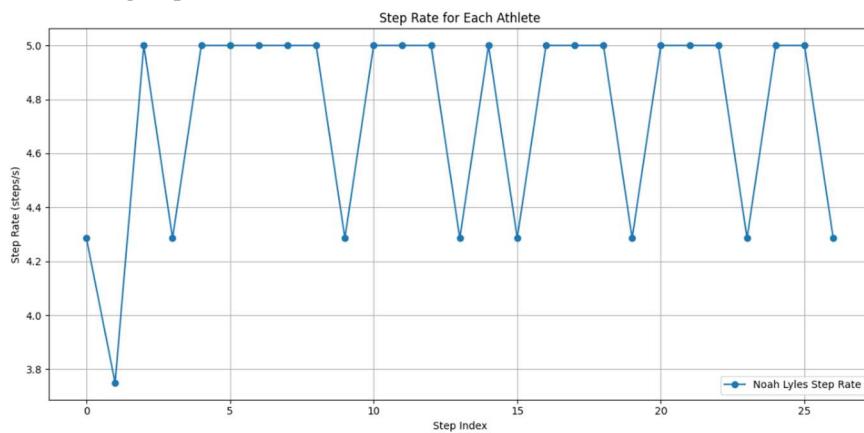


- Step rate graph for each Athlete

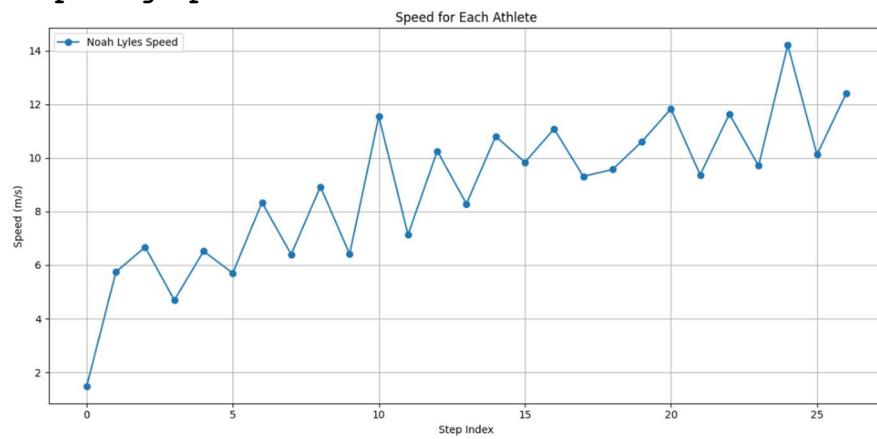
Predicted graph



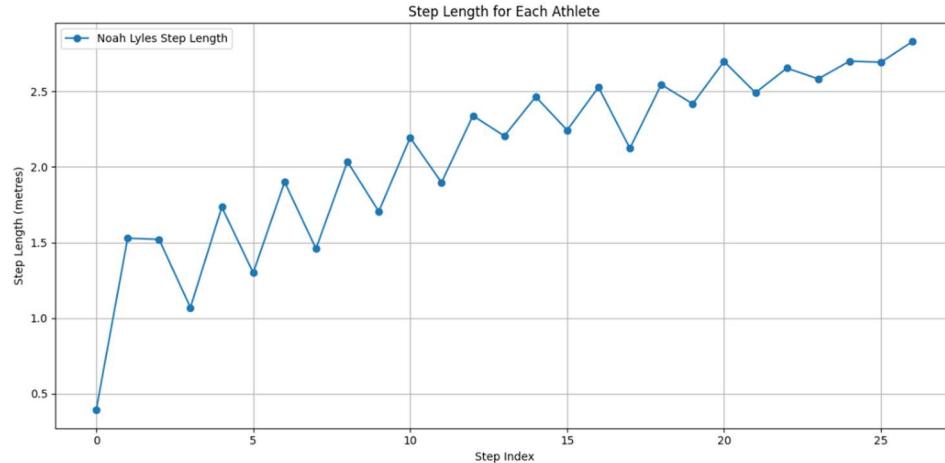
Actual graph



- Speed graph for each Athlete



- **Step Length graph for each Athlete**



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 **Dependencies**

- `numpy`, `pandas`, `scipy`, `matplotlib`, `plotly`, `cv2`
  - Savitzky-Golay Filter from `scipy.signal`
  - Custom analysis class: `SkeletonAnalyzerFineTune1`
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