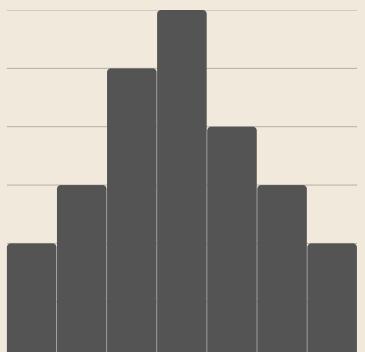


12/03/2025
HHA 507

Siddhika - Naira - Jaison - Paul - Briggs

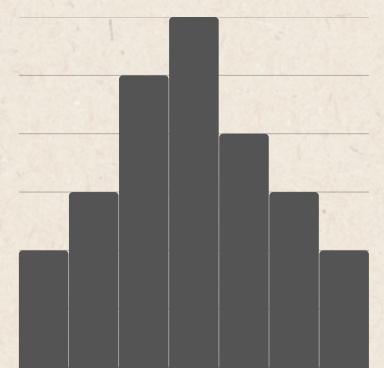
SPORTS METRICS ANALYSIS

SBU Athlete Performance Data



What we'll cover

- 01 Big Picture
- 02 Research Question
- 03 Methods
- 04 Key Findings
- 05 Practical Applications
- 06 Limitations & Future Work
- 07 Outro
- 08 QnA



Every
measurement
has to be based on some
basic framework.

What is that framework?



**Load
Force
Impulse
Workload
Movement
Gait ...**



Research Question

What are the most important metrics for **Rate of Force Development (RFD)** and **Movement-Efficiency & Gait-Complexity (ME&GC)**, and how do female and male athletes perform in these metrics?



Why it matters..

“

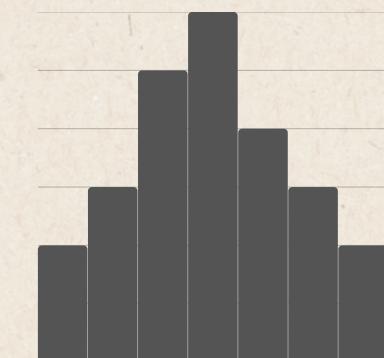
RFD powers an athlete's movement, while ME&GC determine how effectively that power turns into performance. ⁽¹⁵⁻¹⁸⁾

Coaches can combine tests of rapid force and movement coordination to better predict and improve performance. ⁽³⁾

Correlations enable predictive models and game-readiness algorithms for performance prediction. ⁽⁴⁻⁶⁾

Correlations help examine how empirical data supports multi-domain metrics clustering for performance assessment across sexes. ⁽⁷⁻⁹⁾

Female athlete gap: 70.7% of studies focus on males, 8.8% on females. ^(1,2)



The Core Relationship

Cause & Effect?

RFD > Engine
ME&GC > Drivetrain

Metrics

RFD



Peak Propulsive Power

Power

Explosive strength



Jump Height

Lower-limb power output



Peak Velocity

Explosive output & Limb symmetry



Max Sprint Speed

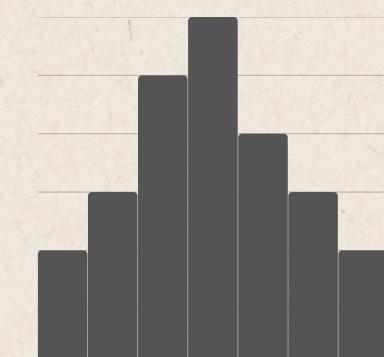
Explosiveness & quickness Peak locomotive capacity



Total Distance

Cummulative movement load

ME&GC



Methods

Paul

Methods

Data Overview

2,492,372
Hawkins

10-15-18 to 10-14-25
6 Yrs 11 Mths

Team Count
92
5904

4,073,754
Kinexon

06-17-21 to 10-21-25
4 Yrs 4 Mths

Unique Metrics
548
5

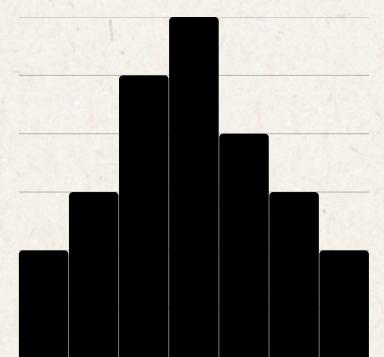
51,300
Vald

12-10-20 to 10-01-25
4 Yrs 9 Mths

6,617,426
Rows
5,097,352

88
Women

111
Male



Quality Assessment

- 1 Checked completeness & consistency**
- 2 Validated accuracy with thresholds**
- 3 Cleaned data: imputation, normalization, etc.**



Methods

Analysis Approach

explored, transform, clean
over all lit review for metrics
metrics ranges
4 players from basketball w & m
1 year lookback most data
lit review for thresholds & ranges
threshold levels
best & worst performance dates
scaled these to basketball m & w teams
flagging logic
flagging system
streamlit app

1

2

3

Descriptive stats & benchmarking

Team-level and player-level analysis

Dashboards - Streamlit



Key Findings

Naira



[1] Coupling

The fundamental coupling between RFD and ME&GC metrics is similar in both genders, but the operating range is shifted upward in males.

[2] Moderator

Interaction models testing Gender as a MODERATOR of RFD demonstrates complexity in relationships.

[3] Relationship

Relationship between RFD and ME&GC is primarily positive and consistent.

Longitudinal performance data for 4 selected athletes over the last 12 months.

- PLAYER_555 (Women's Basketball)
- PLAYER_741 (Women's Basketball)
- PLAYER_755 (Men's Basketball)
- PLAYER_995 (Men's Basketball)

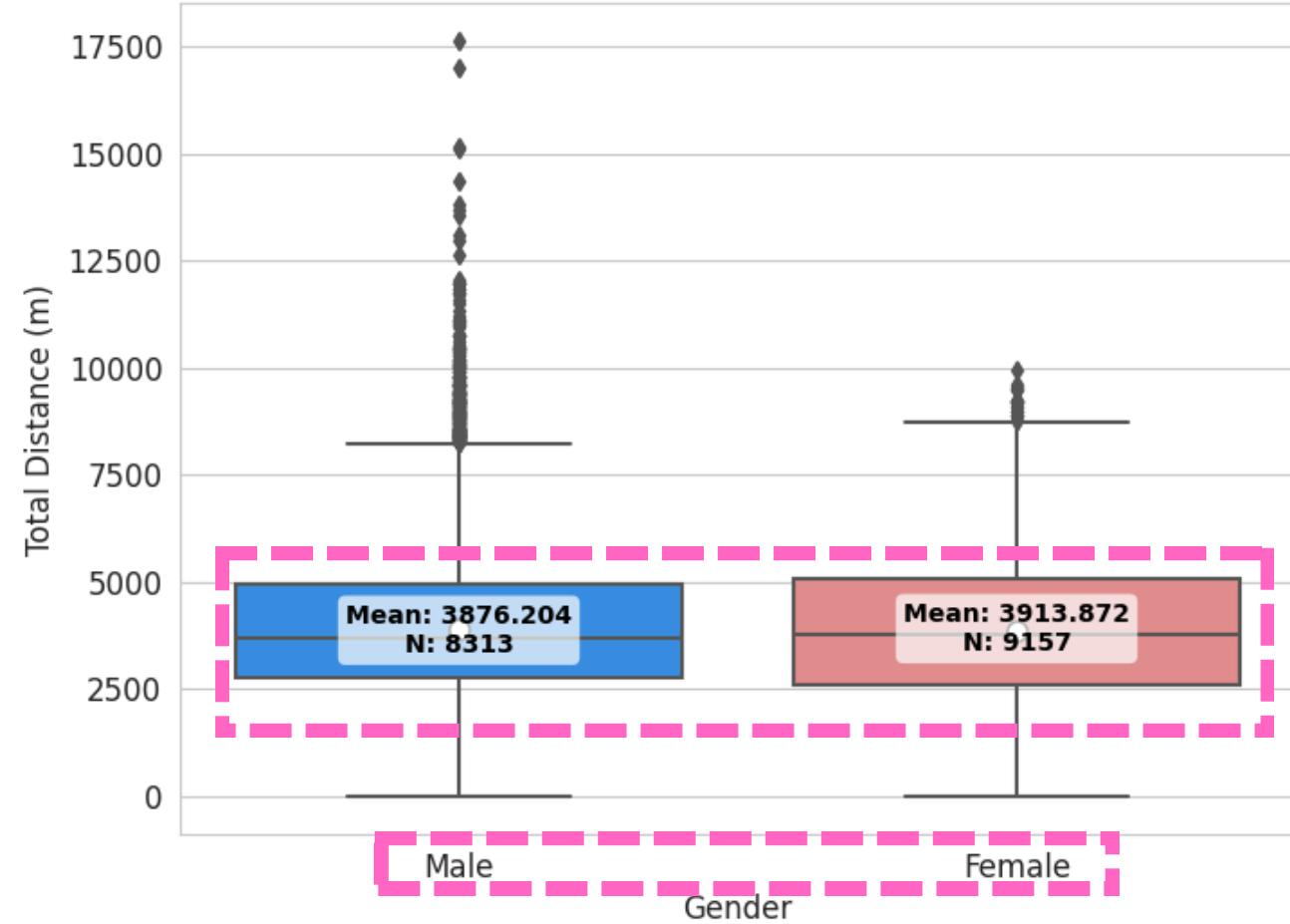
Trend Analysis: Simple linear regression

Statistical Significance: P-value ($p < 0.05$)

Gender-stratified correlations and regressions

Metric	Men	Women	Interpretation
Jump Height (m)	0.419	0.267	Men jump ~57% higher
Peak Power (W)	5519	3483	Men produce ~58% more power
Peak Velocity (m/s)	2.97	2.41	Men move ~23% faster
Speed Max (m/s)	5.65	5.93	Women slightly faster (~5%)
Distance Total (m)	3914	3876	Similar workload

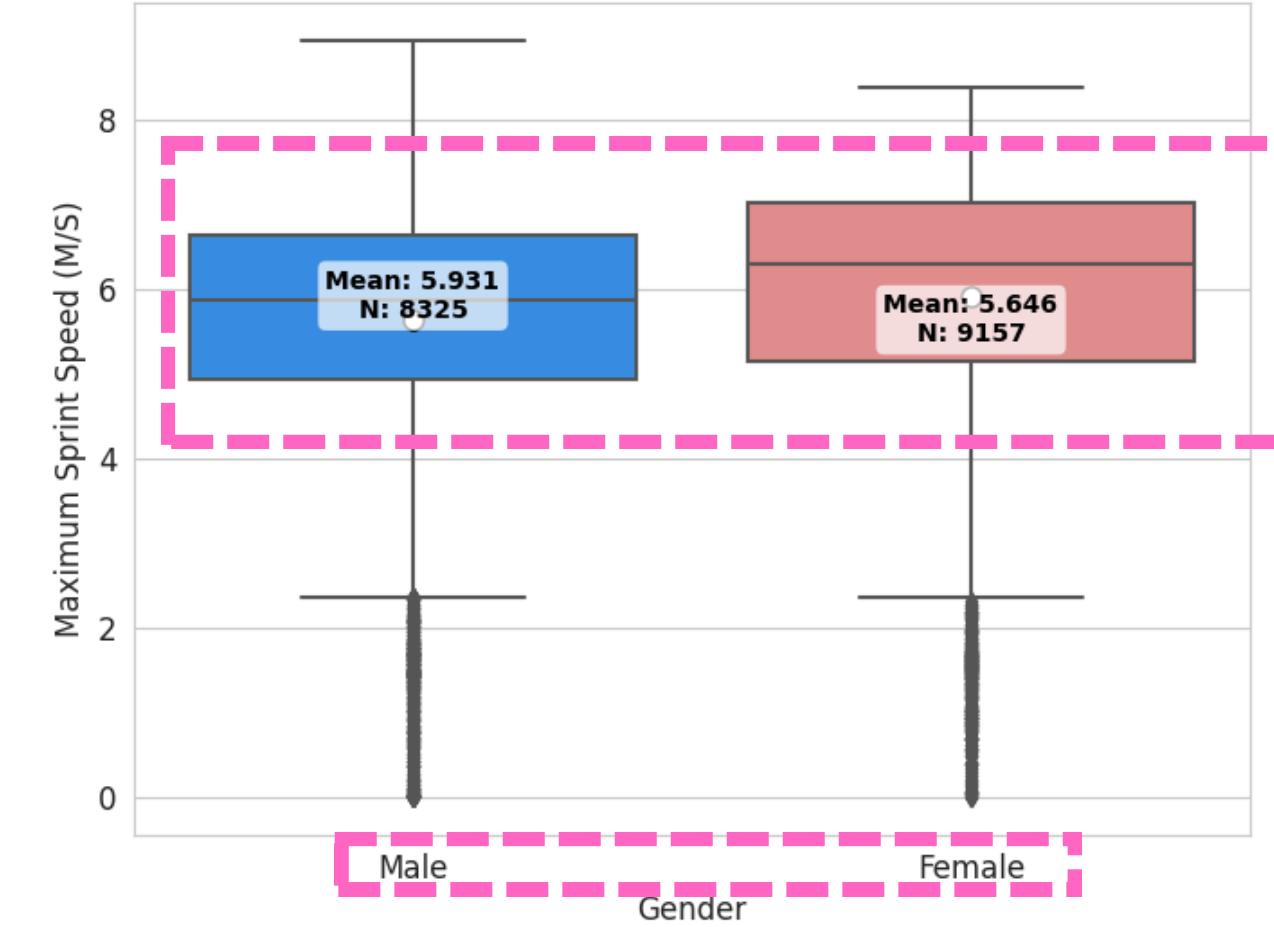
Total Distance (m) by Men's and Women's Basketball



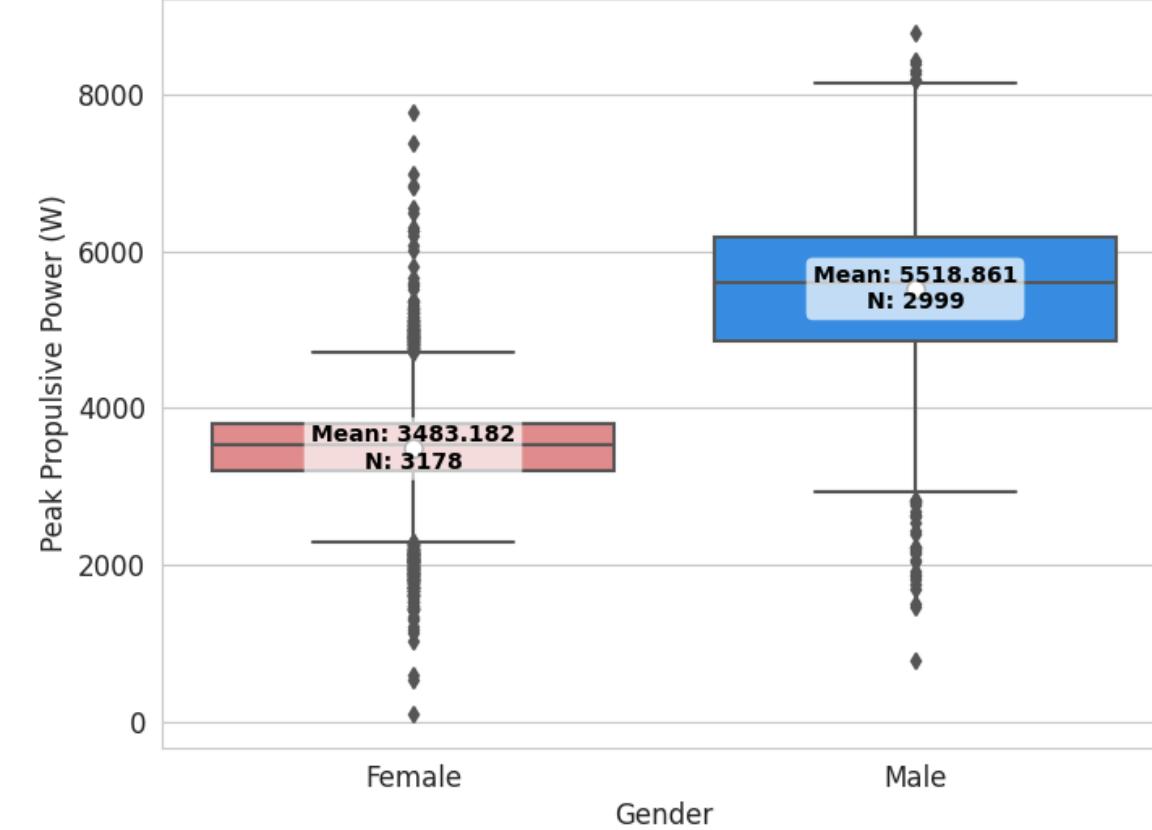
Gender as a Moderator

The complexity is visible in aggregated analysis and comparision of the 2 genders in basketball.

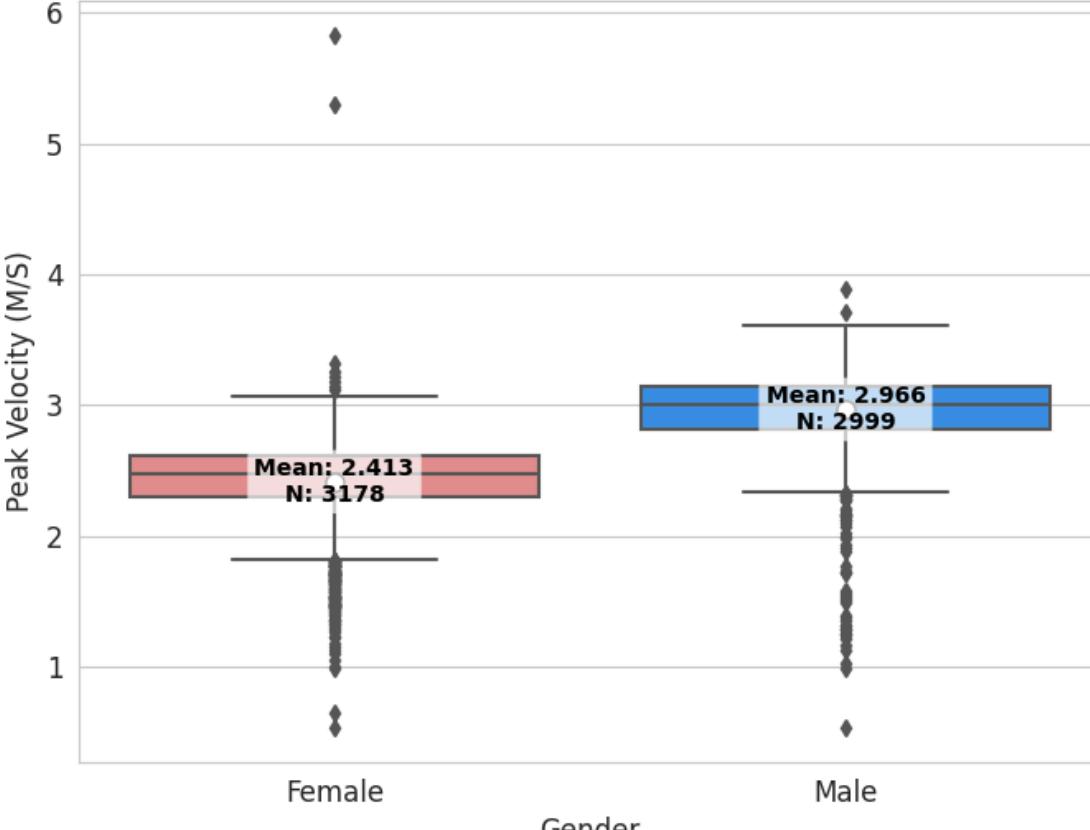
Maximum Sprint Speed (M/S) by Men's and Women's Basketball



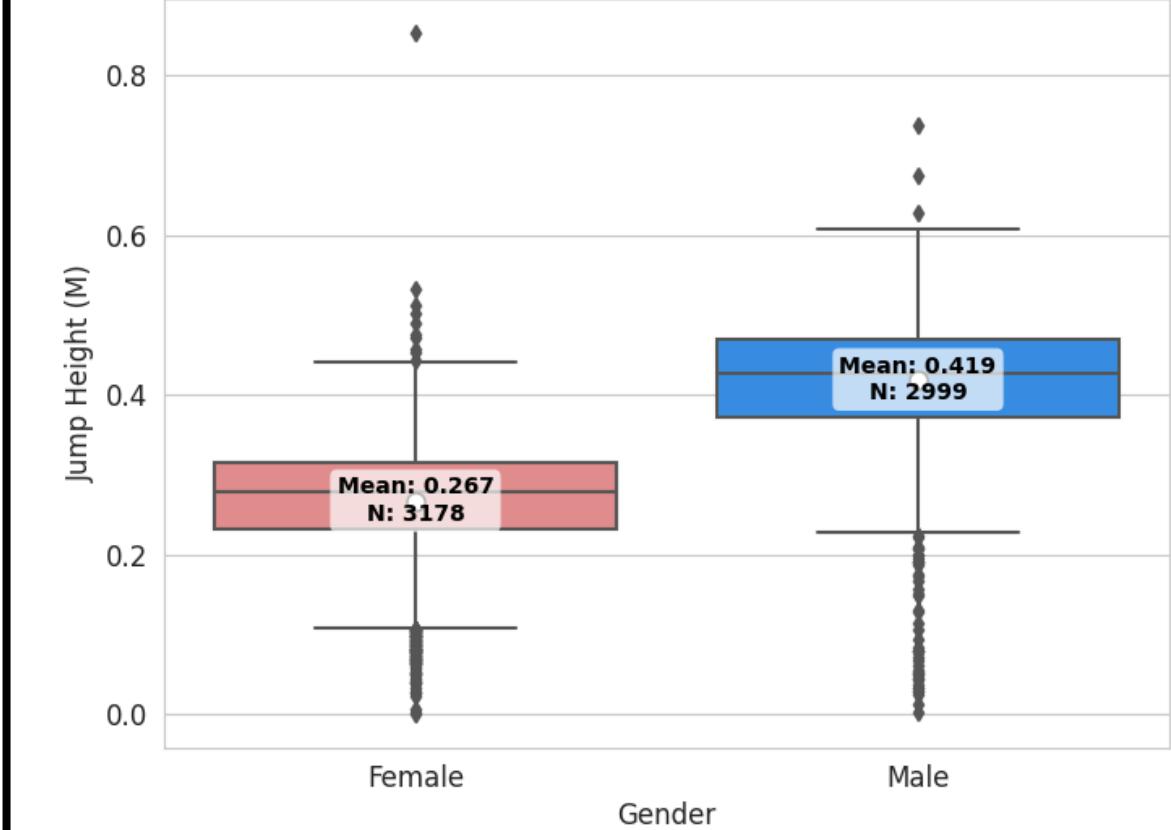
Peak Propulsive Power (W) by Men's and Women's Basketball



Peak Velocity (M/S) by Men's and Women's Basketball



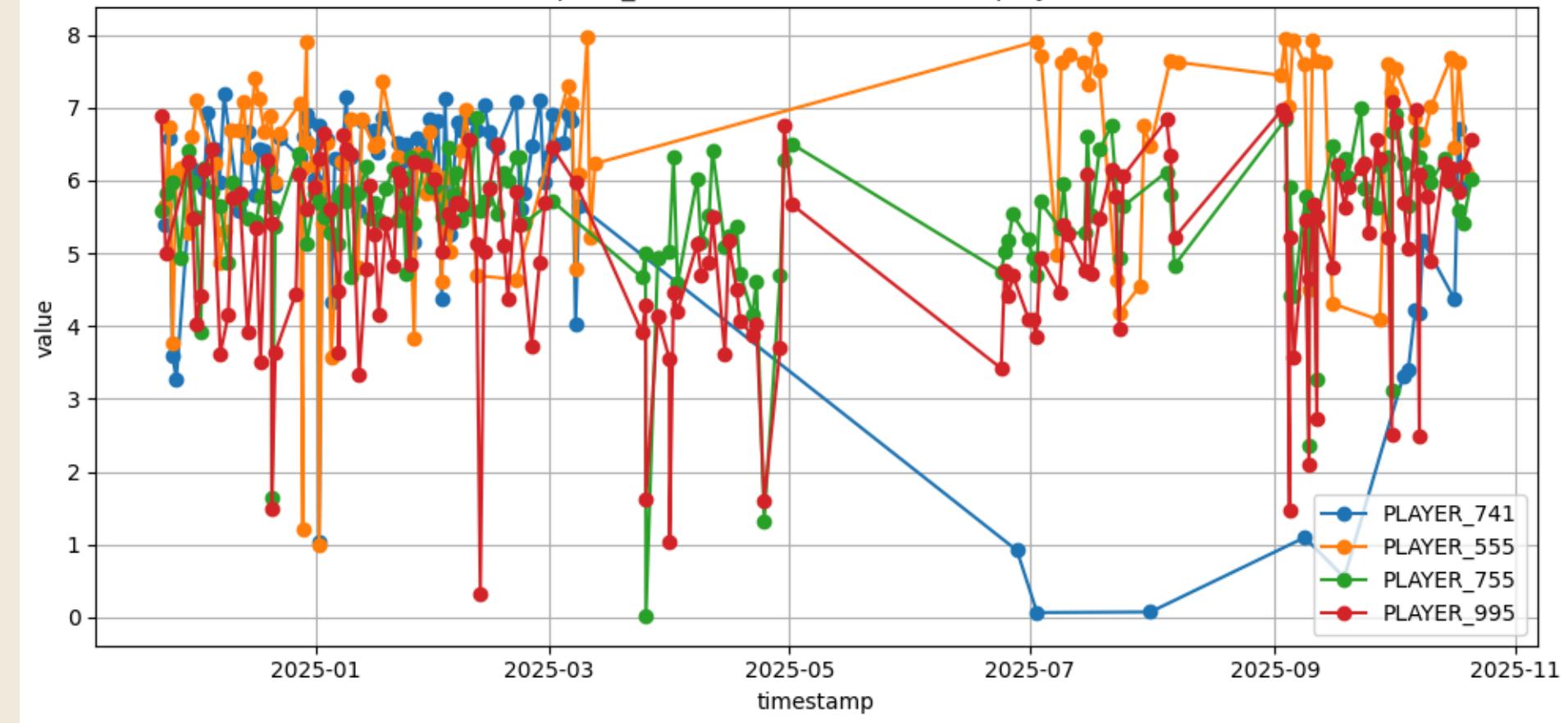
Jump Height (M) by Men's and Women's Basketball



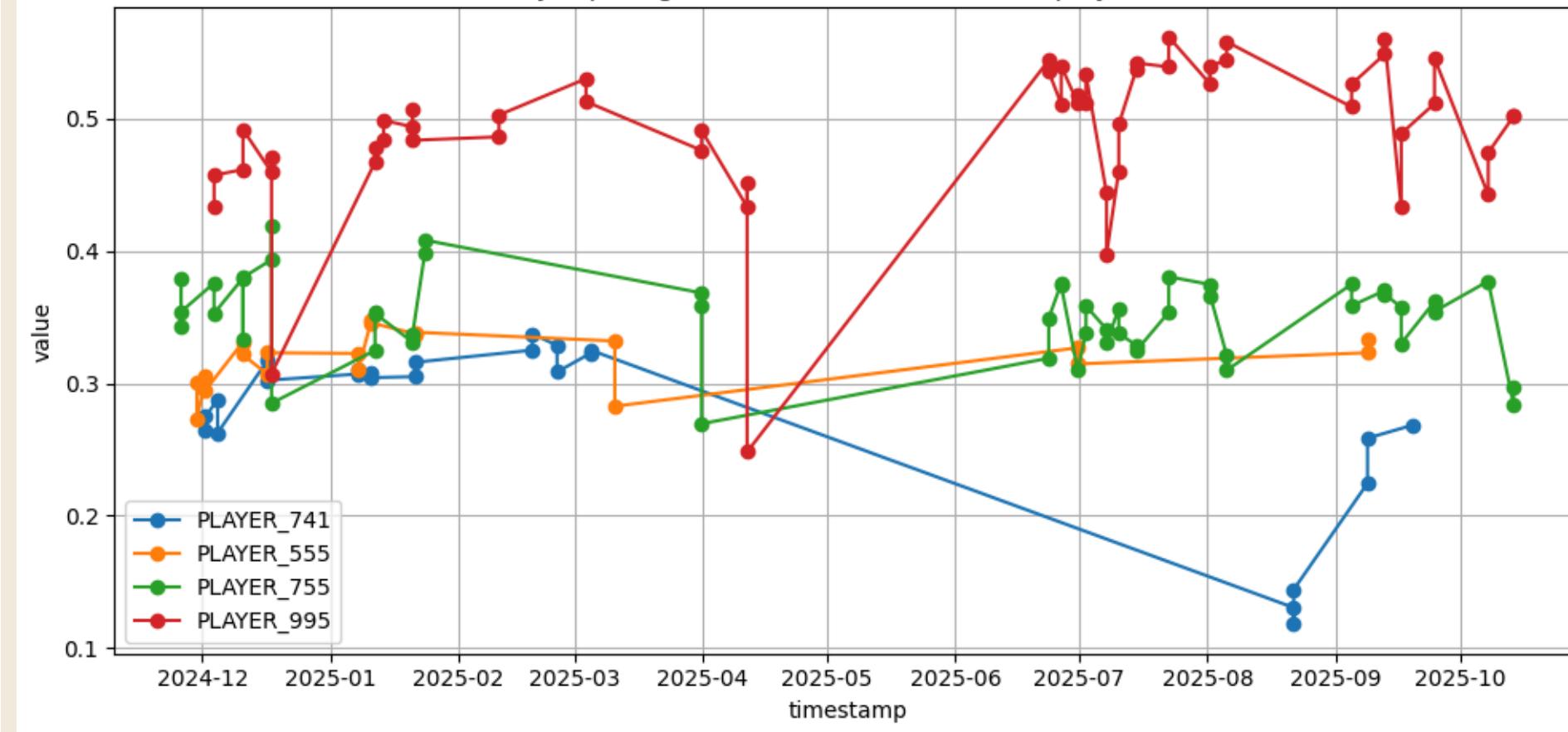
12 month lookback period

4 selected players

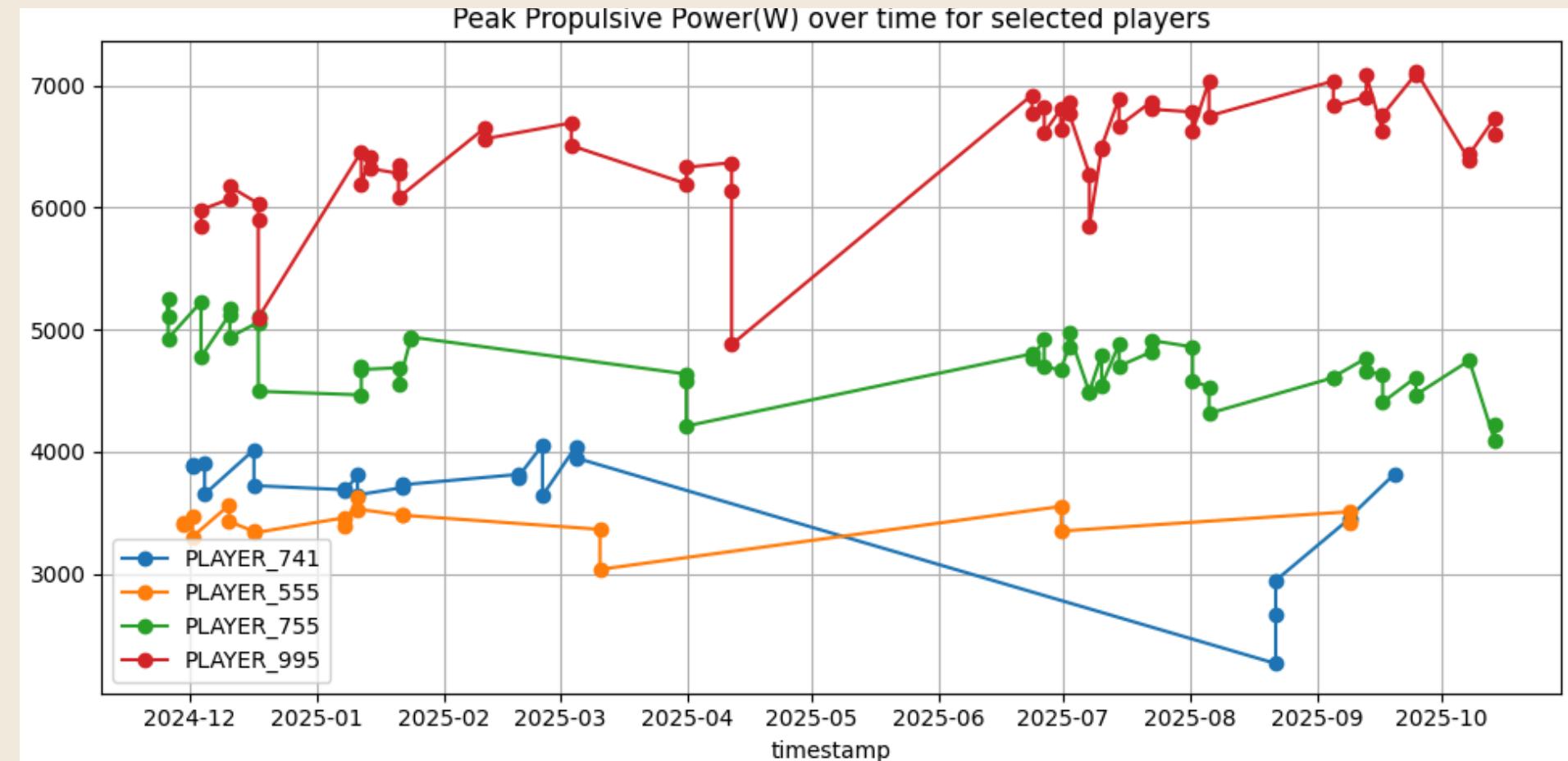
Speed_Max over time for selected players



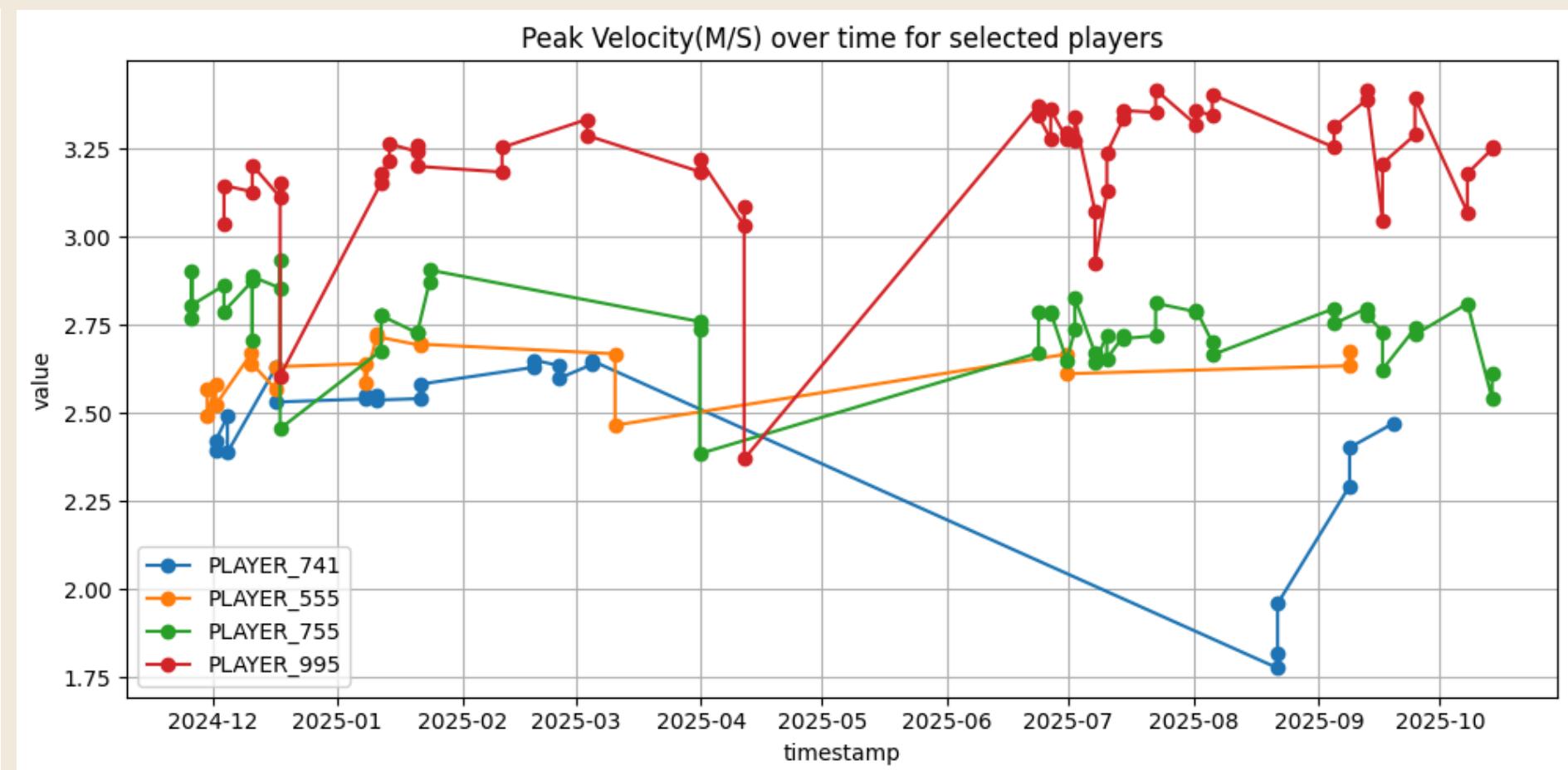
Jump Height(M) over time for selected players

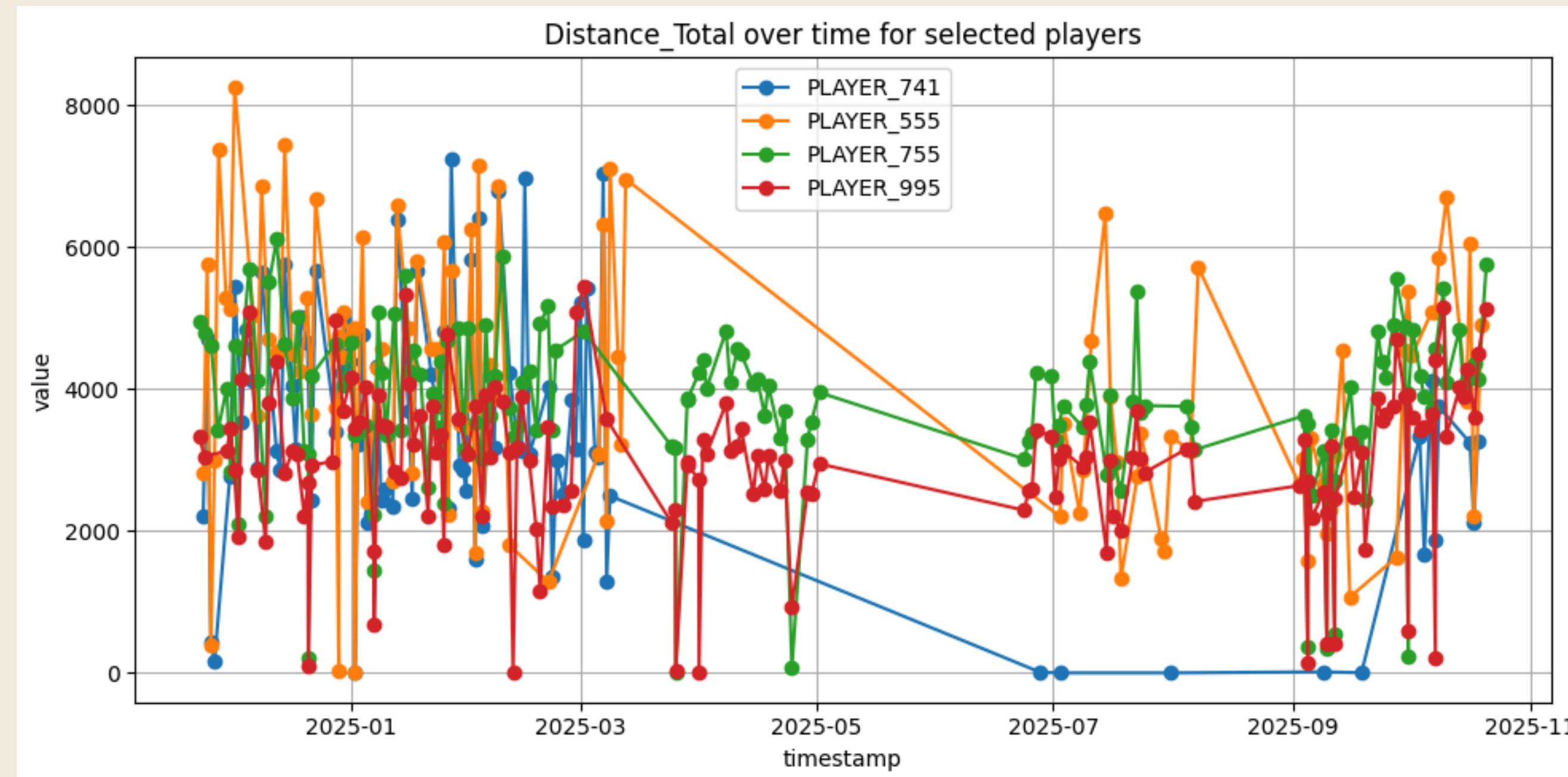


Peak Propulsive Power(W) over time for selected players



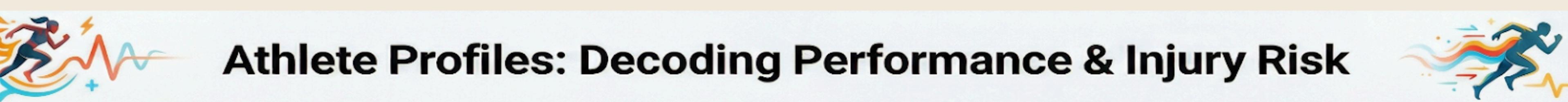
Peak Velocity(M/S) over time for selected players





Key Findings

Jaison



Athlete Profiles: Decoding Performance & Injury Risk

THE FEMALE ATHLETE CONTRAST: Force vs. Elasticity

Player 741: The Force-Dominant Profile

Generates high power but is mechanically inefficient, placing high stress on the knees.



Key Characteristic: High Force, Low Efficiency

mRSI (Reactivity): 0.36 (**Very Low**)

Peak Power: ≈3627 W (**High**)

Primary Injury Risk: Knee (ACL, Patellofemoral Pain)

Recommended Intervention: Neuromuscular Retraining

Player 555: The Tendon-Dominant Profile

Highly efficient and elastic but underpowered, increasing risk to tendons and posterior chain.



Key Characteristic: Elastic, Underpowered

mRSI (Reactivity): 0.52 (**Elite**)

Peak Power: ≈3100 W (**Low**)

Primary Injury Risk: Tendon (Achilles, Hamstring)

Recommended Intervention: Strength & Load Management

THE MALE ATHLETE CONTRAST: Overload vs. Efficiency

Player 755: The Work-Capacity Profile (Overloaded)

Caught in a "volume trap" where high workload suppresses neuromuscular efficiency, leading to fatigue.



Key Characteristic: Overloaded, Fatigued

mRSI (Mean): 0.43 (**RED FLAG**)

Distance / Session: ≈4,060 m (**High**)

Readiness Score: 3/10 (**Caution**)

Recommended Intervention: Reduce Distance by 20%

Player 995: The Explosive-Reactive Profile (Efficient)

Maintains high explosiveness with a balanced workload, indicating a well-recovered and sustainable profile.



Key Characteristic: Balanced, Efficient

mRSI (Mean): 0.66 (**Good**)

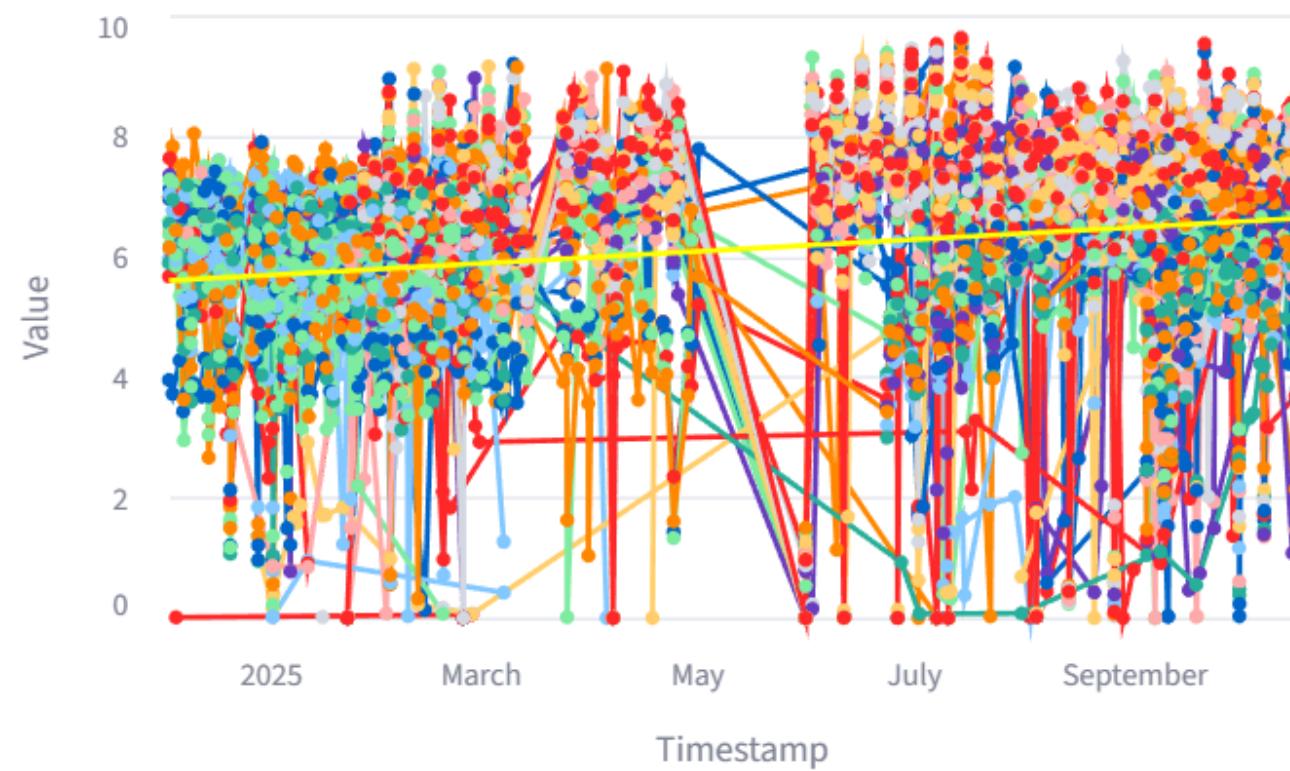
Distance / Session: ≈3,053 m (**Balanced**)

Readiness Score: 8/10 (**Good**)

Recommended Intervention: Maintain Current Load

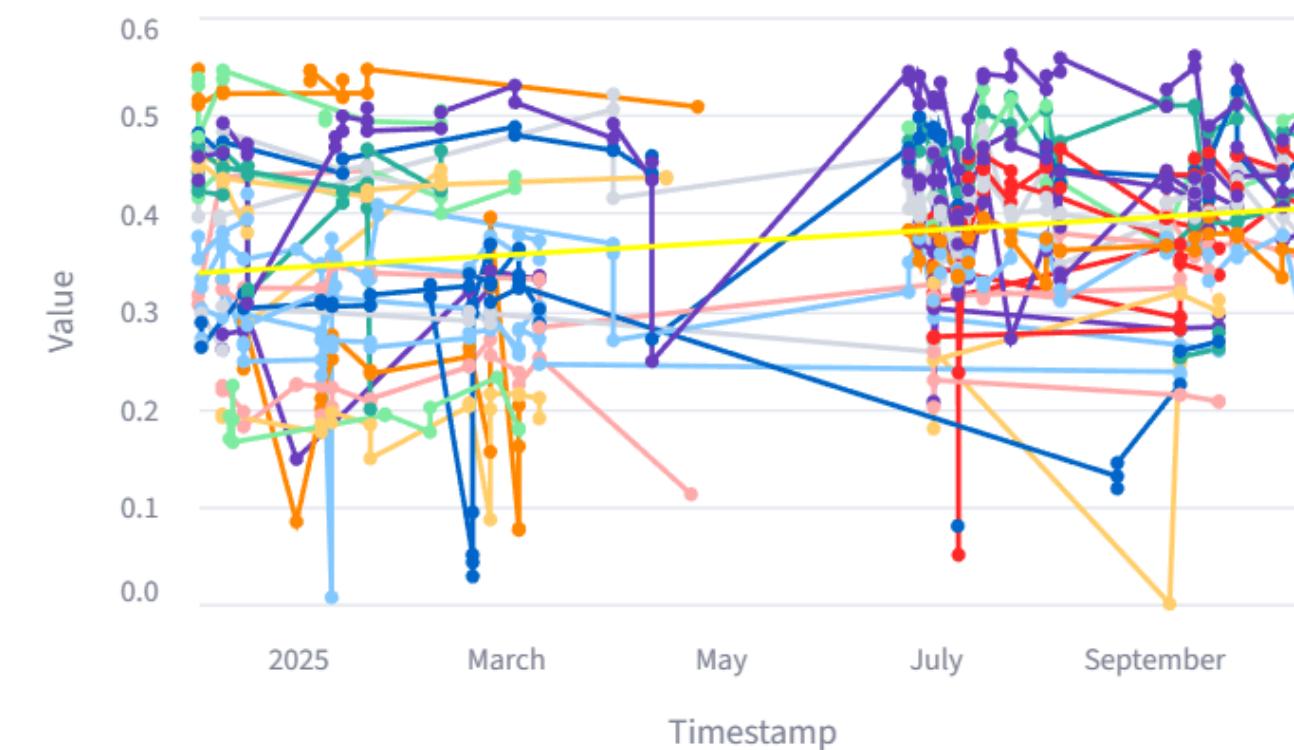
Speed_Max

TREND



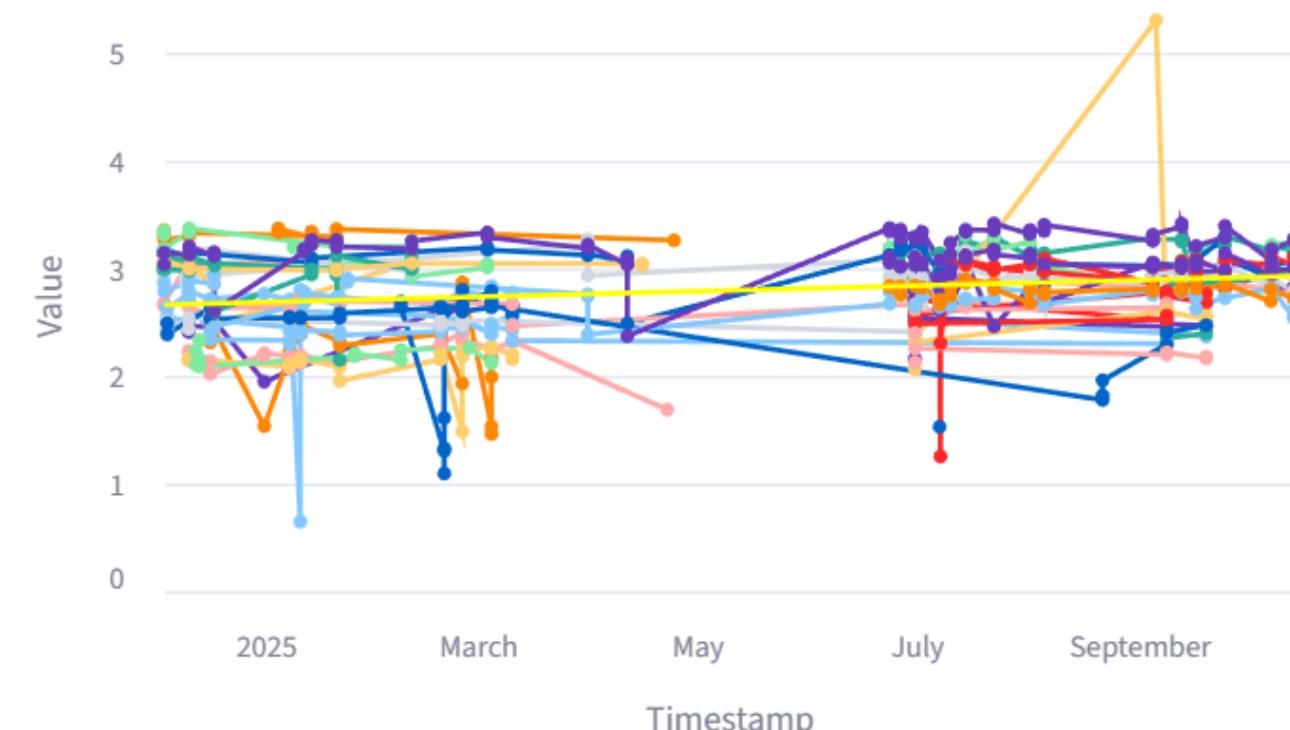
Jump Height(M)

TREND



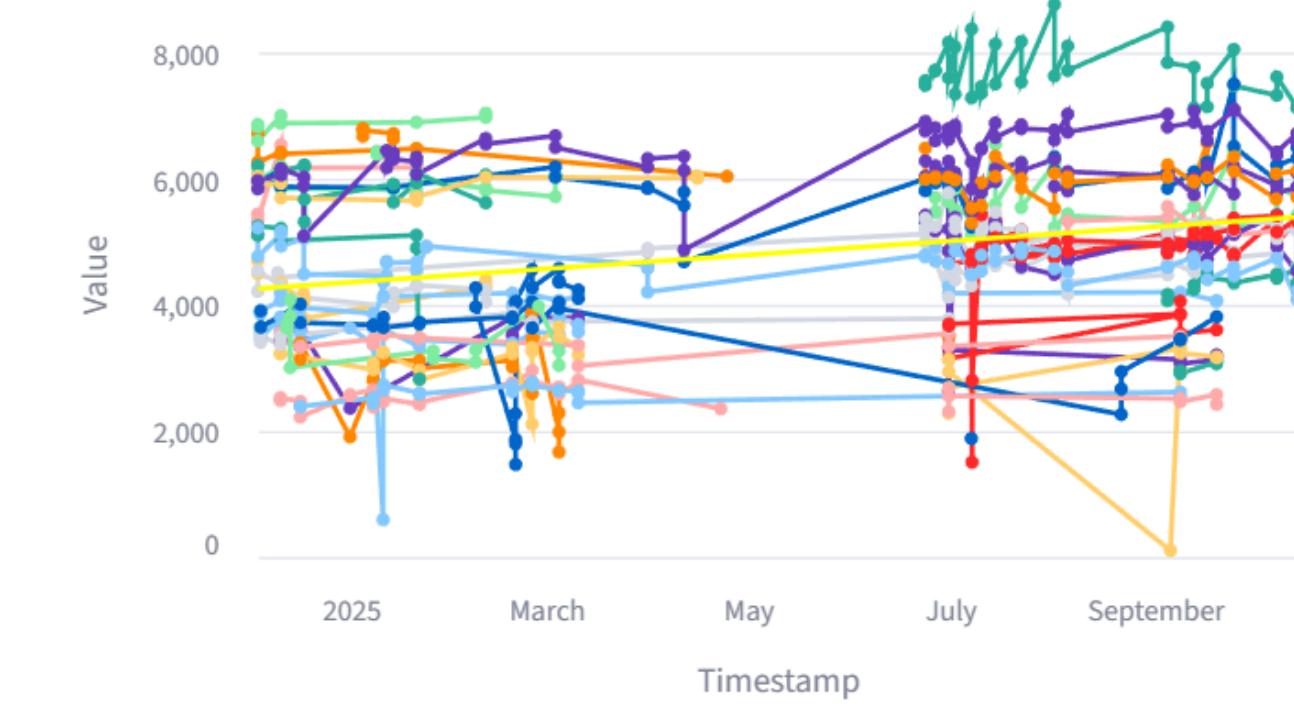
Peak Velocity(M/S)

TREND



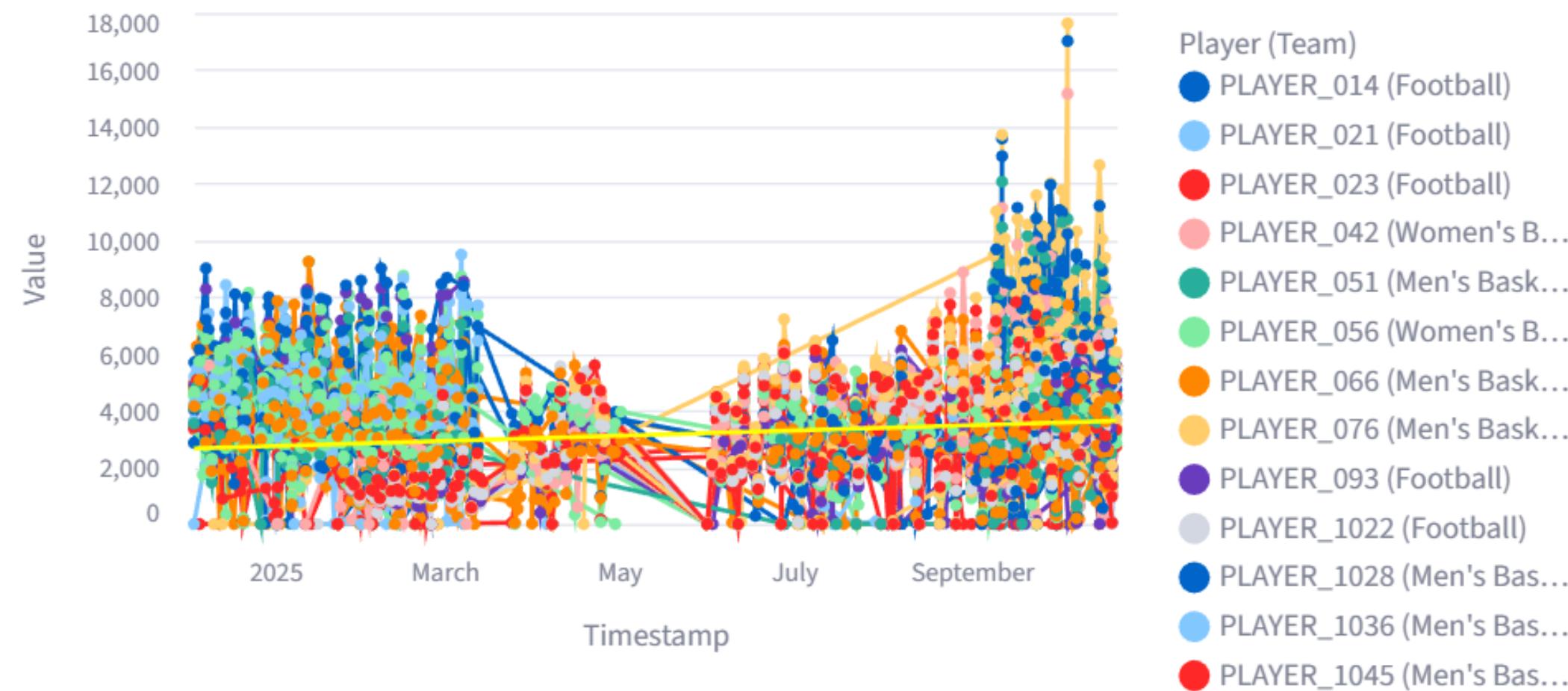
Peak Propulsive Power(W)

TREND



Distance_Total

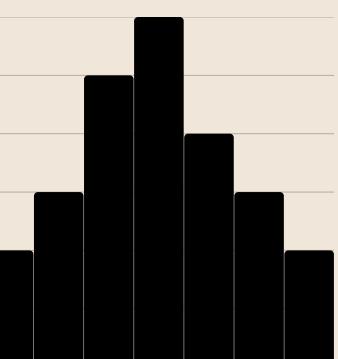
TREND



Practical Applications

Jaision

Metric	Device	Group/Team	Low	Normal	Peak	Flagging Logic	Flagging Interpretation
Jump Height (m)	Hawkins	Men's Basketball	<0.30	0.30–0.70	>0.70	↓ >10–15% decrease from baseline	Indicates neuromuscular fatigue or reduced explosive capacity
		Women's Basketball	<0.21	0.21–0.45	>0.45		
		Football	<0.30	0.30–0.55	>0.55		Recovery advised
Peak Propulsive Power (W)	Hawkins	Men's Basketball	<3500	3500–9000	>9000	↓ >5% decrease across consecutive sessions	Consistent drops suggests cumulative fatigue
		Women's Basketball	<2500	2500–7000	>7000		
		Football	<3000	3000–9000	>9000		or insufficient recovery
Peak Velocity (m/s)	Hawkins	Men's Basketball	<3.0	3.0–4.5	>4.5	↓ >5% decrease from baseline OR	Declines may indicate fatigue
		Women's Basketball	<2.5	2.5–4.0	>4.0	asymmetry >10% between limbs	Asymmetry flags potential injury risk
		Football	<3.0	3.0–4.5	>4.5		
Speed Max (m/s)	Kinexon	Men's Basketball	<4.0	4.0–7.5	>7.5	<90% of personal best sprint speed	Falling below the threshold suggests suboptimal readiness
		Women's Basketball	<3.5	3.5–7.5	>7.5		
		Football	<5.0	5.0–8.5	>8.5		Taper or recovery is needed.
Distance Total (m)	Kinexon	Men's Basketball	<4000	4000–7000	>7000	↑ >20% decrease above rolling 7-day average	Exceeding safe load progression
		Women's Basketball	<3500	3500–6000	>6000	(ACWR principle)	increases the risk of overtraining or injury
		Football	<8000	8000–11500	>11500		



The Analytical Framework: Defining Performance Metrics and Thresholds

Our analysis is grounded in established sports science literature. Performance is evaluated against team-specific thresholds, with alerts triggered by statistically significant deviations from baseline.

Jump Height (m)



Alert Logic

↓ >10–15% from baseline

Interpretation

Indicates neuromuscular fatigue or reduced explosive capacity

Peak Propulsive Power (W)



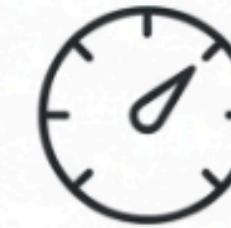
Alert Logic

↓ >5% across consecutive sessions

Interpretation

Suggests cumulative fatigue or insufficient recovery

Peak Velocity (m/s)



Alert Logic

↓ >5% from baseline

Interpretation

Declines may indicate fatigue; potential injury risk

Speed Max (m/s)



Alert Logic

<90% of personal best sprint speed

Interpretation

Suggests suboptimal readiness; taper or recovery is needed.

Distance Total (m)



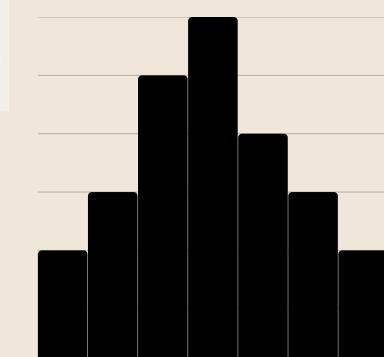
Alert Logic

↑ >20% above rolling 7-day average

Interpretation

Exceeding safe load progression increases risk of overtraining or injury.

Thresholds are specific to sport and gender (Men's/Women's Basketball) as detailed in the source literature.



Recommendations

“

1

Coaches can combine tests of rapid force and movement coordination to better **predict and improve performance.**⁽³⁾

2

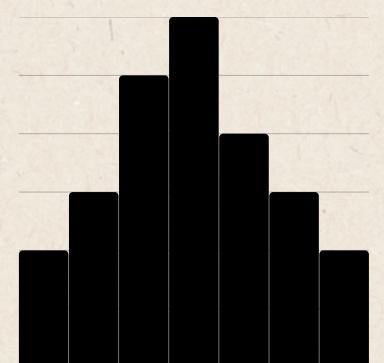
Correlations enable predictive models and game-readiness algorithms for performance prediction.⁽⁴⁻⁶⁾

3

Correlations help examine how empirical data supports **multi-domain metrics clustering** for performance assessment across sexes.⁽⁷⁻⁹⁾

4

Female athlete gap: 70.7% of studies focus on males, 8.8% on females.^(1,2)



Challenges & Future Work

Sid

Challenges

- Data Gaps
- Testing inconsistency > true baseline??
- Missing Positional Context
- Different metric sets & thresholds
- Our knowledge and data quality/accuracy

Future Work

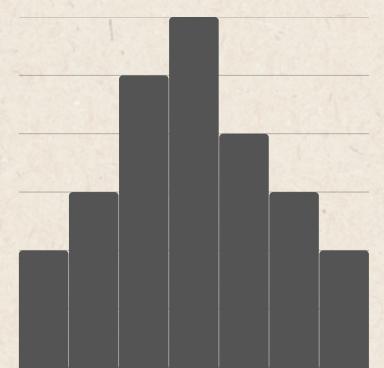
- Standardize key workload & performance thresholds
- Expand coverage of female athletes who remain underrepresented in many device-based studies



Outro

Technical
&
Organizational
Strategies

- | | |
|-----------|------------------------------|
| 01 | Big Picture |
| 02 | Research Question |
| 03 | Methods |
| 04 | Key Findings |
| 05 | Practical Applications |
| 06 | Limitations & Future Work |
| 07 | Conclusion |
| 08 | QnA ----->>> |



QnA

- | | |
|----|--------------------------|
| 01 | Why Basketball? |
| 02 | Most interesting metric? |
| 03 | Best takeaway? |
| 04 | What did not cover? |
| 05 | A data lesson? |
| 06 | Found new in Python? |
| 07 | Most weird finding? |
| 08 | Found new in Collab? |

