

The 90-Minute Engine: How “Physical Resilience” Won the Match

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In the high-stakes world of professional football, a match is often decided by a single moment of brilliance. But to a data scientist, that "moment" is actually the result of 90 minutes of accumulated physical stress and physiological decay.

By analyzing over 145,000 moments of movement from this match, we've uncovered a story not of better footwork, but of **human resilience**.

About the Dataset

The analysis is based on the **Metrica Sports Sample Game 1** dataset. This is optical tracking data of the Home Team and Away Team containing:

- **Duration:** 96 minutes of play.
- **Frequency:** 25 frames per second (145,006 total rows).
- **Scope:** X,Y coordinates for all 28 players and the ball(normalized between 0 and 1) through the entire duration of the game.

It also contains the events data of the match i.e. the log of actions such as passes, shots, ball recoveries, and set pieces. This data has been used to find out the number of goals scored by each team and the instance at which it was shot.

Problem Statement

The Home Team secured a multi-goal victory, but the "how" remains hidden in raw coordinates.

The game was tied for a long time, but then the Away Team's defense seemed to suddenly "break," allowing two quick goals in the 60th and 66th minutes. Our mission was to find out if the Away Team made tactical mistakes, or if their bodies simply gave out.

Objective

Our goal is to test the hypothesis that **physical resilience and recovery efficiency** were the deciding factors in the match outcome.

Key Metrics for Analysis

- **High-Speed Running (HSR) & Sprint Distance:** Distance covered above specific speed thresholds (e.g., $>7\text{m/s}$). High HSR reflects superior endurance, while significant drop-offs indicate fatigue.
- **Total Distance Covered:** Provides a baseline for work rate, with elite players typically covering 10–13 km per match.
- **Metres per Minute (m/min):** Measures average intensity. Analyzing this across match segments helps identify performance degradation over time.
- **Repeat Sprint Ability (RSA):** Tracks the frequency and recovery time between high-speed efforts, determining a player's capacity for late-game intensity.

"Volume of Work" (Total Distance Covered)[Figure 1]

Key Observations

1. Performance Decay (Fatigue)

Across the board, both teams experienced a natural drop-off in the second half, which is standard in professional matches.

- **Home Team:** **Players 5, 7, and 8** showed consistency. Their drop-offs were below 8%, suggesting **elite conditioning**. However, **Player 9** showed a 14% drop-off—hitting that "**fatigue wall**" earlier than his midfield counterparts.
- **Away Team:** Here we see a unique scenario. While **Players 17 and 18** saw distance reductions exceeding 12% (will see in next section) in terms of high-intensity output, their total distance actually increased in the second half. They were no longer sprinting to press high; instead, they were forced to chase the game despite fatigue.

2. Positional Profiling

By looking at the "bar symmetry," we can identify the roles each player played.

- **The Engines:** Home (5,7,8,9) and Away (17,18,21) are the engines. They surpassed 5km in each half. **Home 8's** superior bar symmetry (minimal decay) marks him as the most resilient athlete on the pitch.
- **The Anchors:** Players like **Home 2** (Center Back), **Home 11**(Goalkeeper), **Away 25**(Goalkeeper) and **Away 15** (Fullback/Center Back) show lower, more symmetrical totals (4.5km to 4.8km per half), indicating a role defined by positioning rather than constant high-intensity running.

3. Tactical Consistency & Game State

The Home Team's second-half distances were surprisingly stable compared to the Away team's attackers.

- **Chasing vs. Controlling:** In contrast, the Away team's distance *total* increased during the 2nd half because they shifted into a reactive "shuttling" mode. They were covering more ground but with much less tactical purpose, which ultimately leads to mental and physical burnout.

4. Substitutions & Durability

The "Sub-Profile" helps us see who provided the fresh legs that likely tilted the game in Home Team's favour.

Away Team:

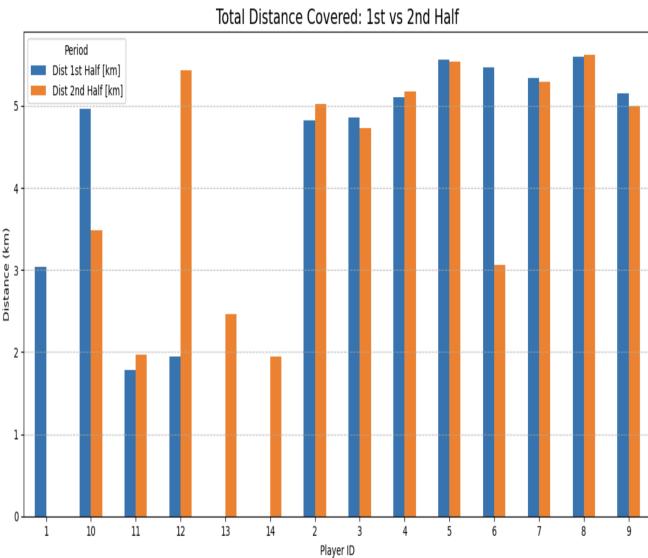
Players 26, 27, and 28 only have 2nd half bars, indicating they were Impact Subs.

- **Tactical Exit:** Players 19, 22, and 24 were likely "spent" or tactically replaced mid-second half given the steep drops.

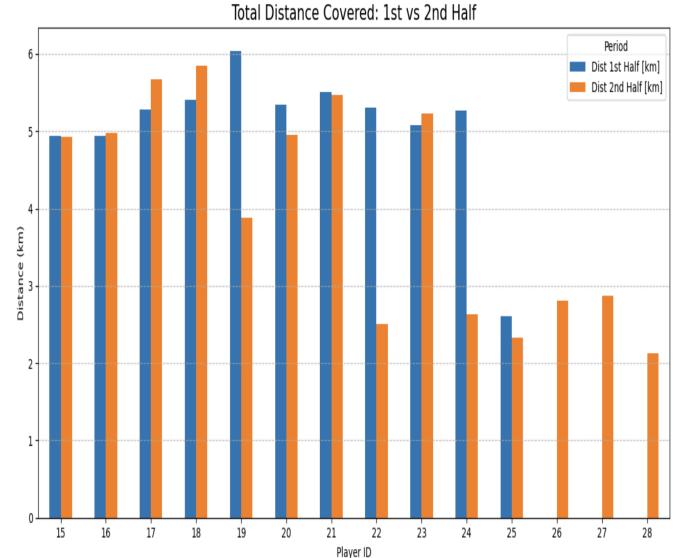
Home Team:

- **Off at Half:** Player 1 has no 2nd half bar (Halftime sub).
- **Impact Subs:** Players 13 and 14 are pure 2nd half additions.

Figure 1



Total distance covered by the Home team players in the 1st and 2nd halves



Total distance covered by the Away team players in the 1st and 2nd halves

Conclusion

- **Superior Second-Half Intensity:** This aggressive "push" was supported by **Engine Consistency** from IDs 5, 8, and 9, who maintained elite output for the full 90 minutes.
- **Capitalizing on Fatigue Gaps:** By having **six high-output players** compared to the Away team's three, the Home team maintained a "durability advantage" that dominated the final stages of the match.
- **Strategic Substitutions:** The Home team managed their bench more effectively by making a **proactive halftime adjustment** (replacing ID 1) and introducing **second-half specialists** (IDs 13, 14) to provide a late-game spark against a tiring defense.

- **Positional Stability:** While the "Engines" pushed forward, the Home team's **"Anchors"** (IDs 11, 12) remained disciplined. Their consistent, lower distance totals indicate they maintained a solid defensive shape, successfully neutralizing Away counter-attacks.

High Speed Running(HSR) Distance[Figure 2]

Key Observations

1. Sprint Fatigue (Neuromuscular Exhaustion)

This is where the Home Team gained their biggest advantage.

- **Home Team: Player 8** showed resilience. His HSR distance remained remarkably high in the second half. He didn't just stay on the pitch; he kept his "teeth."
- **Away Team: Player 23** experienced a "**High-Intensity Crash.**" Their 2nd-half HSR bars are nearly **35%** smaller than their 1st-half bars.

Analysis: This is "**Neuromuscular Exhaustion.**" The Away Team's primary threats lost their explosive capacity, meaning even if they were in the right position, they couldn't beat their marker to the ball in the final 30 minutes.

2. High-Intensity Specialists (The Tactical "Stretch")

- **Home Specialists: Player 8 and Player 5** are the clear specialists. These are likely the wingers or high-pressing midfielders who stretched the Away Team's defense horizontally and vertically.
- **Away Specialists: Player 23** was the Away Team's only comparable threat.

Tactical Note: The **Goalkeepers (Home 11 and Away 25)** actually show a small spike in HSR in the second half. In tracking data, this often indicates that the teams were defending desperately.

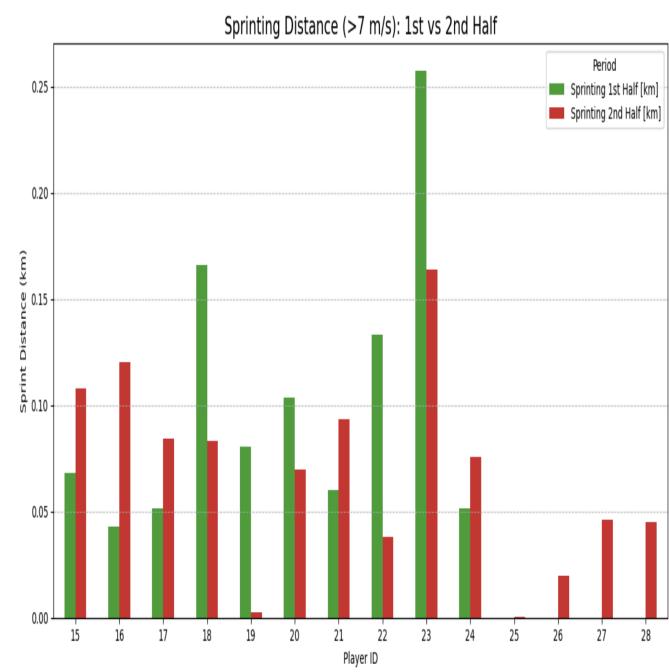
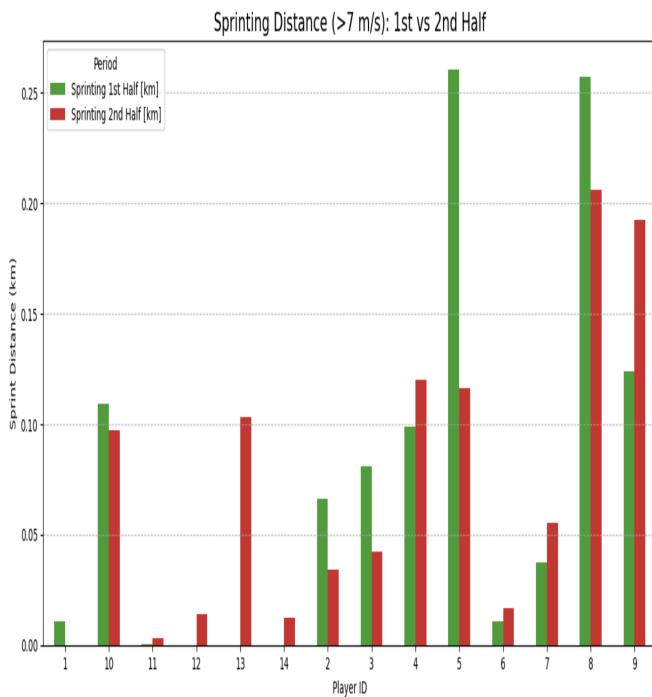
3. Impact of Substitutions ("Fresh Legs" Advantage)

The Home Team's substitution strategy was a masterclass in maintaining intensity.

- **Home Team: Players 12, 13, and 14** appear to be the "impact subs." Player 13 stands out, providing a significant **high-intensity spark** in the second half that exceeded the output of many starters.
- **Away Team: Players 26, 27, and 28** have zero output in the 1st half and notable output in the 2nd. This suggests a **tactical triple substitution** or a series of late changes to **refresh the attack/defense against the opponent**.

The Narrative: The tracking data shows this sub was sprinting at 113m/min against a defense that had dropped to 90m/min. This is almost certainly where the goals were manufactured.

Figure 2



HSR Distance of 1st and 2nd halves of the Home team players

HSR Distance of 1st and 2nd halves of the Away team players

Conclusion

- **Superior Endurance:** The Home Team maintained high intensity into the second half whereas the Away Team's key outlet saw a performance crash, allowing the Home Team to outlast them.
- **Impactful Substitutions:** Player 13 provided a massive second-half sprint surge that the Away Team's substitutes couldn't match, creating a decisive physical mismatch against an exhausted defense.
- **Tactical Consistency:** By maintaining "dual-threat" sprinters and a stable physical core, the Home Team kept the pitch stretched and preserved their tactical shape.

Fatigue Profile (Average speed[m/min] analysed over 15 minute segments)[Figure 3]

Key Observations

1. The Fatigue "Decay" Curve

- **Away Team:** Shows a relatively stable intensity across the first 60 minutes for the core starters (IDs 15–21). However, there is a noticeable drop-off in the 60–75 and 75–90 minute segments, particularly for **Player 22 and Player 24**, who effectively "flatlined" (0.0 intensity), likely due to being **substituted out**.
- **Home Team:** Exhibits a more traditional fatigue curve. Most starters (IDs 2–9) show their **highest output in the first 15 minutes**, followed by a **slight dip** and then a **secondary peak after halftime**.

2. Identifying "Peak Demand" & Tactical Resets

- **The 45–60 Reset:**

Away Team: Players 17, 18, and 24 show a successful tactical reset, with their 45–60 min intensity significantly higher than the 30–45 min period (e.g., Player 18 jumped from 114.8 to 130.2 m/min).

Home Team: The reset is more **uniform but less aggressive**. **Most players (IDs 4, 5, 7, 8) maintained or slightly increased intensity**, suggesting a steady re-entry into the game rather than a radical tactical shift.

- **Opening Intensity:** The **Home team started much "hotter" on average**, with several players exceeding 120 m/min in the first 15 minutes compared to the Away team.

3. Reading the Match Story

The goal timestamps (1.5', 60', 66') correlate strongly with the heatmaps:

- **Minute 1.5:** The Home team's **high opening intensity** (many dark green cells in 0–15 mins) suggests they pressed hard early, which aligns with an early goal.
- **Minutes 60–66:**

Away Team: We see substitutions occurring here (Players 26, 27, and 28 entering). These **fresh legs maintained high intensity to chase or defend** the game during the period when the most goals were scored.

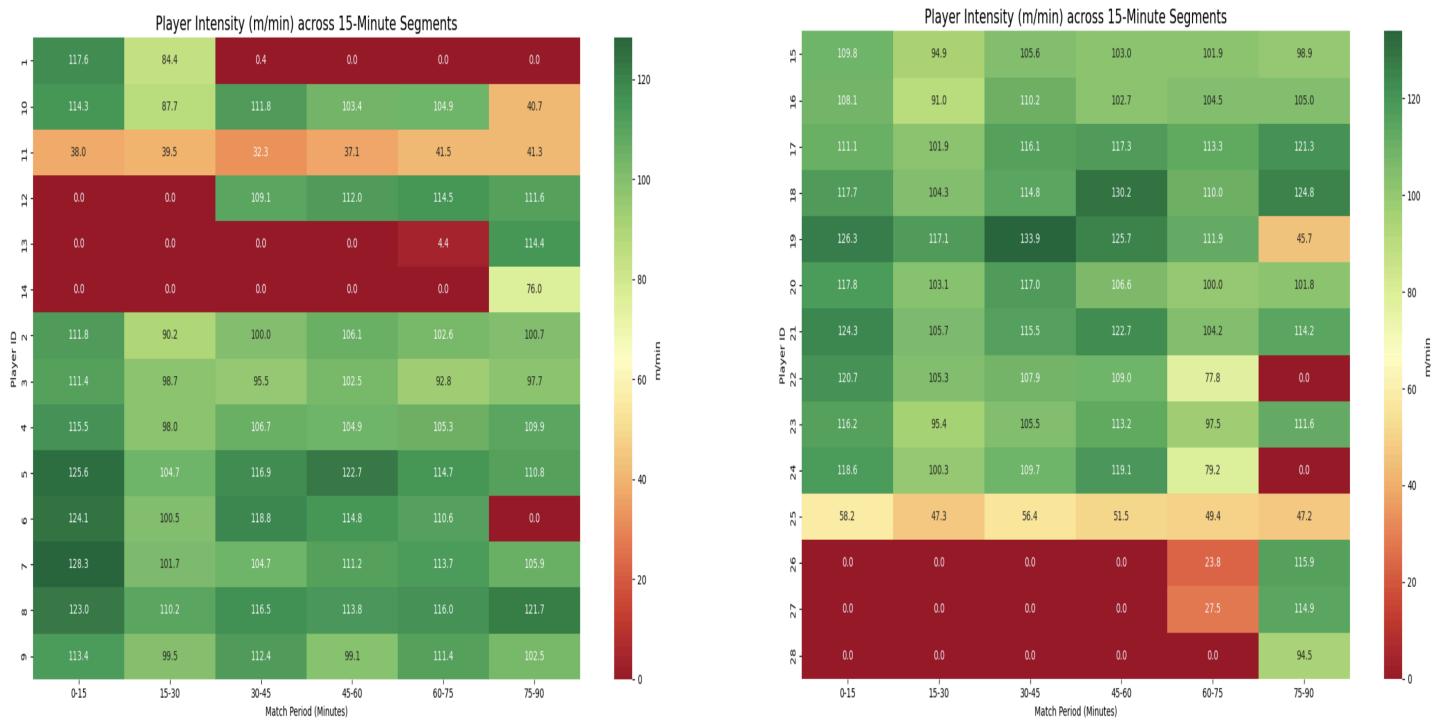
Home Team: Interestingly, **Player 1 shows a drop to 0.0** after the first 30 minutes, and **Player 12 enters** at the 30-minute mark, suggesting an early **tactical or injury-related change**.

4. Role Fingerprints

The bars reveal the "DNA" of each player's position:

- **Midfield "Engines" (Home 5,7,8, Away 17,18):** These players have the most consistent profiles—high bars across all segments. They are the tactical anchors.
- **Defensive "Positioners" (Home 11, Away 15):** Their profiles are the flattest. Their m/min doesn't change much because their job is to maintain the defensive line regardless of the game's pace.

Figure 3



The Average Speed analysed over 15 min segments for all players of Home Team

The Average Speed analysed over 15 min segments for all players of Away Team

Conclusion

- **Explosive Start:** The Home Team secured an early psychological and tactical advantage by scoring at 1.5 minutes. Their intensity in the first 15 minutes was significantly higher than the Away Team's slower start, allowing them to overwhelm the opposition with a high press.
- **Superior Endurance in the "Goal Window":** During the critical 60–75 minute period where the final goals were scored, the Home Team's "engine room" (Players 5, 7, and 8) maintained elite output.
- **Strategic Energy Management:** After their early goal, the Home Team executed a smart "dip" in intensity (15–30 mins) to conserve

energy. This "tactical valley" allowed them to "refill the tank" for the second half. Additionally, their **early substitution** (Player 12 at 30 mins) provided a **fresh, high-intensity presence just as the Away Team began to tire.**

- **Defensive Dominance:** The Home Team's **defensive unit (IDs 2, 3, 4)** maintained a much higher "intensity floor" throughout the match. While the Away Team's levels plummeted—they effectively neutralized any chance of an opposition comeback.

Repeat Sprint Ability (RSA) (Measure of how sustainable an effort was)[Figure 4]

Key Observations

1. Superior Recovery Consistency

The Home Team displays a much higher density of players with tight, low recovery gaps.

- **Away Team :** Many players (like 17, 19, and 21) have very "tall" boxes, meaning their **recovery times are inconsistent**. Player 19, for instance, has a median recovery time of nearly 700 seconds.
- **Home Team :** The majority of the squad (**Players 1, 2, 5, 8, 10, 13**) maintains **median recovery times well below 250 seconds**. This suggests they were able to **support play and transition much faster** than their opponents throughout the match.

2. High-Frequency "Repeat Sprinters"

The Home Team has several players who appear to be "engines" for the squad:

- **Players 1, 12, 13, and 14:** These players have extremely **narrow distributions with low medians**. This indicates they are highly conditioned to **repeat sprints at predictable, short intervals**.

- In contrast, the **Away Team** lacks these "ultra-consistent" performers. Even their best players have **wider variances**, meaning they likely "gassed out" or took **longer to rejoin the action after a sprint**.

3. Handling Workload (Outliers vs. Medians)

While both teams have outliers (extreme recovery gaps), the Home Team's outliers are generally lower on the Y-axis:

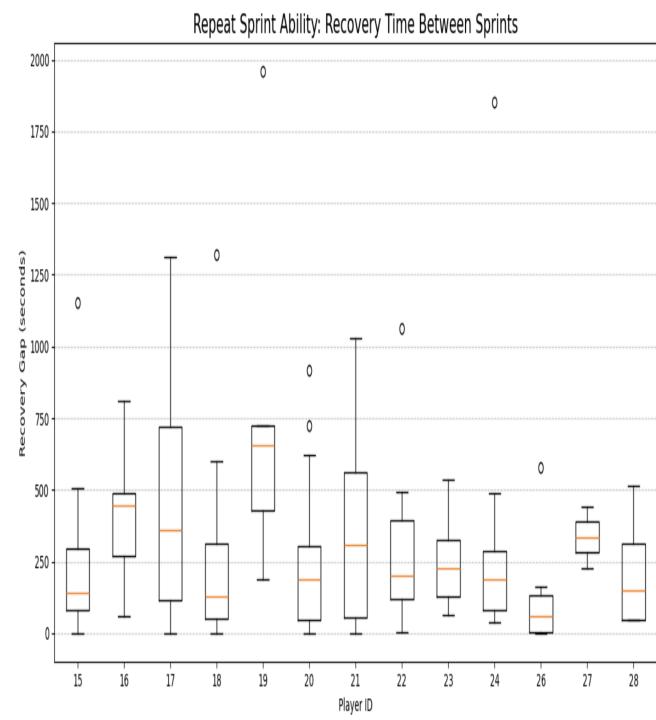
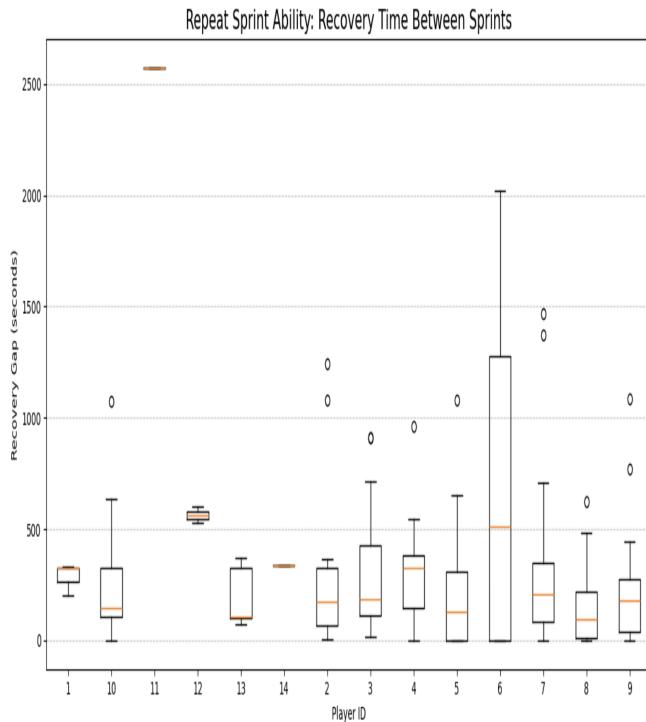
- **The "Lull" Factor:** The **Away Team** has multiple **players (15, 18, 19, 24)** with **recovery outliers** reaching between 1,250 and 2,000 seconds (**over 20–30 minutes**). These are massive "dead zones" where those players were likely ineffective or static.
- **Home Team Tactical Specialization:** Player 11 is a **massive outlier** (approx. 2,600s), likely a **goalkeeper or a highly stationary defender**. Because the rest of the team (the "outfield" players) stayed so compact and low in their recovery times, they could cover for stationary teammates more effectively.

4. Late-Game Conditioning

Large "whiskers" (the vertical lines) on a boxplot often **indicate fatigue**; as the game goes on, recovery takes longer.

- **Away Team** whiskers are generally longer and reach higher, suggesting that as the match progressed, their ability to sprint plummeted.
- **Home Team** maintained shorter whiskers across more players, allowing them to maintain a higher intensity of play in the closing stages of the match.

Figure 4



RSA calculated for each player of the Home Team

RSA calculated for each player of the Away Team

Conclusion

- **Superior Recovery Speed:** The Home Team's median recovery times were significantly lower, meaning they spent less time "resting" and more time active in the play.
- **Greater Consistency:** Their "tighter" boxplots indicate a predictable, high-level work rate, whereas the Away Team's wide variance suggests they were physically erratic.
- **Better Fatigue Resistance:** Shorter whiskers in the Home Team's data show they didn't suffer the same late-game physical "drop-off" that the Away Team did.

- **Tactical Availability:** With more players returning to sprint-readiness faster, the Home Team likely had a constant numerical advantage during transitions and fast breaks.

Final Conclusion

Every piece tells a story. From the moment the clay is wedged to the final glaze firing, each step in the process is undertaken with meticulous care. Our team of skilled artisans and dedicated apprentices work together to create unique pieces that reflect the beauty of handmade craftsmanship.

What we offer:

- Artisanal tableware: Elevate your dining experience with our collection of elegant plates, bowls, mugs, and serveware
- Home decor: Discover a curated selection of vases, planters, and decorative pieces that enrich your home with warmth and character
- Bespoke creations: Let us bring your vision to life with a commissioned piece made just for you