Integrated Athlete Monitoring Analysis

Force Plate, GPS Workload, and Strength Asymmetry

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Introduction

Research Question: How do neuromuscular performance, GPS-derived workload, and strength asymmetry interact over time, and can deviations from these metrics serve as indicators of readiness, fatigue, or undertraining?

Hypotheses:

- H1: Athletes who experience periods of high external load, particularly elevated acceleration load, will show short-term reductions in Jump Height and Peak Propulsive Power relative to their baseline values.
- H2: Athletes with higher MaxForce asymmetry will display greater variability in CMJ performance and may demonstrate different load–response patterns compared to their more symmetrical teammates.

The Gap

Although many teams collect force plate, GPS, and strength data, the literature shows:

- CMJ is useful for fatigue monitoring but often analyzed alone.
- GPS workload (especially accelerations) is strongly associated with neuromuscular stress but rarely paired with force-plate data.
- Strength asymmetry is studied in isolation and not connected to longitudinal workload or CMJ decline.

There is a clear gap: Teams rarely integrate all three systems into a unified readiness or monitoring framework. Our project directly addresses this gap.

Selected Metrics

1

Force Plate (Hawkins)

Jump Height (m)
Peak Propulsive Power (W)

2

GPS Workload (Kinexon)

Total Distance
Accumulated Acceleration Load

3

Strength (Vald)

MaxForce Left
MaxForce Right
Computes inter-limb asymmetry

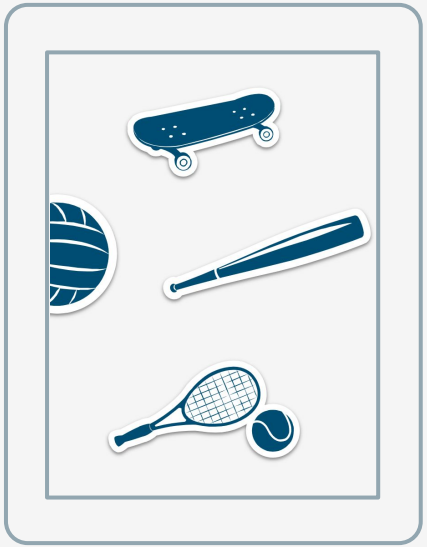
Methods

Data Cleaning

- Pulled from MySQL table `research_experiment_refactor_test`
- Removed rows with missing player/team/metric/value
- Standardized timestamps
- Retained original team labels for authenticity
- Long-format structure preserved
- Reflects real-world testing inconsistencies

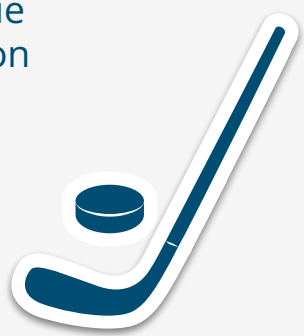
Analytical Approach

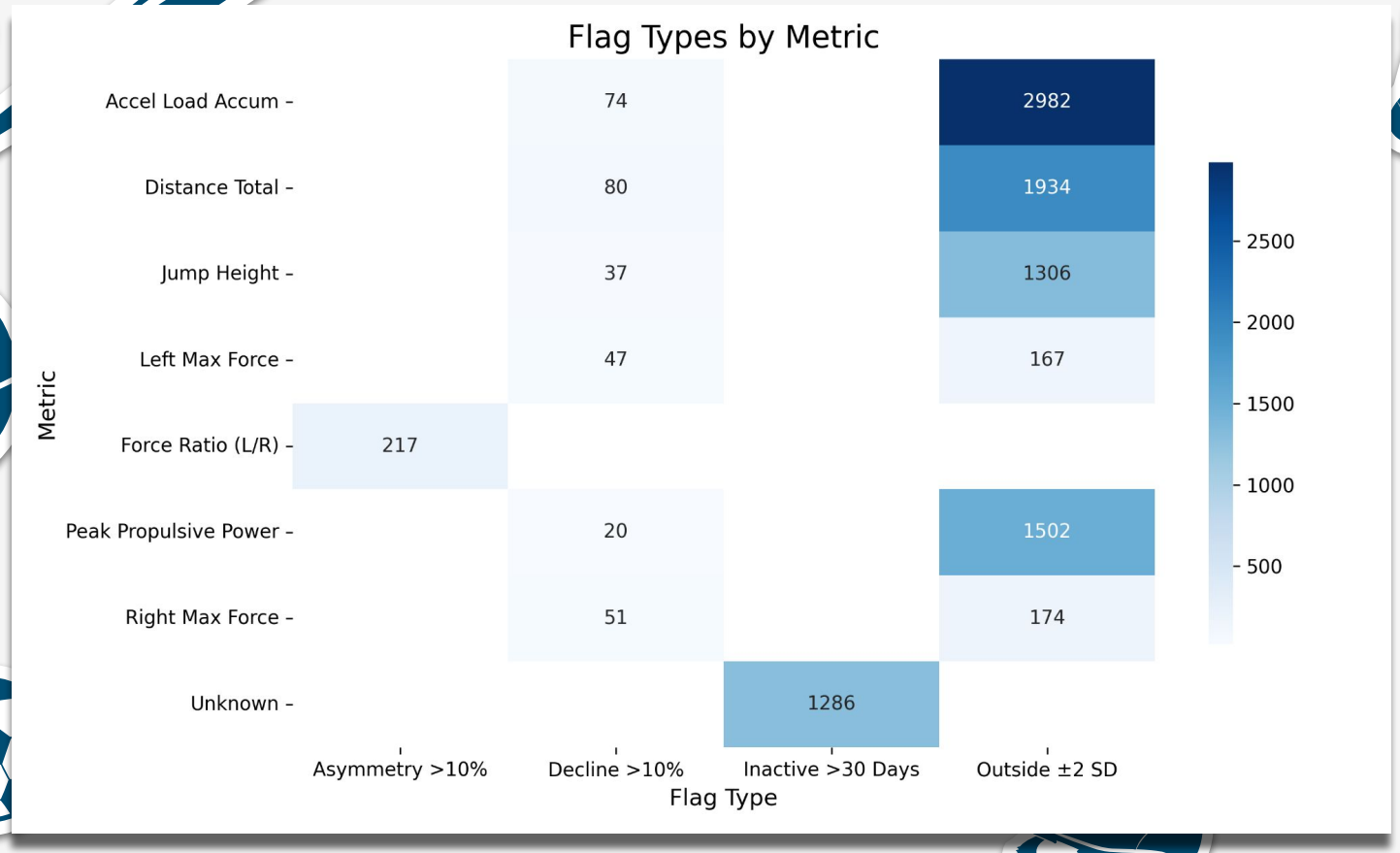
- Literature-based flagging thresholds:
  - Inactivity: >30 days without testing
  - Performance Decline: >10% below 3-test rolling mean
  - Team Deviations: ±2 SD from team mean
  - Asymmetry: >10% left–right difference
- Exported flagged results to part4_flagged_athletes.csv



Key Findings: Inactivity Flags

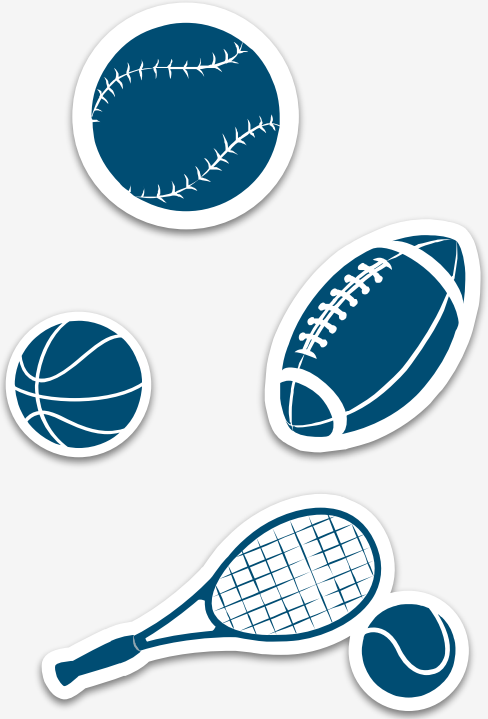
- 1,286 athletes flagged
- Most athletes had last data points from 2023 or earlier
- Consistent with Part 2 findings
- Inactivity helps detect:
  - Neuromuscular fatigue
  - workload accumulation
  - Strength asymmetry




Flag Types by Metric
Metric
Accel Load Accum
Distance Total
Jump Height
Left Max Force
Force Ratio (L/R)
Peak Propulsive Power
Right Max Force
Unknown
74
2982
80
1934
37
1306
47
167
217
20
1502
51
174
1286
2500
2000
1500
1000
500
Asymmetry >10%
Decline >10%
Inactive >30 Days
Outside ±2 SD
Flag Type

Comparison to Literature

- CMJ fatigue trends only appear with regular testing
  - (Gathercole et al., 2015; McMahon et al., 2018)
- GPS workloads require consistent session by session data to interpret meaningful data
  - (Bangsbo et al., 2006; Buchheit & Simpson, 2017)
- Strength asymmetry > 10% is repeatedly linked to higher injury risk
  - (Croisier et al., 2008)



Practical Applications (Flag System)

1. Inactivity flags identify training gaps
2. Asymmetry flags support injury-risk decisions
3. Decline/outlier flags guide load adjustments
4. Supports individualized training plans




Recommendation for Coaches

Monitor Key Metrics

This helps by showing specific datasets

Use Trend Watching

See improvements over time instead of one day

Flag Meaningful Declines

Helps catch and fix an issue before it becomes a problem

Compare Athletes to Team Norms

Use metrics to see where the athlete matches up against the while team

Use Testing Frequency to Improve Metrics

Ensure metrics are tested ever 2-3 weeks to avoid sudden problems

Connect Patterns to Actions

If jump declines week to week, decrease plyometric load

How Findings Fill In Gaps

Real World Data

Most Data is taken in labs. This is real world game data. That means that data shows natural fatigue and variations across multiple sports

Compare Metrics Across Different Sports

Much research isolates certain sports. Jump Height in Volleyball, Speed in track and field, etc. By putting multiple sports together, it shows how the same metrics manifest in different sports

Establish Team and Athlete Baselines

Scientific papers report group averages but coaches need to know about THEIR team. The finding fill in the gap by building individual baselines, team averages, percent differences, etc.

Limitations and Future Research

Limitations

1. Inconsistent Testing Frequencies
   a. Some athletes measures weekly, others a couple times
2. Missing or Sparse Data
   a. Null or Zero values limit statistical strength
3. Lack of Contextual Variables
   a. Doesn't show why metrics changed. Injury? Training Load?

Future Research

1. Standardize and Increase Testing Frequency
   a. Similar data collection times would help increase accuracy
2. Integrate contextual data
   a. Explains why metrics changed
3. Expand Beyond one Institution
   a. Comparison against other institutions would reveal universal vs contextual specific patterns

Any Questions?

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