“Put Me in Coach!”: An Analysis of Fatigue

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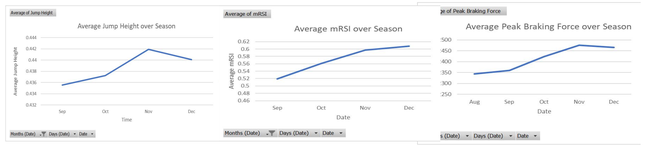
Introduction



Tartan Football Team: Division Three Athletics

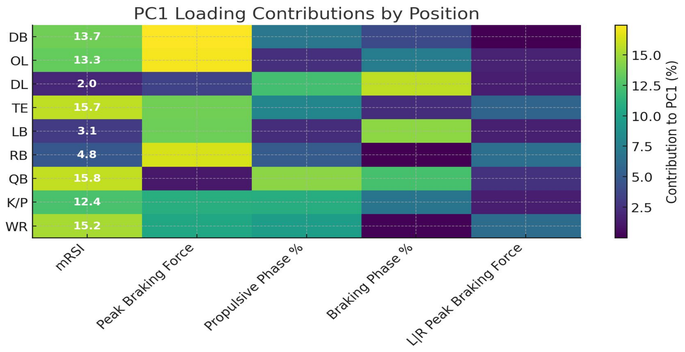
- Countermovement Jump across Football Season
- Joined Games Played, and Player Starter Data
- Positive Upward Trends across Key Variables

Research Question:

- How can a countermovement jump show fatigue across the season?

Data

- Dataset from CMU Football: weekly jump measurements (one row per jump, 2495 × 69)
- Supplemented with player starter info and game schedule data



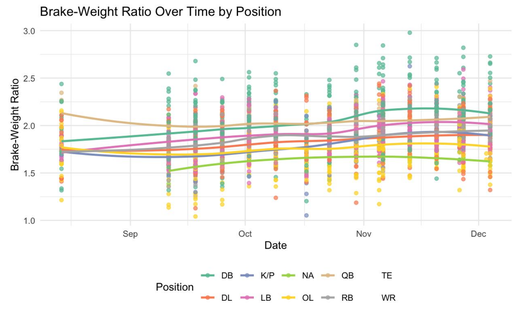
- **Goal**: Pinpoint a metric that distinguishes jumps from each other
- **Method**: Ran a separate PCA for every position (9 groups) and compared the top PC 1 loadings
- **Takeaway**: mRSI consistently tops PC 1 → fatigue indicator

$$\text{mRSI} = \frac{\text{Jump Height}}{\text{Ground Contact Time}}$$

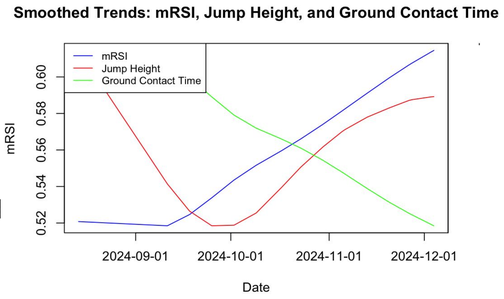
Methods

Two proposed heuristics for fatigue:

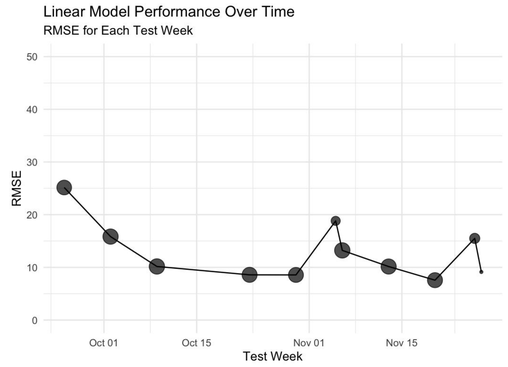
- **mRSI:**
  - A measurement of player elasticity.
- **Brake-Weight Ratio:**
  - Braking Force / Weight
    - Captures the force generated per Newton

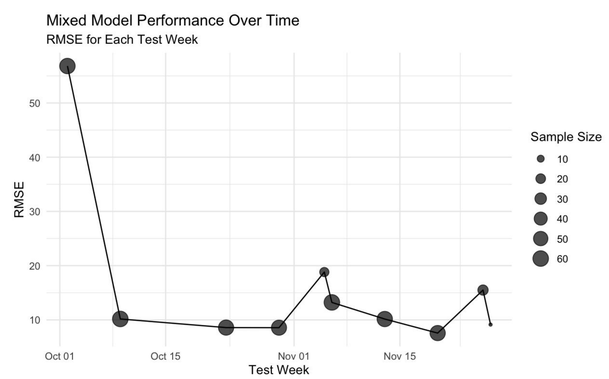


- **Left:** we see the **Brake-Weight ratio** by position over the season.
- **Right:** the **mRSI,** plotted with **Jump Height** and **Ground Contact Time**
- We ran a linear and mixed effect model of mRSI change, due to its relevance to football.



Results





A Linear Model? Or Mixed Effect?

- The mixed effect model revealed that variance attributed to differences between players was 0–effectively making it the same as a linear model.
- We see similar estimates from both (except for the first predicted week).
- We conclude a linear model is most appropriate for this analysis.

Model Formulae:

- $\text{mRSI\_Change} \sim \beta_0 + \beta_1 \times \text{Starter} + \beta_2 \times \text{Previous mRSI Change} + \beta_3 \times \text{Avg mRSI Change} + \epsilon$
- Included (1|athleteID) in the mixed effect model

Model Validation:

- We found that for the mixed model, variance contributed by individual athletes is **approximately 0.**
- Models had an RMSE that oscillates 10% for mRSI change.

Table 1: Model Summary

	Coefficient	SE	T Value	P Value
Intercept	5.1002694	0.6684992	7.629432	1.321954e-13
Previous mRSI Change	-0.2513011	0.0527382	-4.765068	2.520284e-06
Average mRSI Change	-0.4636757	0.1449031	-3.199903	1.467737e-03

- Linear model coefficients are above (equal to Mixed effect)
- Previous mRSI Change and Average (rolling) mRSI change were found to be statistically significant.

Conclusions

- **Quantifying Fatigue:** We were able to show, in accordance with current sports science knowledge, that mRSI is a relevant factor in quantifying fatigue.
- **Training Validation:** Players biometric trends indicate gradual improvement in fatigue over the course of the season. Our client noted this was intended.
- **Player Differences:** Models indicate little random effect between players. Data collected during practice (heart rate monitors, etc.) and snap counts could be used for further analysis

References

- Strength and Conditioning Staff of the Tartan Football Team
- Carnegie Mellon Sports Analytics Center
- Department of Statistics and Data Science
- Jiang, Y., Hernandez, V., Venture, G., Kulić, D., & K Chen, B. (2021). A Data-Driven Approach to Predict Fatigue in Exercise Based on Motion Data from Wearable Sensors or Force Plate. *Sensors (Basel, Switzerland)*, *21*(4), 1499.