Tracking the Intangible: Quantifying Effort in NFL Running Backs

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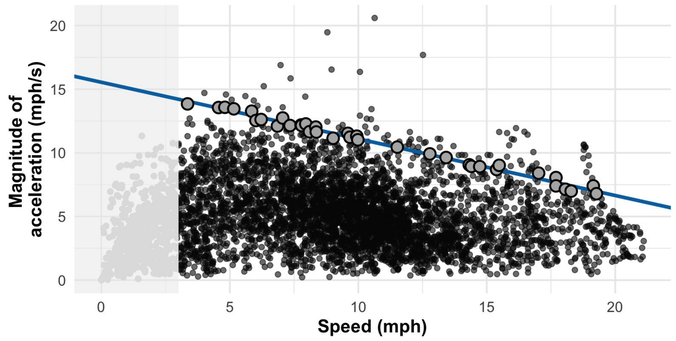
Background

Motivation:
- Effort is a crucial—but intangible and subjective—aspect of sports
- Currently, there is no objective measure of effort in the NFL

Initial approach:
- Adapted from prior work on soccer players[1]: estimate running backs' (RBs') individual theoretical maximal acceleration capacities for each possible running speed

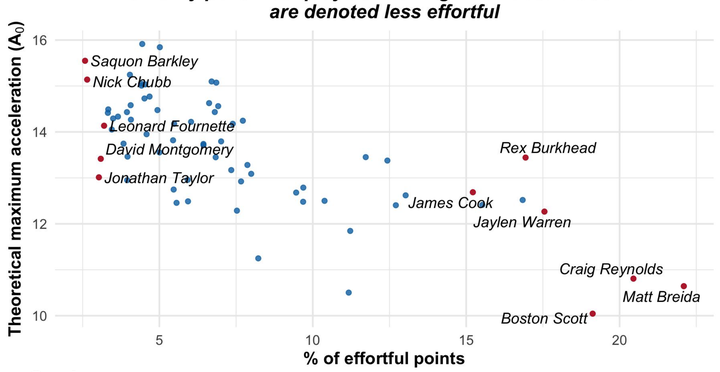
We consider points close to and above a player's maximum acceleration frontier effortful

Acceleration-Speed (A-S) profile for Saquon Barkley



- But this has limitations:
  - Gives no credit to low speed points
  - Estimates unrealistic theoretical max speeds
  - Players are penalized for being athletic *(see figure below)*
  - Does not differentiate between acceleration and deceleration

Unfairly penalized: players with high max accelerations are denoted less effortful



Goals:
- **Improve upon each player's individual max acceleration frontier using statistical models**
- **Assess how often each player comes close to or exceeds their max acceleration frontier as a proxy for effort**

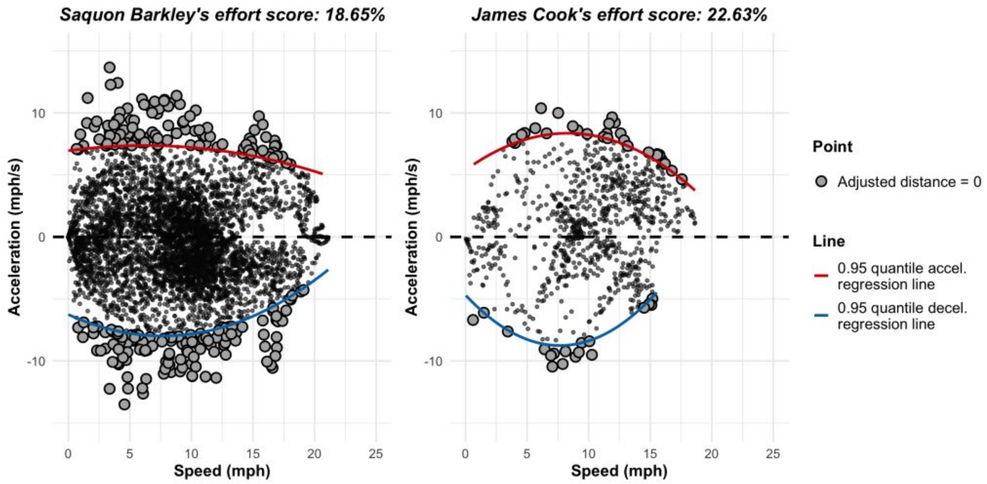
Data

- NFL Big Data Bowl 2025, weeks 1-9 of 2022 NFL season
  - Game, play, player data → 136 games
  - Player tracking data → each observation is a frame in 10 fps
- Pre-processing
  - Filtered running plays in which a RB is the ball carrier
  - Restricted to RBs with at least 20 runs → 69 RBs

Methods

For every RB, examine the joint distribution of frame-level speed and acceleration.
We define two approaches to evaluate effort as follows:

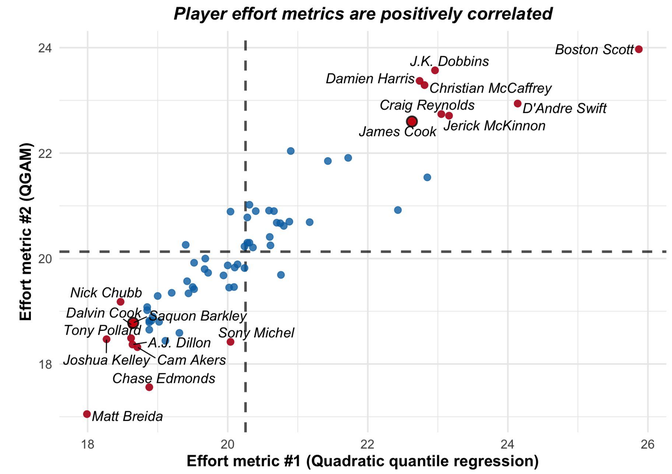
Metric #1:
- Fit two **quadratic quantile regressions** to estimate 0.95 quantiles of acceleration and deceleration, respectively, as functions of speed
- Compute vertical distance d_i from each point to its corresponding regression line, based on the sign of acceleration
- For points outside the regression lines, set $d_i = 0$
- Assign each point a "distance score": $\Psi = \begin{cases} \frac{1}{1+d_i} & \text{accel.} \geq 0 \\ \frac{1}{2} \cdot \frac{1}{1+d_i} & \text{accel.} < 0 \end{cases}$
  - *Note: points with negative acceleration are penalized by a factor of 0.5, as deceleration is deemed less effortful than acceleration[2]*
- Compute average frame-level effort: $\frac{\sum_{i=1}^{n} \Psi}{n}$



Metric #2:
- Fit two **quantile generalized additive models (QGAM)** with adaptive spline bases to 0.95 quantiles of acceleration and deceleration, respectively, as functions of speed
- Compute average frame-level effort in the same manner as for Metric #1 *(see above)*

Results

Player effort metrics are positively correlated



- **Back-up RBs consistently lead in both effort metrics**
  - Make the most of their limited opportunities
  - Play fewer snaps → less fatigued
  - Starters might simply have more innate talent or ability → do not have to exert as much "effort" on every play

Effort metrics do not show a strong correlation with play outcomes

Mean acceleration and speed per play included for reference

EFFORT METRIC TYPE	YARDS GAINED AFTER CONTACT	EXPECTED POINTS ADDED	RUSHING YARDS
QGAM	-0.081	-0.103	-0.079
Quadratic	-0.086	-0.097	-0.083
Mean Acceleration	-0.070	-0.026	-0.049
Mean Speed	0.377	0.446	0.523

Discussion

Conclusion
- A–S-based effort alone does not explain performance
  - A RB's ability to consistently reach and exceed their max acceleration frontier does not directly translate into successful play outcomes

Limitations:
- Model does not fully account for in-play context
- Individualized A-S curves hold players to different standards → limits cross-player comparison

Future work:
- Apply effort metric to wide receivers
- Develop effort definition and metric tied to performance

References

[1] Morin, J., Mat, Y. L., Osgnach, C., Barnabò, A., Pilati, A., Samozino, P., & Di Prampero, P. E. (n.d.). Individual acceleration-speed profile in-situ: A proof of concept in professional football players. Journal of Biomechanics, 123, 110524. https://doi.org/10.1016/j.jbiomech.2021.110524

[2] Hader, K., Mendez-Villanueva, A., Palazzi, D., Ahmaidi, S., & Buchheit, M. (2016). Metabolic Power Requirement of Change of Direction Speed in Young Soccer Players: Not All Is What It Seems. PloS one, 11(3), e0149839. https://doi.org/10.1371/journal.pone.0149839

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