STATS 011: “Drained or Just Tired – Effects of Consecutive Minutes Played on Free Throw Accuracy”

(note - for those who don’t follow basketball: the word “drained” can refer both to “being tired” or it can refer to “making a shot in basketball”)

Eli Young, Jack Bayanmunkh, Ravi Naidu, Armaan Sheik

Introduction

The past thirty years or so have seen a large increase in the importance of quantitative analysis in the world of sports. Our goal was to bridge a gap in the publicly available quantitative analysis about the NBA. It may seem intuitive that fatigue negatively impacts a player's performance, particularly in high-stress situations like free throws, we aimed to test this assumption empirically. In this project, we aimed to take a quantitative look at the effects of consecutive minutes played on free throw accuracy in the NBA.

Research Question

Does playing consecutive minutes in a game negatively affect a player's free throw accuracy in the NBA?

Hypothesis

As a player’s time in game increases, their free throw percent (or FT%) is predicted to decrease.

Method

Data Description

Using play-by-play data dating back to 1996 stored on Basketball Reference’s website, we were able to analyze all free throws attempted in that duration in the context of how many consecutive minutes the shooter had played at the time of the attempt.

- We analyzed data from 27 NBA seasons (1996–2024), tracking free throws attempted during players’ first continuous stretches of playing time in each game.

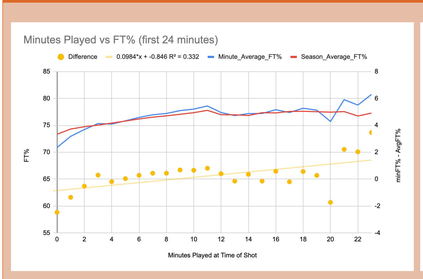
Using Python's basketball_reference_web_scraper API by Jae Bradley

- We processed play-by-play data to calculate each player’s elapsed playing time in seconds, later converted to minutes. Free throws at each minute mark were tracked, and shooting percentages were calculated.

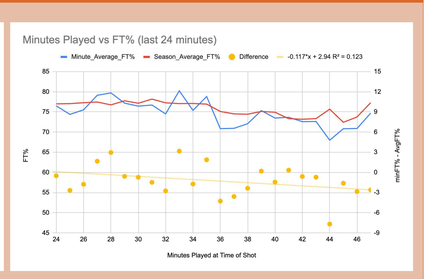
Statistical Analysis:

Linear regression was used to evaluate the relationship between the difference in FT% at a given minute and the player’s season average FT%. This approach controlled for variation in FT% due to player skill rather than playing time. Each minute had a sufficiently large sample size, with the smallest minute totaling 332 attempts. We split our analyses between the first 24 cumulative minutes in game and the second 24 cumulative minutes in game, since players can rest at halftime (24 minutes in). Statistical calculations, including p-values and confidence intervals, were performed using R, while graphs were created in Google Sheets. (note: all FT%s are scaled by a factor of 100 [e.g. 1% becomes 1, 100% becomes 100])

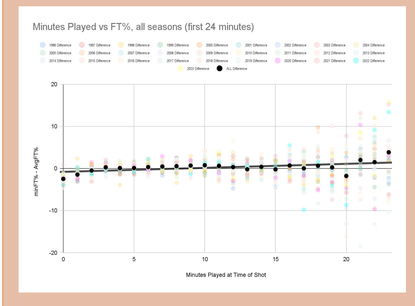
Figures



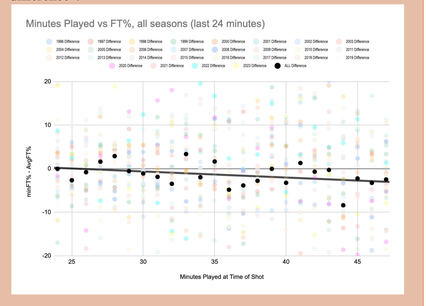
This graph compares the “Minutes Played at Time of Shot” (when the number of minutes played was between 0 and 24) to the FT% at that minute, the season FT% for the players who shot at that minute, and the difference between those two values.
Running a linear regression on that difference yields a trendline of 0.0984 * (minutes played at time of shot) -0.846, indicating that for the first 24 minutes a player is playing, their free throw % increases over time. The slope is 0.0984, 95% CI [0.0366, 0.1601]. The R^2 value is 0.332, and the p-value is 0.003234. At a $\alpha = 5\%$ significance level, we can reject H_0, meaning that we believe there is some relationship between “minutes played” and “difference” where the slope $\neq 0$.



This graph compares the “Minutes Played at Time of Shot” (when the number of minutes played was between 24 and 48) to the % of free throws made at that minute, the average free throw % for the players who shot at that point, and the difference between the % made at that minute and the average free throw % for those players.
Running a linear regression on that difference yields a trendline of -0.117 * (minutes played at time of shot) + 2.94, While this suggests a decline in free throw percentage as playing time increases, the R^2 value is 0.1232, and the p-value is 0.09261. The slope is -0.117, 95% CI [-0.2559, 0.0211], meaning the confidence interval for the slope includes 0. At a $\alpha = 5\%$ significance level, we cannot reject H_0, meaning that we cannot conclude there is some relationship between “minutes played” and “free throw % difference”.



This graph compares the “Minutes Played at Time of Shot” (when the number of minutes played was between 24 and 48) to the difference between the % of free throws % made at that minute and the average free throw % for those same players. The black points and trendline reflect the combined data for all seasons 1996-2023, while the other points reflect the “difference” at those minutes in each individual season.



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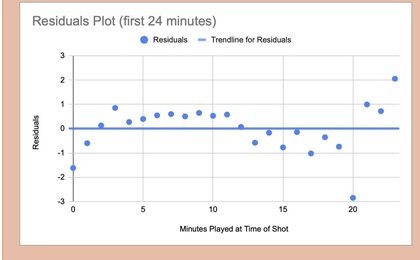
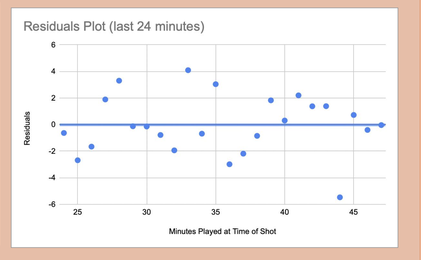


This is the residuals plot comparing “Minutes Played at Time of Shot” (when the number of minutes played was between 24 and 48) vs the observed “Difference” minus the expected “Difference” from the trendline. These residuals have no discernible pattern, indicating that a linear regression is the right choice.



This is the residuals plot comparing “Minutes Played at Time of Shot” (when the number of minutes played was between 0 and 24) vs the observed “Difference” minus the expected “Difference” from the trendline. These residuals have no discernible pattern, indicating that a linear regression is the right choice.

Discussion

Our initial hypothesis—that increased playing time would decrease free throw accuracy—was not supported.

In fact, during the first 24 minutes of play, free throw accuracy increased slightly over time (slope = 0.0984, 95% CI [0.0366, 0.1601], $p < 0.05$). This unexpected result could be attributed to players “warming up” or performing better under higher pressure as games progress. However, the effect size is minimal, with each additional minute increasing accuracy by roughly 0.1%.

For free throws attempted between 24–48 minutes of play, accuracy showed a slight decline (slope = -0.1232, 95% CI [-0.2559, 0.0211]), but this result was not statistically significant ($p = 0.09$). Thus, we cannot conclude that fatigue reduces accuracy in this time frame.

Limitations:

Our findings are constrained by smaller sample sizes for larger playtime values, as few players remain in the game for extended periods. Additionally, our dataset exclusively examines NBA players, limiting its generalizability to other levels of basketball.

Conclusions:

The effect of cumulative playing time on free throw accuracy in the NBA is minimal. However, the slight increase in accuracy during the first 24 minutes is significant, though not impactful in practical terms. Future research could explore this relationship in amateur players or under different game conditions, such as longer games. Given the limited correlation we found, it may be difficult to extrapolate our data to larger questions of muscle memory tasks under stress, as we had hoped to originally. However, it may simply be the case that muscle memory ensures that free throw accuracy doesn’t change, or that cumulative playing times under a certain time are not enough to cause significant fatigue.

References

Sports Reference LLC. (1996–2024). *Sports Reference LLC: NBA, NHL, and MLB statistics* [Data set]. https://www.sports-reference.com

Acknowledgements

We thank Professor Pat Devlin for his knowledge and guidance; without him, this project would not be possible. We also thank Jae Bradley for developing the basketball-reference scraper we used to collect our data.