Measuring Performance Peaks in Sports
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INTRODUCTION

Each sport has an age range in which athletes perform at their highest levels. Many variables may affect performance, but the main purpose of this research was simply to estimate and compare age ranges for peak performance for Major League Baseball (MLB), the National Basketball Association (NBA), and the Professional Golf Association (PGA). Two research questions are addressed:

1. **Are there differences in age peak performance among the three sports?**

2. **What can be said about the length in years of "near-peak" performance?**

PERFORMANCE MEASUREMENTS

In order to compare the sports peak performance ages, we identified a statistic for each sport that seems to adequately measure success:

- **Baseball**: Wins Above Replacement (WAR) estimates how much better (or worse) a player is as compared to the average "replacement" player. Several formulas for this statistic exist; the baseball-reference.com formulation was used in part for ease of data collection.

- **Basketball**: Game Score (GS) was developed by a statistician named John Hollinger in the 1990s. His formula encompasses many commonly recorded basketball game statistics such as points scored, blocks, assists, etc.:

$$GS = Points + Steals - Turnovers + 0.7(OREB + AST + BLK - FGA) + 0.4(FGM + FTM - FRA - PF) + 0.3(DREB)$$

- **Golf**: Cuts Made (CM)‡: When a player makes the cut in a tournament, they proceed deeper into the tournament, thus having greater success in that specific tournament.

Data used in the analyses were obtained from the following sources:

- http://www.baseball-reference.com/
- http://baseball1.com/
- http://www.basketball-reference.com/
- http://databasegolf.com/

‡ Other measures may be preferred here; however available recorded data for golf proved difficult to locate.

METHODS AND RESULTS

In data collection, we must avoid selection bias that may come from two sources:

- Players that are either quite young or quite old compared to most others in their sport. Such players are overly likely to be among the very best (which would result in over-estimation of "average" performance for all players of that age).

- Players who are missing several seasons within a typical player-career. Such players are more likely NOT to be among the best (resulting in under-estimation).

To avoid these issues, inclusion criteria from the following table were applied in sampling:

Sport	Inclusion Criteria	
	Age Range	**Minimum Number of Seasons**
Baseball	23 – 33	7
Basketball	22 – 35	10
Golf	26 – 39	12

Analysis of Variance with Tukey adjusted multiple comparisons was used to identify age ranges of peak performance for each sport. Our repeated measures model also adjusted for player-to-player variability. The blue bars in the graphs below represent intervals for which significant differences in average performance level were not found.

Baseball: WAR for Hitters

Basketball: Game Score

Baseball: WAR for Pitchers

Golf: Cuts Made
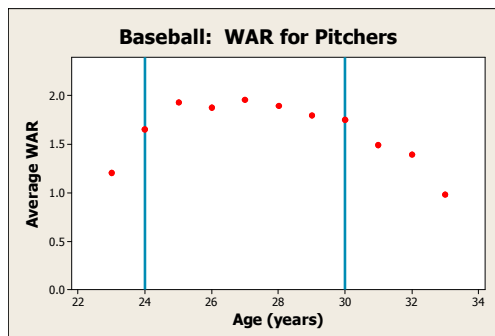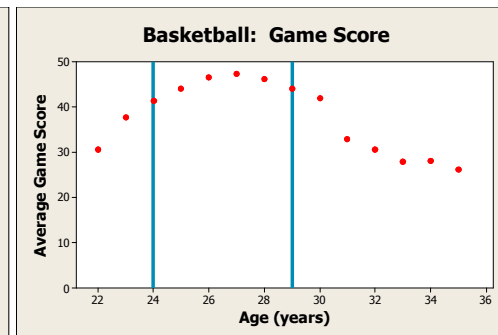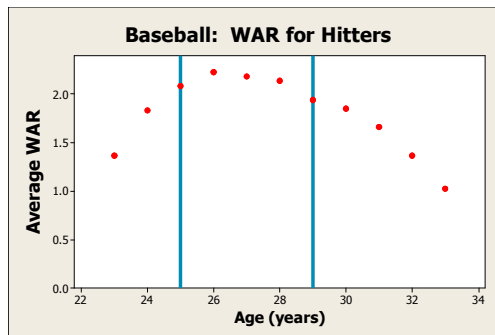
CONCLUSIONS

Several general findings result from our analyses:

- Within baseball, hitters and pitchers appear to have similar ages of peak performance.

- Baseball appears very similar to basketball, with peak performance levels occurring around 26 or 27 years of age.

- Baseball and basketball also appear to have a similar window of near-peak performance ranging about 6 years in length.

- Unfortunately there was not enough discrimination within the golf data to obtain a precise estimate of age of peak performance. Lack of statistical significance may be in part due to small sample size; there is also the possibility that the decline in performance in golf is not as sharp as in other sports.

FUTURE WORK

Future study of the implications of age for athletes might include some of the following questions:

- Additional sports may be studied and compared.

- In addition to hitters and pitchers having similar peaks – is it plausible that the performance curves for their entire careers are similar?

- Can we connect physical requirements of the sports themselves with the age of peak performance? The inclusion of football might be interesting here.

- Are there other variables that might better measure performance in golf? Wins are the indicator of greatest success, yet this measure is too draconian as it will not discriminate well among players. We suggest some measure of success that uses tournament rankings – perhaps based on the percentage of the purse won for each event.

- Can individual data be used to identify athletes who significantly deviate from general lifetime models? Detection of PED use?