Why do games take so long?

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Game length has been a common topic in the baseball media for several years and many have noted increasing game time over some short interval of a few years. Various explanations have been offered and different aspects of the game emphasized depending on who is doing the analysis. I decided to take a long view to examine many years to look for patterns and trends that can be measured quantitatively. The data for this study come from Retrosheet of course and here is a summary of what I had available.

183,224 Games

108 Seasons:
1908 to 2017 minus 1918 and 1919

The exclusion of 1918 and 1919 reflects the unavailability of time of game for those two seasons. I checked several newspaper sources to no avail. This coincides with the demise of the Sporting Life weekly newspaper and the monopoly that resulted for The Sporting News beginning in 1918. The Sporting Life reported time of game faithfully, but The Sporting News did not fill this need until 1920 although it was useful thereafter. Most of my analysis will have those two seasons omitted.

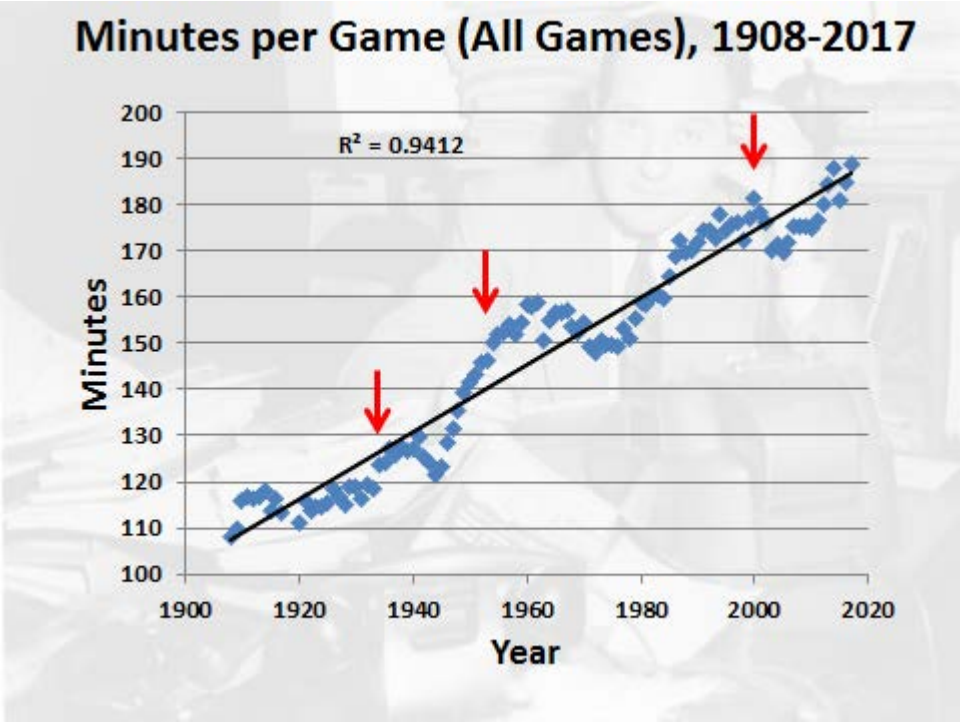
In order to make fair comparisons, it is necessary to remove extra inning games since they would naturally be expected to take longer and skew the overall average. Games that ended early due to rain, curfew, or the like were also removed. The remainder can be termed "regulation-length" games and they are divided by whether or not the home team bats in the bottom of the 9th. The home team wins about 54% of these regulation-length games.

Regulation-length Games

	Games	Percentage of total games
8.5	80968	44.3
9.0	83516	45.7
All Regulation-length	164484	90.0

How has the length of the average game changed? Figure 1 shows the data from 1908-2017, excluding 1918 and 1919, but including the extra innings games this time to see the extreme values.

Figure 1. Average minutes for all games, 1908-2017



There have been the expected annual variations and periods of rise as well as decline. However, when a linear regression is performed to determine the best fit line, the result shows an extremely strong direct relationship with the R^2 value indicating that 94% of the variance in the game length is accounted for by the passage of the years. Highlights along this 110 year trip are here.

Landmarks in game length

First year with average of over two hours
1934 (123.6 minutes)

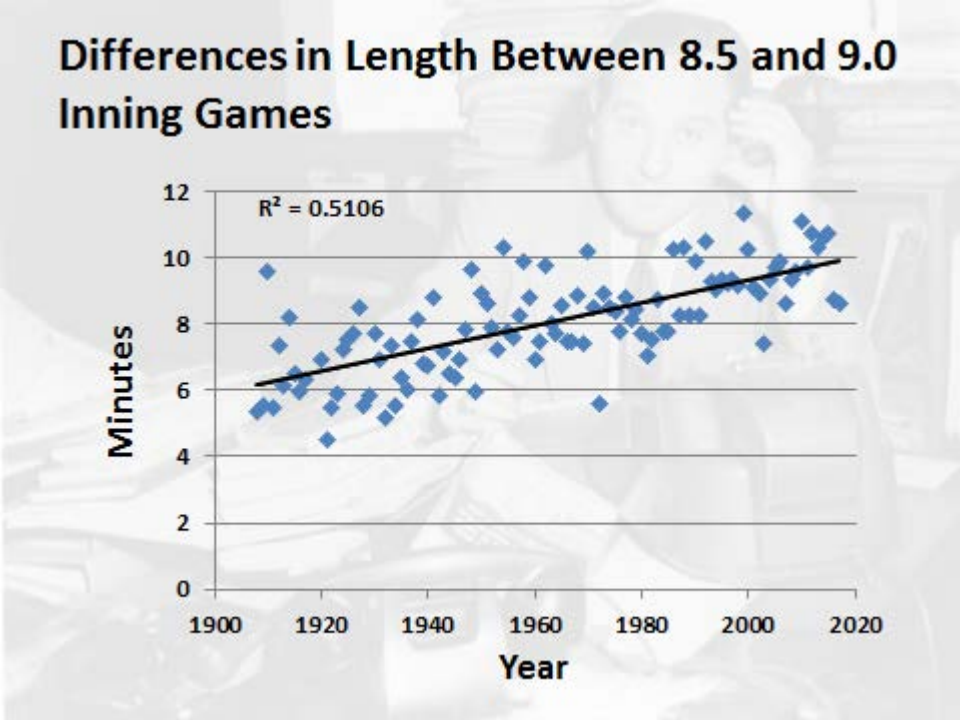
First year with average of over two and a half hours
1954 (150.3 minutes)

First year with average of over three hours
2000 (181.4 minutes)

Longest average game time
2017 (188.7 minutes)

The patterns of annual variation for the regulation-length games by themselves are parallel with similar high values of R^2 in the linear regression. Since my focus is on the regulation-length games, I explored the time differences between the 8.5 and 9.0 games in more detail. Figure 2 has the differences between these two types of games in minutes over the 108 seasons

Figure 2. Annual differences in game length between 8.5 and 9.0 inning games, 1908-2017

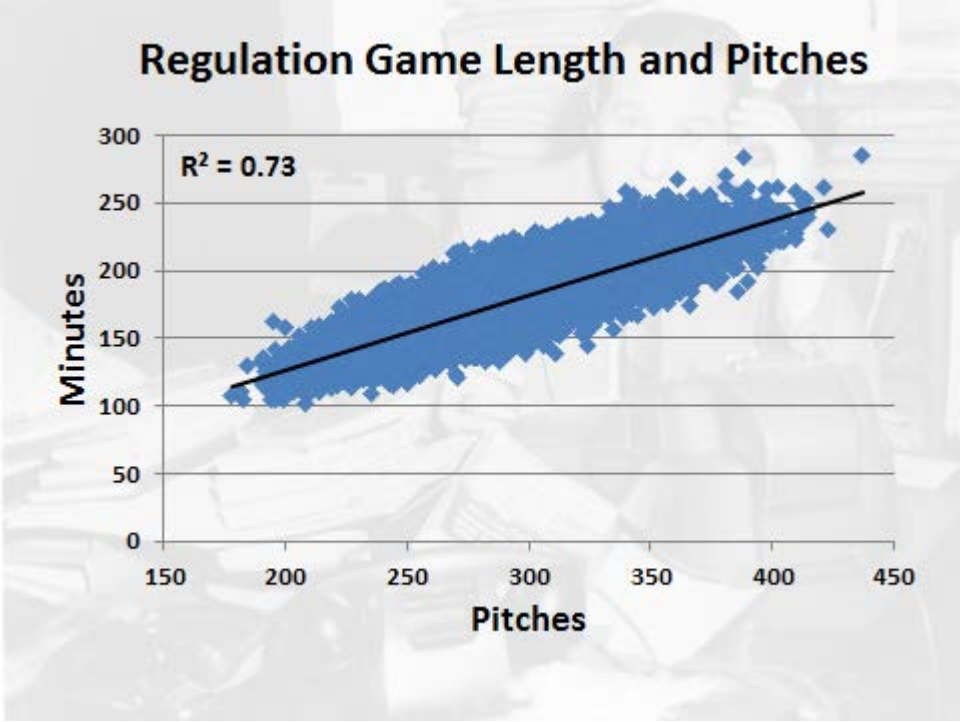


The average difference has increased, but there is much year to year variation. The linear regression R^2 value of 0.51 shows a moderate relation, but certainly less than for the game times. There has been a general increase in the time difference, from around 6 minutes until 1930 to over 10 for most years since 2011. This result is not unexpected since increased game length likely means that each inning is getting somewhat longer. Of course, the only half inning for which we can do this exact calculation is the bottom of the 9th. Interestingly, if we take this current value of 10 minutes for the bottom of the 9th and assume that it applies to all 18 half innings, then we find an expected average of 180 minutes (3 hours) which fits the observed data well.

I began researching this topic last summer during SABR47 in New York when my friend Steve Steinberg asked me what the relation was between number of pitches and game length. First I need to make a digression on the data we have. Retrosheet's pitch data has two distinct components.

The answer to Steve's question is shown in Figure 3 for all regulation-length games from this entire period.

Figure 3. Regulation game length and number of pitches.



There are several points to make about this result. The R^2 value of 0.73 means that the number of pitches in a game explains nearly three quarters of the variance in the time of game for this set of over 64,000 games covering more than 18 million pitches. That is a strong relation, although we would always like it to be more. I did analyze the 8.5 and 9 inning games separately and also the Roth games separately from the modern ones. The Roth data fits in extremely well with the modern information so there is no need to present separate graphs. Also the calculated slopes of the lines for 8.5 and 9 inning games are only slightly different and I therefore combined them all into this one figure. Examination of this figure shows very large ranges in both pitch totals and game times. These extremes and the averages are summarized as follows

Ranges and Averages of Pitch Totals and Game Length in Regulation-Length Games

	8.5 innings	9 innings
Minimum Pitches	145	178
Maximum Pitches	439	437
Minimum Minutes	93	101
Maximum Minutes	271	285
Average Pitches	274	289
Average Minutes	166	176

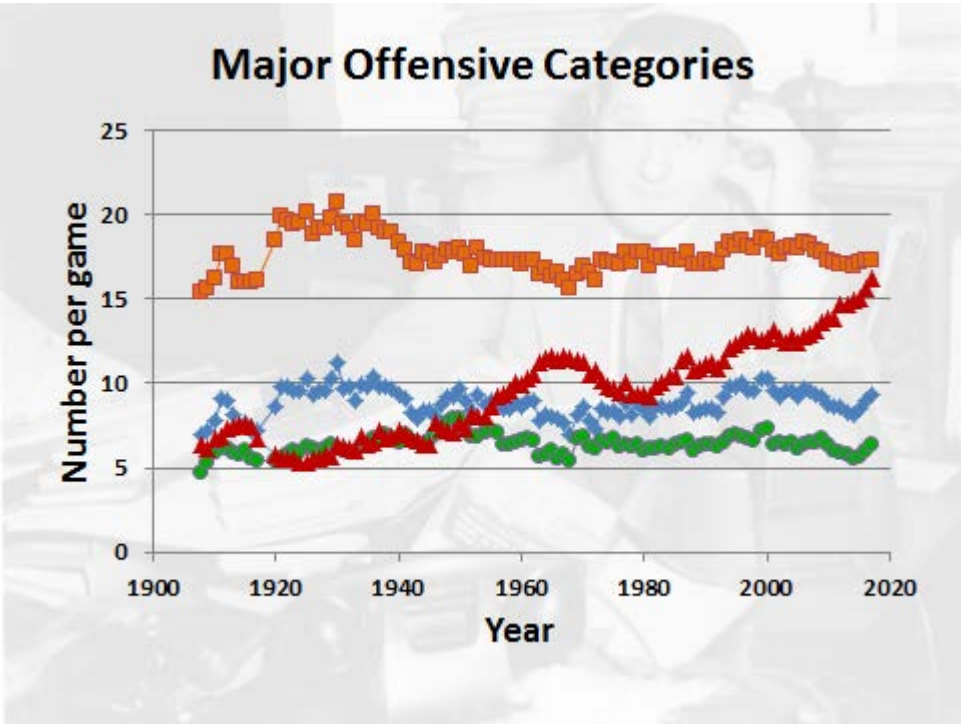
With ranges this large, it is essential to have big data sets to find statistically meaningful differences. Playing the bottom of the 9th adds an average of 10 minutes to the game. The average number of pitches for these 10 minutes is 15.

With this clear importance of the number of pitches on the time of game, I then set about looking for explanations of what would make the number of pitches increase. Here are the quantitative, measurable causes of game actions I considered.

Activities with possible effect on number of pitches in a game. Amount of scoring and other offensive actions Changes in proportions of different types of events

The level of scoring is presented in Figure 4 along with several other offensive statistics, all for regulation-length games.

Figure 4. Major offensive categories, 1908-2017



Runs are, of course, the net result of all offensive action. They are presented in the blue line here. Scoring has varied over the last 110 years, but there is no obvious upward trend to match the time of game. We have still not returned to the level of scoring seen in the first 15 years of the lively ball era although the average game length then was more than an hour less than it is now. So more scoring doesn't give us our answer. The orange line has the average number of hits per game and the changes there are pretty close to the pattern for runs, but once again there is no systematic upward trend.

Walks, shown here in green, take more pitches than other kinds of event (more details on that in a moment), but they also show little systematic change. On the other hand, strikeouts, shown in red, have changed dramatically. As the lively ball era began, the number of strikeouts per game fell, being less than six per game for both teams combined until 1930. The average stayed in the mid-7 range until 1952 when it began a steady increase to a peak of 11.6 in 1967. After the mound was lowered in 1969, the average began to drop, reaching 9.2 in 1981. However, since

then there has been a steady rise (with some short-term oscillations) and the value really took off in 2006. The strikeout rate in 2017 was 16.2 per game, the first time it has passed 16.

We must address home runs as well and those annual rates are in Figure 5.

Figure 5. Home runs per regulation-length game, 1908 – 2017, both teams combined

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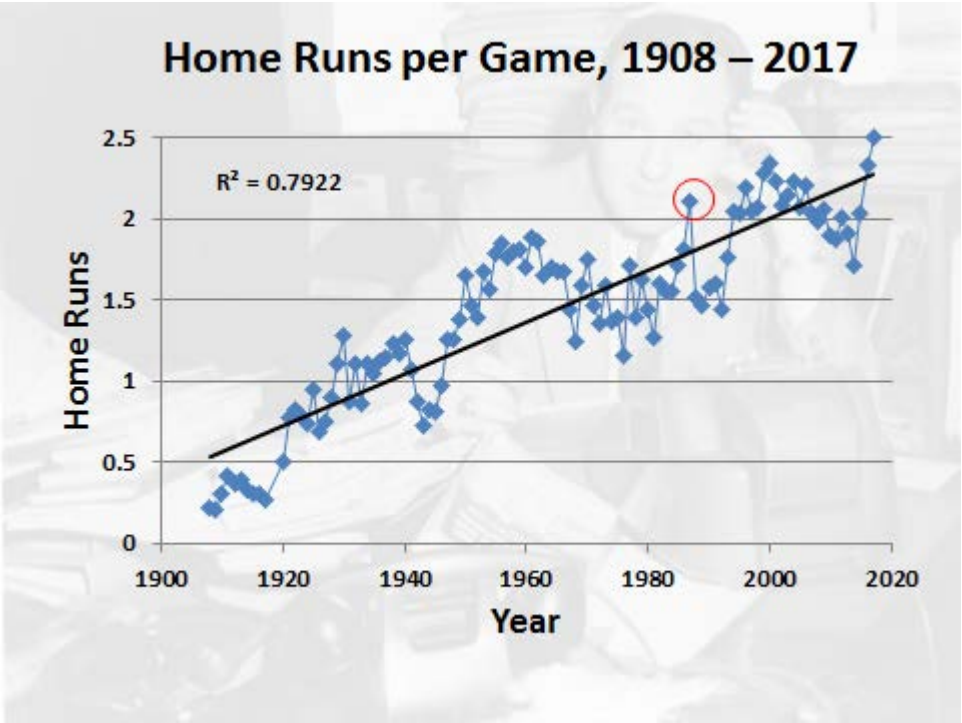
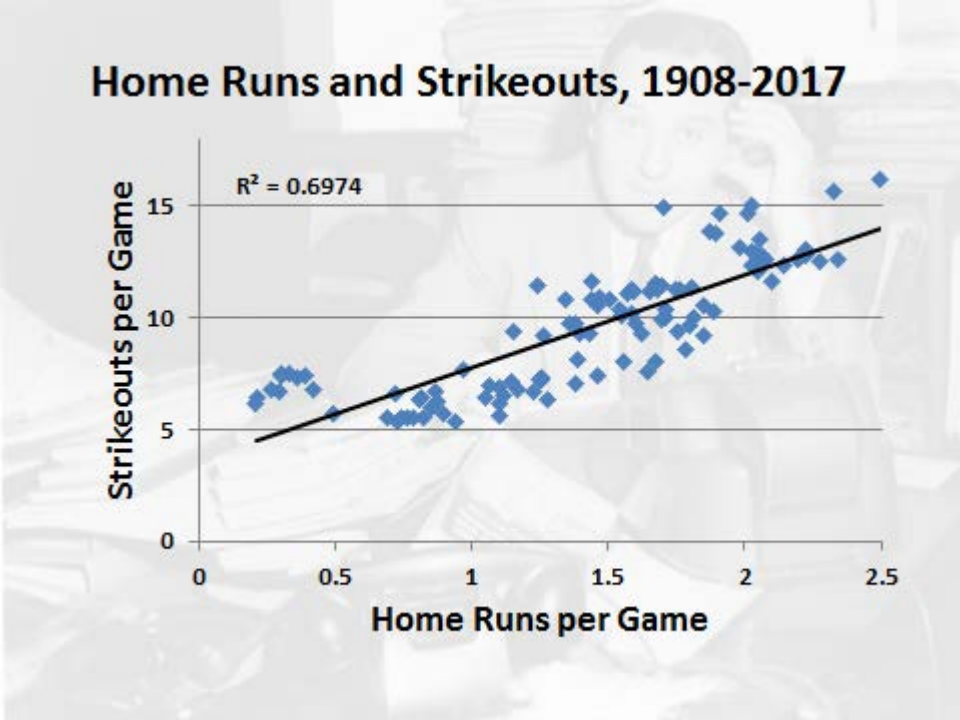


Home runs have certainly increased since 1908, but there have been boom and bust years here as well. As expected, there was a surge with the introduction of the lively ball in 1920, but that ended dramatically in 1940, with a drop of 42% to 0.7 per game in 1943, perhaps reflecting changes in the construction of the ball due to wartime shortages. However, that slack time was followed by a dramatic upsurge from 1945 to 1961 when it reached 1.9 per game. The next dramatic point was in 1987 which has been written about a great deal. There is no satisfactory explanation for this 16% spurt in a single year although there was much speculation at the time about a "juiced" ball. Sports Illustrated published a study in which the physical properties of the 1987 ball were studied and nothing was detected to account for this large increase. The decline of 28% the next year is equally mysterious. At any rate, the next sustained increase was from 1992 to 1999, followed by a slow decline to 2014 when it was 1.7. In the four seasons since (2014 to 2017), we have seen an extraordinary 46% increase to last year's all-time high of just under 2.5 per game. The R^2 shows a strong relationship over time.

I go through all this detail to make the point that there is a strong relationship between home run increase and strikeout increase. This is shown clearly in Figure 6.

Figure 6. Home runs and strikeouts, 1908-2017.



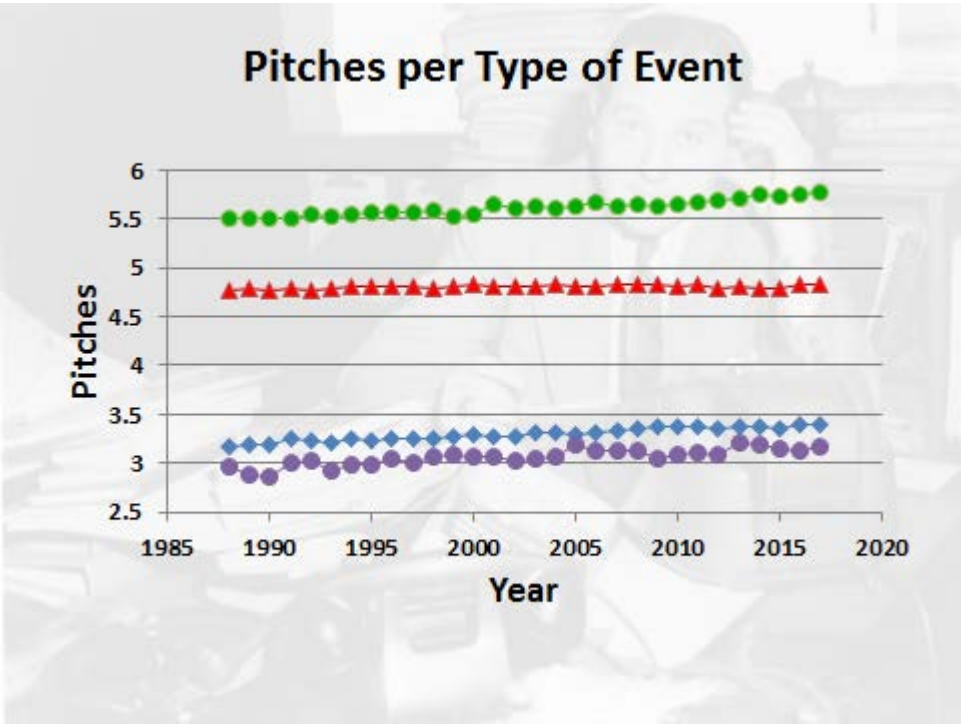
The R^2 value of 0.69 shows a strong relation. No other pair of variables showed this close relation. I am led to a conclusion that others have reached as well, namely that the correspondence between home run rate and strikeout rate is one of cause and effect. One consequence of Sabermetic analysis has been that strikeouts no longer have the stigma they once did. Statcast data shows launch angles and swing velocities and batters have clearly used this information to adjust their swings so that they hit the ball further. Of course, as these harder swings happen, it is much more likely that the ball will be missed so we have a pretty clear all or nothing phenomenon.

I then calculated the average number of pitches for four types of event since 1988, the period for which we have pitch data for every game.

- balls in play
- strikeouts
- walks
- and hit by pitch

These are shown in Figure 7.

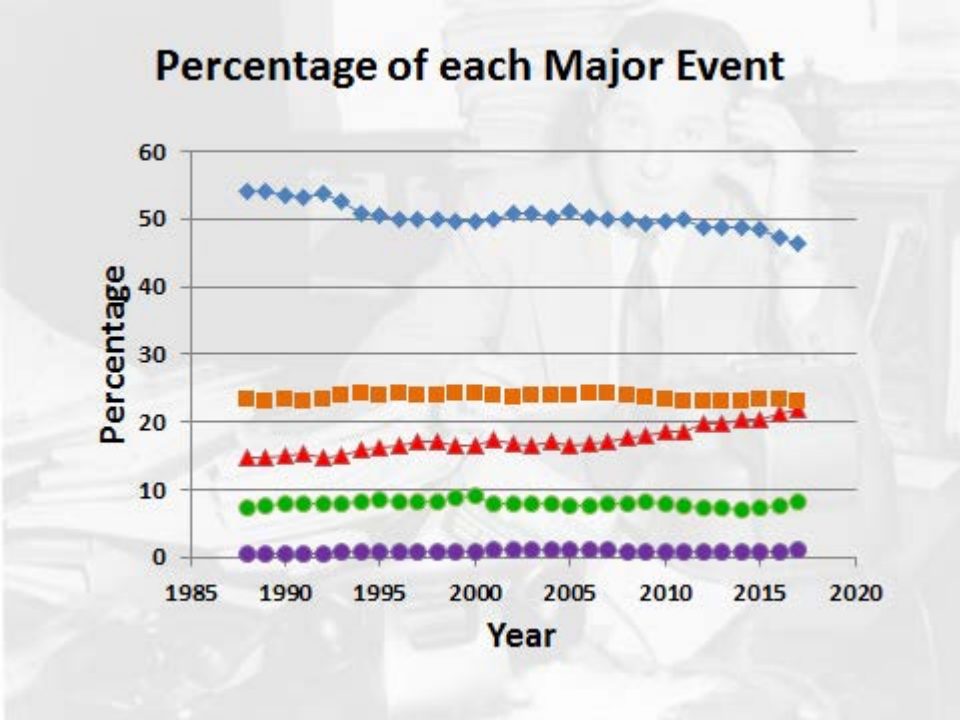
Figure 7. Number of pitches for each type of event.



Balls in play (blue line), walks (green line) and hit by pitch (purple line) show a slight, but discernible increase with the average walk now taking 5.8 pitches to complete. These increases, especially in walks may indicate greater patience on the part of hitters or greater concern ("nibbling") by pitchers. Strikeouts (red line) have not had a comparable increase in the average number of pitches, showing a remarkably stable pattern.

One last way to look at this is to examine how often each type of event occurs. Figure 8 has these results, again from 1988 to 2017.

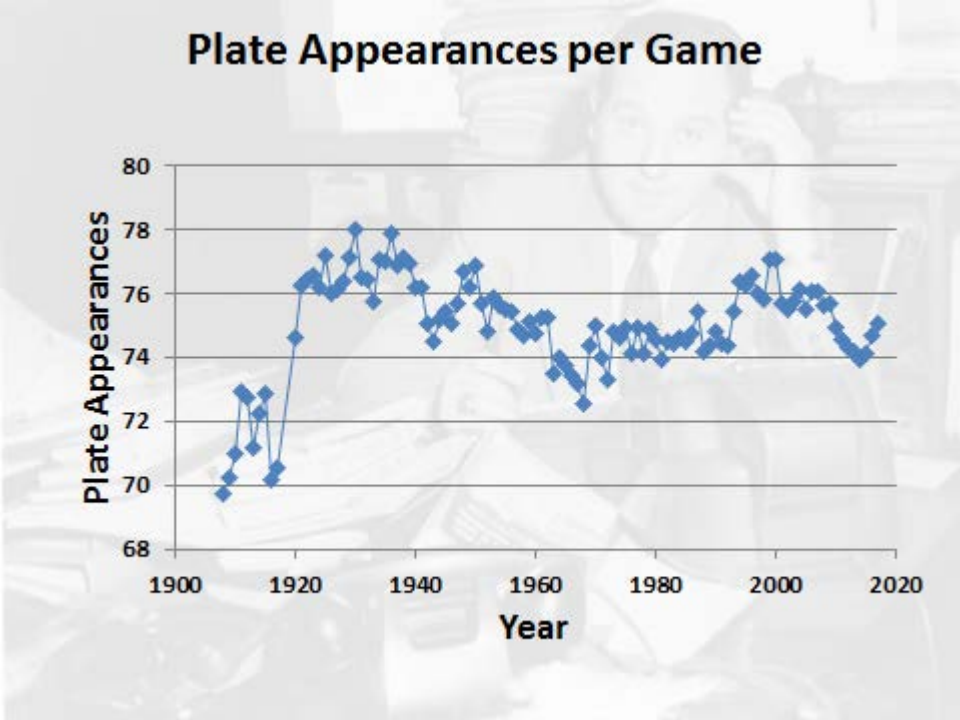
Figure 8. Percentage of different events, 1988 to 2017



There a clear inverse relation between outs on balls in play (blue line) and strikeouts (red line) while hits (orange line), walks (green line) and hit by pitch (purple line) have stayed quite steady. On average, strikeouts take 1.5 pitches more than other kinds of out, so this trade of strikeouts for outs on balls in play will also add time to the game. In fact, all of the factors point in the same direction of contributing to increasing game length.

Another important measurement is the number of plate appearances per game and their pattern of change, shown in Figure 9, parallel scoring quite closely. This is to be expected since more runs necessarily requires more plate appearances.

Figure 9. Plate Appearances per Game.



This pattern is rather similar to what we saw for scoring which is reasonable since games with more runs will of necessity have more batters. The rapid increase in plate appearances as the lively ball was introduced and the decline with the higher mound in the mid-1960s stand out as did the changes in runs scored. The recent decline and subsequent rise also parallel scoring.

Finally we must consider actions affecting game length which are not directly related to the actual playing of the game. My choices for these are as follows.

Non-playing events that affect time of game.
Time between pitches (attributable to both batter and pitcher)
Time between innings
Replay reviews
Visits to the mound
Relief pitchers, especially mid-inning changes

Time between pitches has received attention from several sources in recent years. Baseball Prospectus has documented differences in pitch interval between bases empty situations and those with runners on base. Jim Albert has used PitchFX data very impressively to demonstrate among other thing that intervals are longer in the later stages of the game. Fangraphs published overall data on the time between pitches for all games since 2008

(**https://www.fangraphs.com/leaders.aspx?pos=all&stats=bat&lg=all&qual=0&type=22&season=2017&month=0&season1=1871&ind=0&team=0,ss&rost=0&age=0&filter=&players=0&sort=1,d**). . These results are especially interesting to me. They measured an increase in the average time between pitches of 21.6 to 24.7 seconds between 2008 and 2017 with over 40% of the difference happening in 2017. The interval has both increased and decreased over this period. If we apply the full value of 2.6 seconds to the average number of pitches in a regulation game, the conclusion is that this increased interval has added 8 minutes to the average regulation game in these last 10 years. Since the average regulation game has increased by 14.5 minutes in that time, the 8 minutes are a significant part of the increase. I am grateful to FanGraphs for this valuable information. Grant Bisbee published an intriguing article at sbnation.com (**https://www.sbnation.com/a/mlb-2017-season-preview/game-length**) in which he did an extraordinarily detailed analysis of two comparable games, one from 1984, the other from 2014, which were available on youtube. The more recent game was over 30 minutes longer and Bisbee's biggest conclusion is that it was due to "lollygagging" by both pitchers and batters.

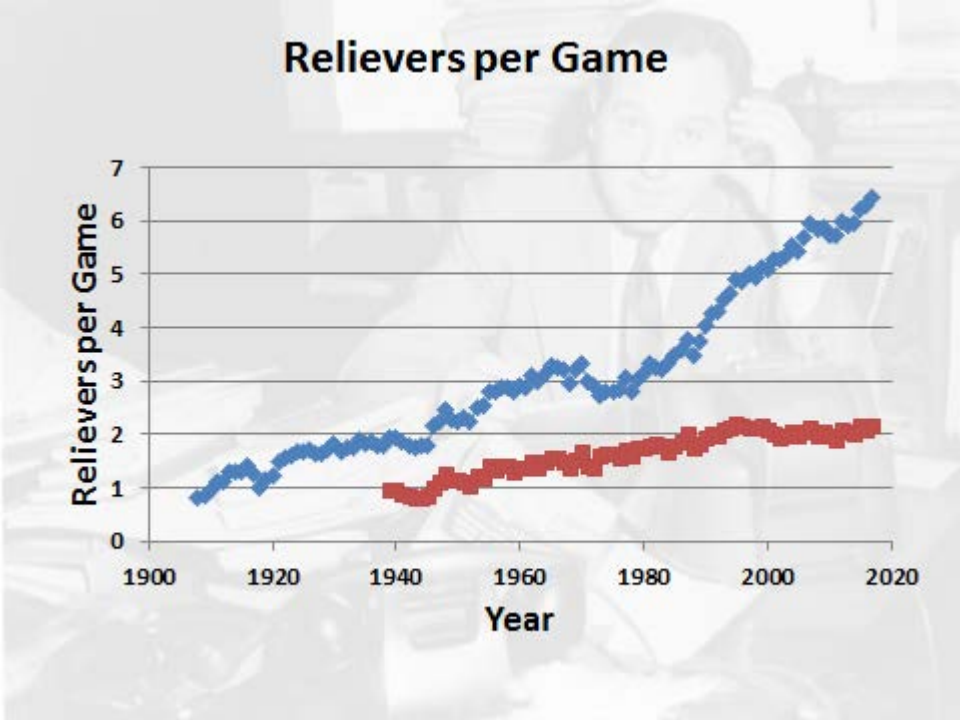
Time between innings is not routinely measured or reported so it is hard to know how long it takes to change sides, especially in earlier seasons. There have been various rules on the timing of these breaks and it is clear that the current limit of two minutes is being enforced more stringently. As an anecdotal observation, I must say that the games I have attended this year go much more quickly between innings.

Replays have been with us for about a decade now and so far this year they occur about one time for every two games, similar to the rate in 2017. They were somewhat more frequent earlier in the decade. For 2018, these reviews are formally listed to date as taking one minute and 23 seconds, with an average on 59 seconds "on the headset". This does not count the potential delay of 30 seconds granted to teams to decide if they want to challenge. On the other hand, the replay system has greatly reduced the number of managerial arguments on the field, which will lead to a shorter game. So, although it will be hard to get exact numbers for the time taken by reviews, this is obviously another factor that may make games longer.

Visits to the mound by the catcher, infielder or someone from the bench (pitching coach or manager) also consume time, but I know of no data that systematically measure the time used by visits. MLB has taken some steps in this regard in 2018 by limiting mound visits to six per game per team. The visits were limited to 30 seconds beginning in 2016, the first restriction of this kind. There was consideration of imposing a 20 second limit between pitches as well this year, but that rule was not adopted.

The change in the playing of the game with potentially the biggest effect is the increased number of relief pitchers. There are two kinds of relief appearances: those at the start of an inning and those that happen during an inning. It seems reasonable that the mid-inning changes should take more time than a change at the start of an inning which should be virtually identical in terms of time consumed to having the same pitcher stay in the game. Figure 10 has the data for these two aspects of relief pitcher usage.

Figure 10. Average number of relief pitchers per game.



The line for total relievers (blue) per game goes back to 1908 because our data allow that determination. The line for mid-inning relievers (red) starts in 1939 because that measurement requires full play by play for every game and Retrosheet's complete seasons begin with 1939.

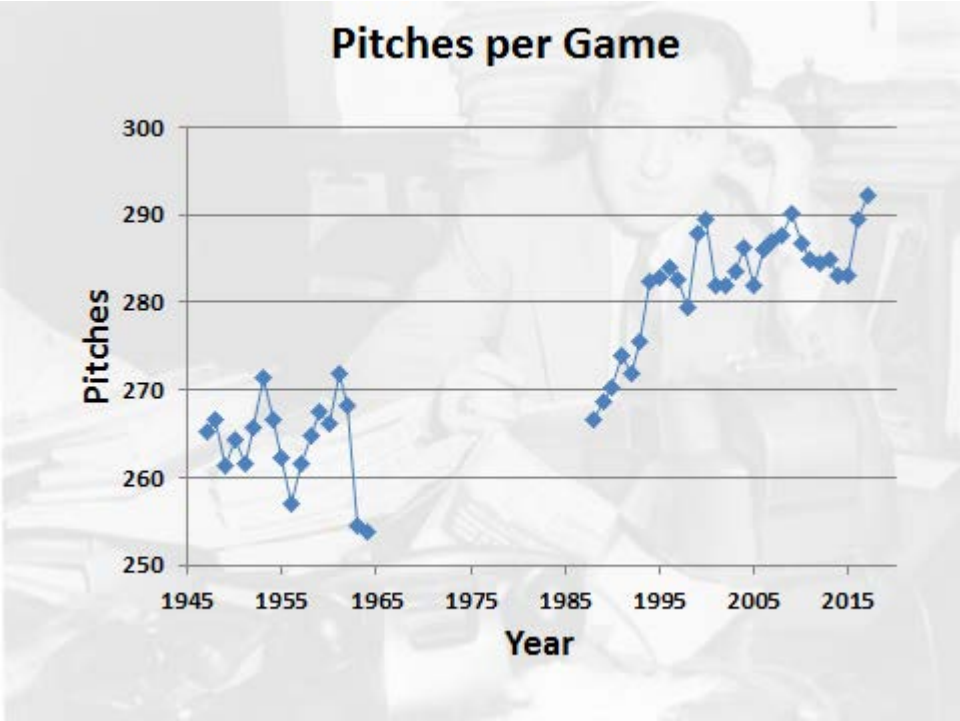
The line for total relievers has several distinct portions. First, there is a dip during each of the World Wars, although the first drop was bigger. However, there is a fairly steady overall increase from 1908 through 1968 and then a decline for most of the next decade after the mound was lowered. The advent of the DH had no immediate effect.. From 1975 to the present, we have another long period of increase, much faster than the earlier one. The average passed 6 relievers per game for the first time in 2015 and reached 6.4 in 2017. By the way, through games of last night, the average in 2018 is over 6.5, right in line with the recent pace of an additional tenth of a reliever per game for each year.

However, the surprising results to me are the mid-inning changes. These have increased by more than a factor of two since 1939, but essentially not at all since 1994. This indicates to me that the use of additional relief pitchers has had minimal effect on the time of games. These extra pitchers appear to be the "role" players who are dedicated to the 7th, 8th, and 9th innings.

My major conclusion is that the single biggest factor contributing to the longer games is the number of pitches. I have identified other factors and other researchers have as well, but the number of pitches stands out as predominant. Although there are more batters per game than there were a century ago, the biggest part of the increase is that each plate appearance besides strikeouts takes more pitches than 30 years ago. Perhaps this is a result of the "homer or strikeout" mentality or perhaps it just reflects greater plate discipline by batters in modern

times. This conclusion is supported by the data in Figure 11 which covers 1947-2018, minus 1965-1987.

Figure 11. Pitches per game.



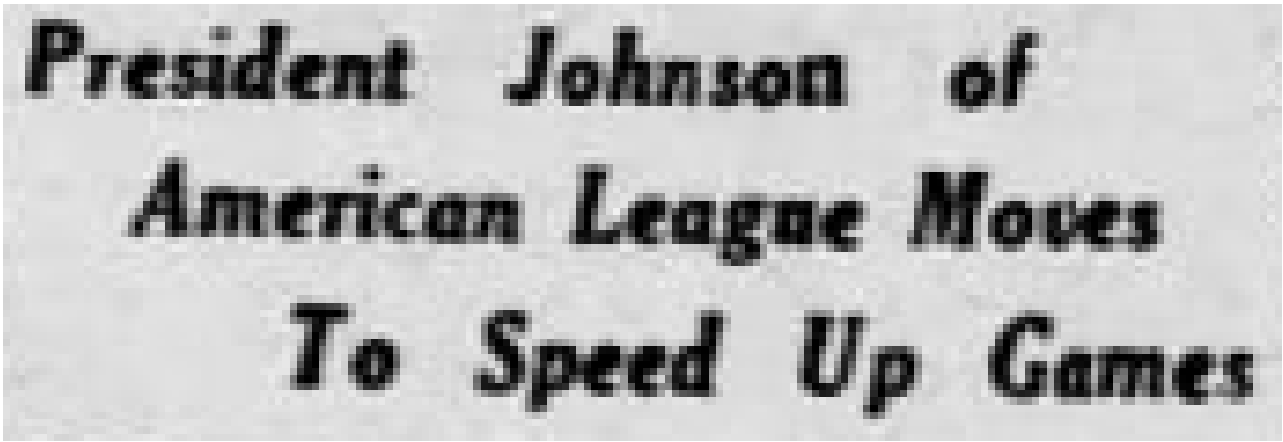
The inclusion of the Allan Roth data reveals interesting patterns. The general average for his era is some 25 pitches fewer per game than current levels, but the first few years of the 1988 to 2017 interval are similar to his values. Of course, we do not know the shape of the line for 1965 to 1987, but I note that the last two years that Roth covered, 1963 and 1964, are clearly the lowest of any seasons for which we have data. These were of course, the first two years of the raised mound.

My last point is to note that the length of the game is not a new concern. Ban Johnson, the founder and long-time President of the American League, was agitated by what he considered slow games as long ago as 1909. Here is a headline from the December 2, 1909 issue of The Sporting News, as pointed out to me by my friend Herm Krabbenhoft.

WHY GAMES DRAG

TOO MUCH PRACTICE TIME TAKEN BETWEEN INNINGS

Johnson had noted that several games had exceeded two hours and he decided that a big problem was that teams took too much time throwing the ball around the infield at the start of each inning at the conclusion of the pitcher's warmup throws. He was supported by veteran umpire Tom Brown who said: "The practice work does not belong in the game". However, Johnson didn't let go of this issue and in 1925 the St Louis Post-Dispatch had a story with this headline:


President Johnson of American League Moves To Speed Up Games

The article noted:

"Contests in the A. L. this season have frequently run more than two hours and Johnson wants to know the reason why. A report must be sent to President Johnson on all games running over two hours, with the reasons for the delays. If it is because of arguments, the guilty athletes will be punished". For the record, 269 of the 616 AL games that year were over 120 minutes, which is 44% and the league average was 120.8 minutes. Of the 546 regulation-length games, 216 were over 120 minutes (40 %) and the average time was 118 minutes.

One can only imagine what his reaction would be to an average of more than three hours!

I must give proper respect to the first Sabermetrician, Allan Roth, whose work with the Dodgers, initially with Branch Rickey, was truly groundbreaking and set the stage for the analytic revolution we currently enjoy.

Figure 12. Allan Roth

Appendix 1

Other ideas to pursue:

- Games with big run innings
- Month
- Specific umpires, pitchers batters
- Specific teams

Appendix 2

Shortest and longest games

Athletics at Yankees, 08-25-2011
271 minutes, 427 pitches, score was 22-9

Dodgers at Reds, 05-22-1949 (game 2)
93 minutes, 166 pitches, score was 2-0

Yankees at Red Sox, 08-18-2000 (game 2)
285 minutes, 437 pitches, score was 14-11

Four 9-inning games with 101 minutes, 3 in Roth era, last was
Devil Rays at Tigers, 07-24-2000, score was 4-2.
Pitch totals were 181, 208, 172, 192

Appendix 3

Average game time in different sports with home team winning percentage

	Win	Time
MLB	54.0	188 minutes
NHL	55.7	140 minutes
NFL	57.3	192 minutes
NBA	60.5	140 minutes