Starting pitching staffs and pitching rotations

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At the start of Major League baseball in the 19th century, pitching staffs were very small, with most teams using only one or two different starting pitchers. Peter Morris has thoroughly examined these early patterns and how they changed at SABR35 in 2005 (which won the Doug Pappas award for best research presentation) and in his book, *A Game of Inches*, published in 2006. The subsequent evolution of pitching rotations since 1900 has not received the same detailed attention. In the 21st century teams organize their staffs around a planned "five-man rotation" and this is a topic of great attention in the baseball press, especially in spring training. When teams announce a plan to use a four-man rotation, as the Colorado Rockies did in 2004, then it becomes a major story.

What is missing from most of these discussions is a clear definition of what a pitching rotation is. For a current team, are the same five men started in a strict sequence, interrupted only by injuries and doubleheaders? Are starters scheduled so that the best four start disproportionately more games and the fifth man gets skipped as the schedule allows? Is the "fifth starter" really a collection of multiple pitchers, with no single player in this role? Does the pattern change during the season for a given team due to injuries or new pitchers from the minor leagues or trades? Is the number of days rest more important than the exact sequence? Other considerations may come into play as well. For example, there are more frequent days off at the start of the season, both because of open spots on the schedule and greater chance of cancellations due to weather. Occasionally starters are chosen selectively due to the opponent. Early in his career, Whitey Ford had "extra" starts against the St. Louis Browns. And for most of his time in the majors, Warren Spahn was not used against the Dodgers since they were the only team against which he had a losing record (except for an 0-2 mark against the Braves). Finally, teams sometimes alter their rotations during pennant races, with the 1964 Phillies being a classic example. The raw data for this analysis are the Retrosheet game logs which identify starting pitchers for each game. These logs are freely available on the Retrosheet website at: http://www.retrosheet.org/gamelogs/index.html.

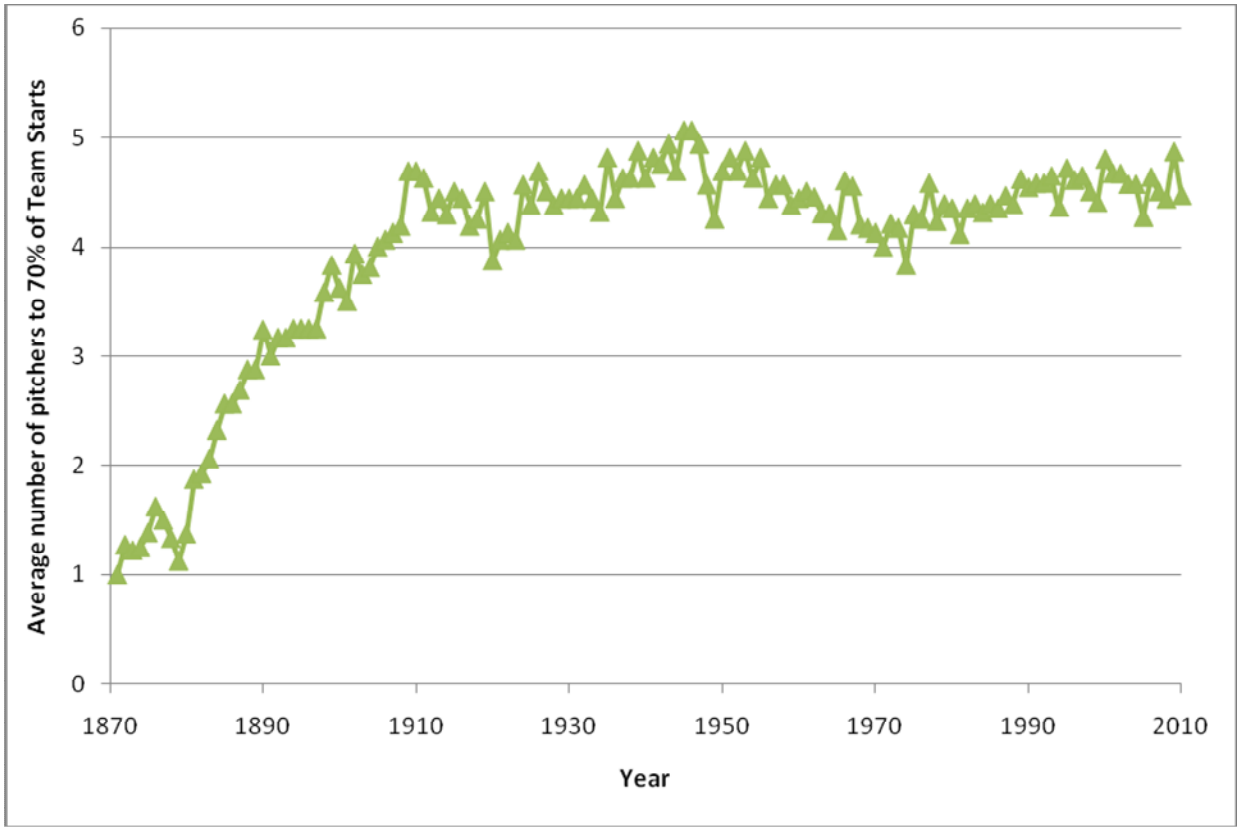
I usually include a table at the start of my SABR presentations with a summary of how many games were used in the specific study. In this case, I was able to analyze the data for every major league played from 1871 through 2010. That is a total of 198,721 games as summarized in Table 1.

Table 1. Games examined for present study (listed by league in chronological order)

National Association	1,081
National League	101,809
American Association	5,039
Union Association	428
Player's League	529
American League	88,592
Federal League	1,243
Total	198,721

It is important to distinguish between a pitching rotation and a pitching staff. Before delving into the analysis of specific starter sequences, let us first examine teams in terms of how many men handled the bulk of the starts. For example, what was the average number of starters needed to account for a specific percentage of a team's starts? I first chose 70% as a threshold and did the following. For each team I ranked pitchers in order of the number of games started, then calculated cumulative games started as I went down the list and reported the number of starting pitchers it took for that team to reach the 70% threshold. For each season I averaged these values from each team and obtained the results shown in Figure 1.

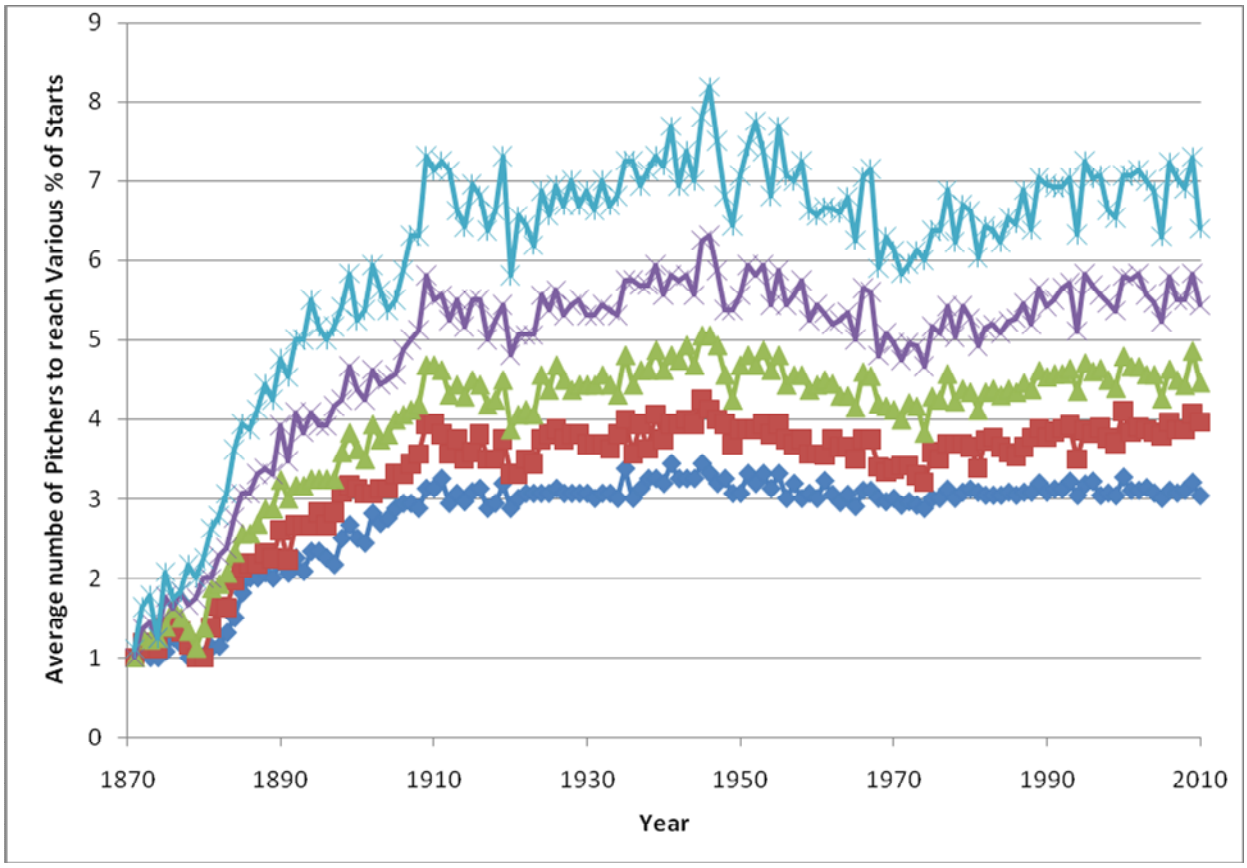
Figure 1. Average number of pitchers accounting for 70% of team starts.



As expected, during the National Association seasons (1871 to 1875), the average per team was below 1.5 since many teams used only one starting pitcher for the whole season. Interestingly, the average dropped to just over 1 (1.12 to be exact) in 1879 when there were only six Major League teams and then began a fairly steady increase to about 1910. There have been fluctuations since then, but the value has stayed remarkably stable for the last 100 years. This is somewhat surprising since this period covers the deadball era, lively ball introduction in 1920, integration, expansion, implementation of the DH, and the offensive surge of the last 15 years. The only year the team average fell below 4.0 was 1974, which presumably reflects early adjustment to the DH.

The threshold of 70% is obviously arbitrary, so I redid the analysis with a series of different cutoffs, namely 50, 60, 70, 80, and 90%. The results are in Figure 2.

Figure 2. Average number of pitchers accounting for different percentages of team starts.

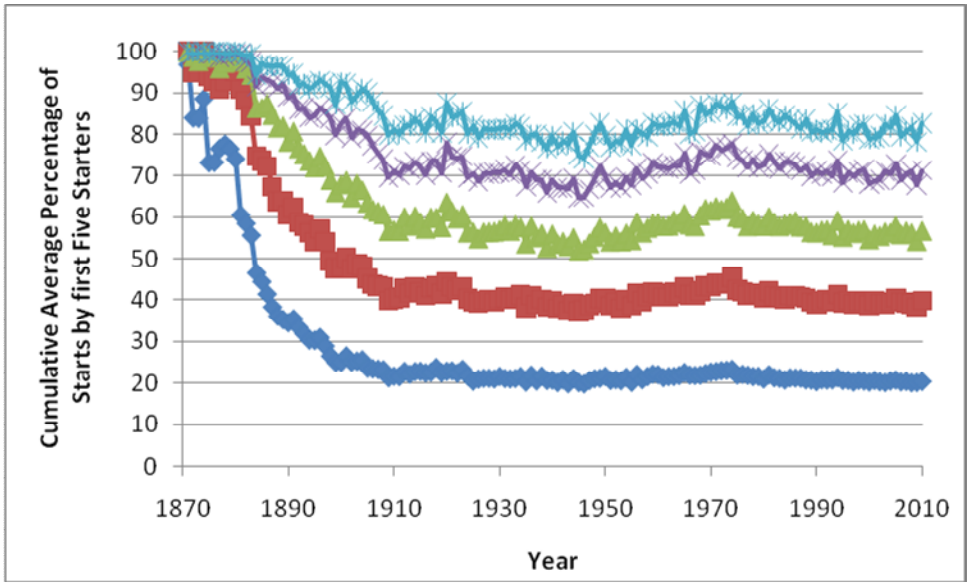


Not too surprisingly, the five curves are very similar in shape. There has been very little variation in the average number of pitchers needed to reach 50% of team games (the bottom line), with the value holding very close to 3 for the last century. Examination of the top three curves shows some interesting variations. The highest values were observed in 1945 and 1946 as World War II and its immediate aftermath caused teams to need more pitchers to reach these

thresholds, which is probably not surprising. However, the strong drop for the last years of the 1940s is not so obvious, perhaps reflecting the return of veterans and the reestablishment of stable farm systems. The lowest values were in 1920 (advent of the lively ball) and 1968 to 1974, a notoriously strong pitching era.

There is another way to look at this same point, which is essentially the reverse, namely what percentage of a team's starts are accounted for by the pitcher with the most starts, by the top two, etc. These results, up to the five most frequent starters, are in Figure 3.

Figure 3. Cumulative percentage of games started by first Five Starters.



There is a big change in the first 40 years of Major League history, as seen before, followed by a century of stability. Once again we have a family of related curves with the general pattern that the most frequent starter accounts for 20% of the team's starts, the second for another 20% and the third for just a bit less than another 20%. The fourth and fifth starters together contribute another 20%. This pattern suggests to me that most teams have two men they use a lot and a third one who gets the ball only a little less often. The lower percentage contribution from the 4th and 5th most frequent starters indicates that the "back end" of the rotation has a lot more variation, presumably reflecting lower performance levels.

The next approach was to go beyond team averages and look at the usage patterns of individual pitchers. I started by looking at the number of days rest that each starter had between starts. The form of these results can be seen in Table 2, which has the data for the 2010 Giants, who led the majors in team ERA at 3.36. I examined the top six starters because most teams have six men with double digit numbers of starts.

Table 2. Number of starts on indicated number of days of rest for top 6 starters of 2010 Giants

Pitcher	Total	0	1	2	3	4	5	6	>=7	Avg
Tim Lincecum	33	0	0	0	0	17	14	0	1	4.5
Barry Zito	33	0	0	0	0	16	14	1	1	4.5
Matt Cain	33	0	0	0	0	17	14	0	1	4.5
Jonathan Sanchez	33	0	0	0	0	17	14	0	1	4.5
Madison Bumgarner	18	0	0	0	0	9	6	1	1	4.5
Todd Wellemeyer	11	0	0	0	0	4	5	0	1	4.6
Total	161	0	0	0	0	80	67	2	6	4.5

Note that the columns for each pitcher add to one less than the number of games started, since there was no interval to calculate before the first start. Also, the values in the ">=7" column were not used in calculating the average, since there could be very long intervals here due to injuries. At least for the 2010 Giants, this is a very minor adjustment since there were only six games in this category, one for each of the starters listed.

There is a related but distinct way to do this analysis and that is on the basis of games, not days. Since teams do not play every day and even today there are occasional doubleheaders, the manager must make adjustments. Table 3 repeats the summary for the Giants on the basis of team game number and not calendar days.

Table 3. Number of starts on indicated number of games of rest for top 6 starters of 2010 Giants

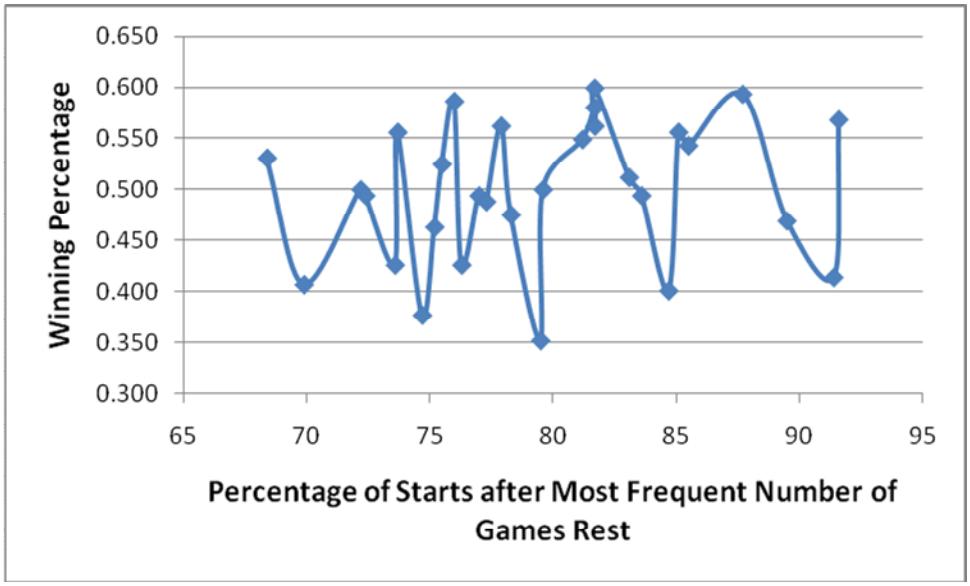
Pitcher	Total	0	1	2	3	4	5	6	>=7	Avg
Tim Lincecum	33	0	0	0	3	29	0	0	0	3.9
Barry Zito	33	0	0	0	2	29	1	0	0	4.0
Matt Cain	33	0	0	0	3	29	0	0	0	3.9
Jonathan Sanchez	33	0	0	0	2	30	0	0	0	3.9
Madison Bumgarner	18	0	0	0	0	16	1	0	0	4.1
Todd Wellemeyer	11	0	0	0	0	9	0	0	1	4.0
Total	161	0	0	0	10	142	2	0	1	3.9

The differences between the day and game approaches are striking. These six pitchers had about half of their starts on four days rest and nearly that many on five days. However, they had 92% of their starts after four games. That appears to be a very solid pattern of rotating five starters, but since it used six men, it does not exactly fit the notion of a five-man rotation.

Not every manager has the luxury of the stability that Bruce Bochy did with these six starters, since injuries are nearly inevitable and changes are made when a particular starter is performing poorly. I therefore looked for a way to summarize the information in these tables so I could make a meaningful comparison between teams. My first thought was to use these average numbers of days rest and games rest for each team. However, that showed very little variation: from a low value of 3.8 and a high of 4.5. For games, the extremes were 3.7 and 4.0.

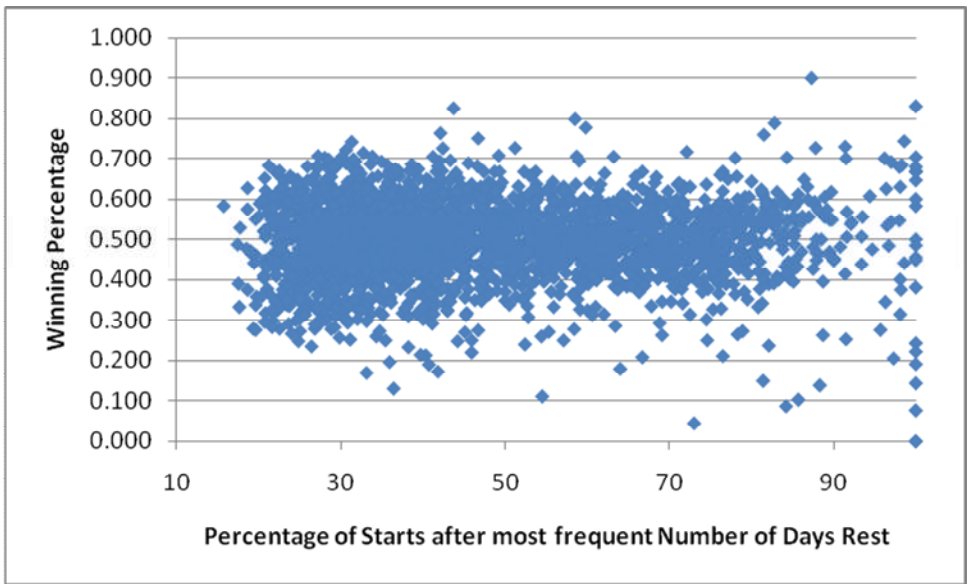
As I thought about what a meaningful measure might be, I kept returning to the basic question of what I was trying to discover in comparing teams. The answer was "stability" or perhaps "regularity," especially as they might relate to team success. I also decided to focus exclusively on games of rest and not days of rest. The measure I came up with was the percentage of a team's starts from the top six starters which were in the most frequent interval for that team. In 2010, all teams had 4 games of rest as the most common interval. The percentage of starts that came on four games rest for starters in 2010 varied from 68% (Cardinals) to the 92% of the Giants. This range seemed broad enough to allow some comparisons. How about the relation to winning? The answer to that is shown in Figure 4.

Figure 4. Team winning percentage in 2010 after most frequent number of games rest .



There is no obvious relation between winning percentage and the stability of the relation. To finish off this thought, I did this for all teams for all seasons and those results are in Figure 5.

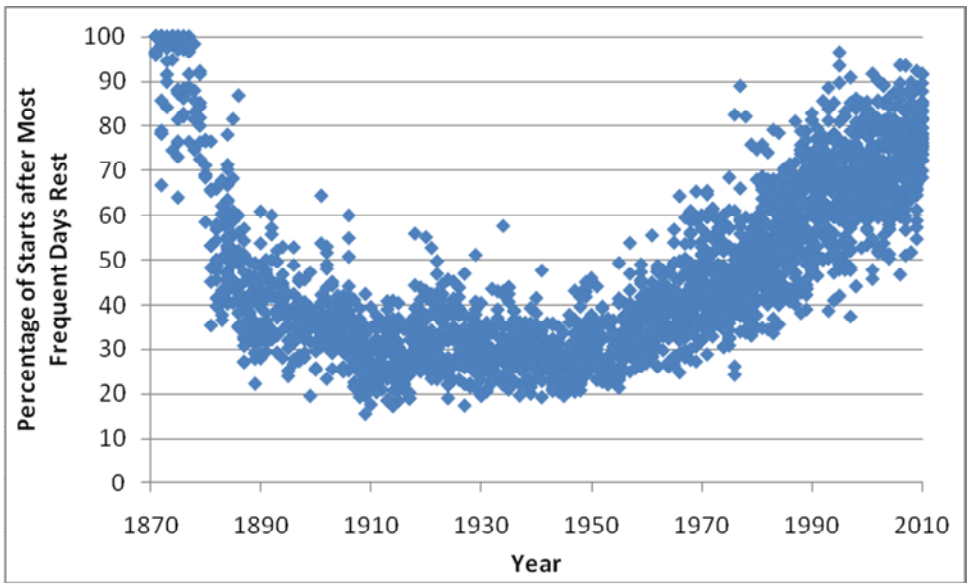
Figure 5. Team winning percentage from 1871-2010 in relation to percentage of starts after most frequent number of games rest.



There is no discernible pattern and of course the values are centered on a winning percentage of .500, as they must be. So by this measure of stability, there is no general relation between a team's rotation and the chance of a successful season.

Putting aside the matter of performance, there is still some interesting information to be gleaned from this measure of rotation stability. My next approach was to identify the most common number of game rest for each team, express it as a percentage of the starting intervals, average this for each season, and present it across all seasons. That result is in Figure 6.

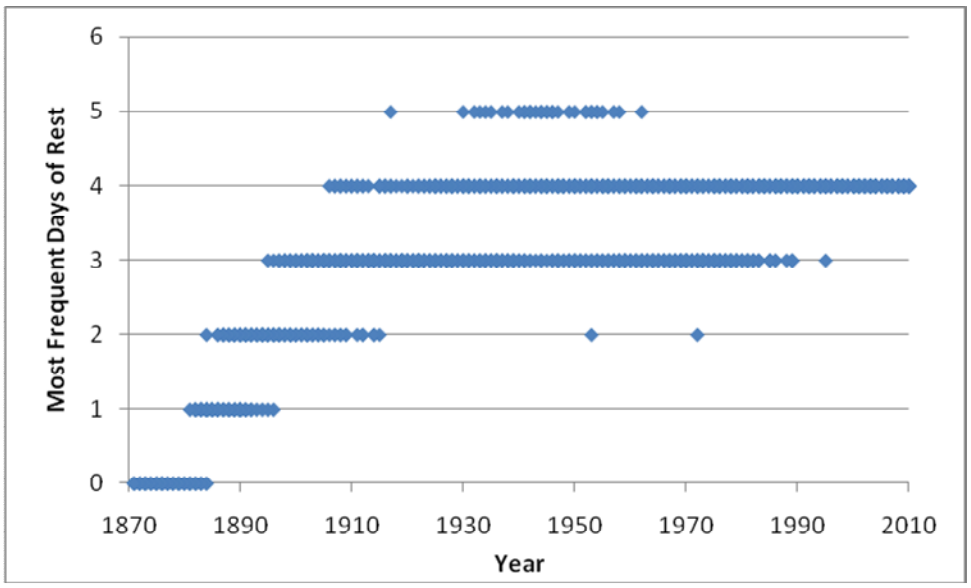
Figure 6. Percentage of starts made after the most frequent number of games rest.



In the early years, the percentages were very high as most teams used predominantly one or two starters. In fact, from 1871-1880, every team had 0 as the most frequent interval. The first season in which no team had 0 as the most frequent was 1885 and the first year that any team had 2 as the most frequent was 1886. From that point until just before 1910, the percentage declined, indicating that teams were varying their starting pitcher choices more and expanding the number of starters. From then until about 1950, the values were pretty constant, in the 20 to 40% range. These low values may come from many factors, but the first one that occurs to me is that most pitchers both started and relieved in the same season during this time, with the result that a relief appearance could push back a subsequent start by a game. For example, in 1908 Ed Walsh started 49 games and relieved 17 times. Since 1950 until the present, the trend has reversed and the percentage has climbed to its current values in the 60 to 90% range. I suspect this reflects the practice of having more pitchers specialize as starters, with many men now being exclusively starters. This is consistent with and something of the mirror image of my earlier presentation at SABR31 in West Palm Beach on changes in relief pitcher usage. An additional factor is the great decrease in doubleheaders during this time.

The last use I made of these “interval data” was to graph the numbers of times a team had a given interval as its most frequent one and to present them as a function of the year. These results are in Figure 7.

Figure 7. Most frequent games of rest for each team.



The year ranges overlap, showing that the transition was not happening at the same rate for all teams. As noted above, all teams had their most frequent interval as 0 at the start of Major League baseball. This gradually transitioned to one, then to two by 1910. The three-game rest ("four-man rotation") first appeared in 1898 and continued until 1995. The pattern of four games of rest ("five-man rotation") started in 1898, but has been the only one used by any team since 1996. This is the only period of the exclusive use of a single interval since the 1870s. The top line on the graph shows the five-game rest pattern, which I think does not represent much of a rotation at all. This usage pattern existed from 1917 (Yankees) to 1962 (Senators) but the bulk of these teams played between 1932 and 1958. I suggest that this represents the era of mixed-use of most pitchers, that is starting and relieving, that I mentioned before.

Before leaving this graph, I must address the two outliers on the line with two games rest. These are the 1953 Phillies and the 1972 White Sox. They deserve a bit more attention as examples of the unexpected results that can pop up with big effects on the conclusions. The starters for the 1953 Phillies are in the first half of Table 4 and for the 1972 White Sox in the bottom half. The columns are the same as I showed for the 2010 Giants in Table 2.

Table 4. Number of starts on indicated number of games of rest for top 6 starters of 1953 Phillies and 1972 White Sox.

1953 Phillies										
Pitcher	Total	0	1	2	3	4	5	6	>=7	Avg
Robin Roberts	41	0	3	14	12	7	4	0	0	2.9
Curt Simmons	30	0	1	8	9	6	1	2	2	3.1
Karl Drews	27	0	1	7	3	6	4	3	2	3.6
Bob Miller	20	0	0	4	2	5	2	0	6	3.4
Jim Konstanty	19	0	0	1	4	4	3	0	6	3.7
Steve Ridzik	12	0	0	0	1	1	3	0	7	4.3
Total	155	0	5	34	31	32	16	5	24	3.3

1972 White Sox										
Pitcher	Total	0	1	2	3	4	5	6	>=7	Avg
Wilbur Wood	49	0	6	31	10	1	0	0	0	2.1
Stan Bahnsen	41	0	0	20	15	4	0	0	1	2.6
Tom Bradley	40	0	0	19	13	5	2	0	0	2.7
Dave Lemonds	18	0	0	1	6	2	5	0	3	3.8
Eddie Fisher	4	0	0	0	0	1	0	0	2	4.0
Total	152	0	6	71	44	13	7	0	6	2.6

The Phillies were almost evenly divided between three, four and five man patterns during the 1953 season. They also had a large number of starts after 7 or more days, reflecting the mixed starter-reliever usage mentioned before. It is amazing that Robin Roberts had more of his starts after two games off than any other interval.

The 1972 White Sox were unusual in many ways, largely relating to the pitching pattern of Wilbur Wood. His 49 starts is an extremely high value, leading to his most frequent interval of two games. His basic pattern is that of pitching every third game, but Bahnsen and Bradley also had more starts on three games of rest. Bahnsen was a knuckleballer by then as well, but Bradley was not. The presence of Eddie Fisher with four starts is odd, but only two other men started for that team, with one start each. Remember that this was a strike-shortened season so all the totals are lower.

In the discussion above, I looked at total starters and then at intervals between starts. The last approach was to examine each team's starts to see what the actual rotation was and how often it varied. To do this, I assigned a number to each starter, based on the sequence they first started for that team in that year. To illustrate, let me once again look at the 2010 Giants. Table 5 presents the sequence for their 162 games.

Table 5. Starting sequence for 2010 Giants

1 = Lincecum, 2 = Zito, 3 = Cain, 4 = Sanchez, 5 = Wellemeyer, 6 = Martinez, 7 = Bumgarner

1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 1 2 3 4 5 1

2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1

2 3 4 6 1 2 3 4 1 2 3 4 7 1 2 3 4 7 1 2 3 4 7 1 2 3 4 7 1 2

3 4 7 1 2 3 4 7 1 2 3 4 7 1 2 3 4 7 1 2 3 4 7 1 2 3 4 7 1 2

3 4 7 1 2 3 4 7 1 2 3 4 7 1 2 3 4 7 1 2 3 4 7 1 2 3 4 7 1 2

3 4 7 1 2 3 4 1 7 3 2 4

It is clear that they had two separate 5-man rotations, first 1, 2 3, 4, 5 and then 1, 2, 3, 4, 7 with Bumgarner replacing Wellemeyer, but each of these rotations was used heavily.

How can these sequences be examined in terms of stability and possibly to make comparisons between teams? My basic answer to that question was to look at every group of 5 games, starting with games one through five, then two through six, then three through seven, etc. After all, starting the sequence with pitcher 1 is arbitrary and a sequence of 2, 3, 4, 5, 1 is really the same thing as 1, 2, 3, 4, 5. I then expanded my search to look for the same group of five in any sequence. So in addition to cyclic permutations, I counted sequences such as 5, 3, 1, 4, 2. Table 6 shows how that looks for the 2010 Giants.

Table 6. Frequency of each 5-man rotation for 2010 Giants

Sequence	Number	Sequence	Number
1 2 3 4 5	11	1 2 3 4 7	17
2 3 4 5 1	11	2 3 4 7 1	17
3 4 5 1 2	11	3 4 7 1 2	17
4 5 1 2 3	11	4 7 1 2 3	17
5 1 2 3 4	11	7 1 2 3 4	17
		2 3 4 1 7	1
		4 1 7 3 2	1
		1 7 3 2 4	1
	55		88

Since the Giants played 162 games, then there are 158 consecutive groupings of five. The ones listed in Table 6 account for 143 of this total. One of these other sequences occurred 3 times and

is interesting. Table 7 is a reproduction of Table 5 with the occurrences of this sequence highlighted.

Table 7. Starting sequence for 2010 Giants

1 = Lincecum, 2 = Zito, 3 = Cain, 4 = Sanchez, 5 = Wellemeyer, 6 = Martinez, 7 = Bumgarner

1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	**1**	**2**	**3**	**4**	**1**	2	3	4	5	1
2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1
2	3	4	6	**1**	**2**	**3**	**4**	**1**	2	3	4	7	1	2	3	4	7	1	2	3	4	7	1	2	3	4	7	1	2
3	4	7	1	2	3	4	7	1	2	3	4	7	1	2	3	4	7	1	2	3	4	7	1	2	3	4	7	1	2
3	4	7	1	2	3	4	7	1	2	3	4	7	1	2	3	4	7	1	2	3	4	7	1	2	3	4	7	1	2
3	4	7	**1**	**2**	**3**	**4**	**1**	7	3	2	4																		

It appears that Bruce Bochy took the opportunity to give Lincecum an extra start on these occasions. In the first occurrence, the Giants were off between the 4th and 5th games. The second time it appears was at the transition point between the two stable rotations and there were two off days: between the 1st and 2nd games and between the 4th and 5th games. The final occurrence had an off day between the 3rd and 4th games.

I tallied these recurring sequences (in all their permutations) for all teams for all years. The leaders by this measure are shown in Table 8.

Table 8. Teams with most frequent occurrence of a single five-man sequence (all permutations).

2003	Mariners	148
1993	Dodgers	143
2006	White Sox	140
1997	Pirates	134
1977	Dodgers	134
2010	Rays	130
2005	Cardinals	130
2004	Cardinals	126
2002	Giants	124
1995	Braves	124

The 2010 Giants come in at 52nd on this list. Of course, this is potentially misleading, because the Giants had two separate long stretches, but since they were different, they don't appear here. Therefore, I went back and for each team combined the two longest streaks for each season. The result is in Table 9.

Table 9. Teams with highest frequency of two five-man rotations in combination (all permutations)

2003	Mariners	150
2006	White Sox	146
1993	Dodgers	146
2010	Giants	143
2010	Rays	142
2002	Giants	140
1997	Pirates	140
2005	White Sox	139
1977	Dodgers	139
2000	Cardinals	138

By this combination, the 2010 Giants jump to 4th place, showing what a remarkable season they had. By the way, the 2003 Mariners are at the top of both lists and you may recall what an extraordinary starting staff they had. They used exactly 5 starters for the whole season, presented in Table 10.

Table 10. Starting pitchers for 2003 Mariners

Freddy Garcia	33
Jamie Moyer	33
Joel Pineiro	32
Ryan Franklin	32
Gil Meche	32

This is the most stable rotation in history, but even they were not a strict 1, 2, 3 4, 5 as the totals of 148 and 150 in the last table indicate. There was a little variation in the second week of the season and a resetting of the rotation after the All-Star game.

The final spin on this is to address four-man rotations. After all, this was the norm for many years, as we saw in Figure 7 and many writers still wax nostalgic about the glorious days of regular rotations. So I repeated the 5-man analysis on a 4-man basis. Table 11 has these results, both in the same table, parallel to Tables 8 and 9.

Table 11. Teams with highest frequencies of 4-man rotations

Single Rotation			Top 2 Rotations Combined		
1966	Dodgers	109	1966	Dodgers	122
1972	Orioles	102	1972	Orioles	114
1901	Braves	98	1968	Giants	106
1978	Orioles	86	1975	Dodgers	105
1975	Dodgers	85	1974	Phillies	105
1971	Orioles	84	1974	Orioles	104
1906	Braves	84	1901	Braves	104
1973	Angels	83	1971	Orioles	101
1980	Orioles	82	1978	Giants	100
1975	Orioles	82	1970	Orioles	100

The lists are not identical, but there is a lot of overlap. The Dodgers make the list twice with the 1966 and 1975 teams, but it is amazing to see that the Orioles occupy half of the ten single rotation spots and four of the 10 combined rotations, but not all for the same years! For the 11 seasons from 1970 to 1980, they were on one list or the other seven times. It is hard to imagine that such organizational stability will come again. My wife Amy, a longtime Orioles fan, developed a nice analysis of the transition from one group of starters to the next over this period, examining exactly which pitchers were added or subtracted each year due to trades and/or injuries.

The last point I wish to make about the 4-man rotation is to note that the 1966 Dodgers only used five starting pitchers as well, being the first team to do so since 1904, when the number of starters was still expanding. However, unlike the 2003 Mariners, the 1966 Dodgers did not distribute their starts evenly, as shown in Table 12.

Table 12. Starting pitchers for 1966 Los Angeles Dodgers

Sandy Koufax	41
Don Drysdale	40
Claude Osteen	38
Don Sutton	35
Joe Moeller	8

However, the rotation was a very stable 4-man group as we saw. Of Joe Moeller's 8 starts, 5 came in doubleheaders, two were after Sutton was hurt in September and the other was two days after the team's first doubleheader of the season, in which Sutton and Drysdale started.

Summary:

1. Three different approaches were used to evaluate starting pitching staffs:
    a. Number of pitchers needed to reach a threshold of games started.
    b. Average number of days or games of rest
    c. Direct analysis of starting pitcher sequence.
2. The threshold approach shows that the average team has changed little in the last century.
3. The most frequent number of games of rest per team has progressed through history. All teams now follow a predominant 4-game (5-man rotation) pattern.
4. Sequence analysis shows more variation between teams than the other methods.

Conclusions:

1. Strict rotations of four or five men are not observed.
2. Most teams show general stability.
3. Rotation pattern has very little relation to team success