

STAT 847 WINTER 2019

FINAL PROJECT

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## How NBA has changed

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## 1. Introduction

NBA, the National Basketball Association, was founded in 1946, and has developed to be the most famous basketball league in the world nowadays.

As a basketball lover, I started to watch this game when I was 12, I still remember the unstoppable performance by ‘The Flash’(Dwyane Wade) in 2006 finals and my first basketball idol, MVP, Steve Nash. Nearly 15 years passed, from Kobe to Curry, I have been sitting in front of the screen and witnessing endless miracles and Movings . Until someday, people started to discuss about big changes happened in NBA, I started to think about the game I love. Does the NBA really change? If it does, How?

In this project, we try to find this answer by exploring the statistics of every single NBA players’ performance during 37 years(1980-2017). The reason I choose the start year to be 1980 is because this year, 3 points has been introduced in the game, which is a symbol of current basketball game and completely improves the game to a whole new level. In addition, since the topic of changes is very big, we mainly focus on the changes in terms of 3 positions in the game,namely, Center(C), Forwar(F), and Guard(G). Players in Those 3 positions usually have their own speciality, and their unique abilities are indispensable for a team to win. Our research scope includes but not limits to the changes in their Body shape like height and weight, as well game statistics such as points and assists. Hopefully, from the exploratory data analysis of NBA players on 3 positions, we can conclude how the NBA has changed in nearly 40 years.

## 2. Data

### 2.1 Dataset Description

Our dataset, ‘NBA Players stats since 1950’, is from Kaggle(<https://www.kaggle.com/drgilermo/nba-players-stats>). It is composed by a small player\_data(4551 \* 8) and a big seasons\_stats\_data(24.7k \* 53). The player data records every NBA players’ basic information like positions, height and weight. The seasons stats data contains every players’ annual statistic data in the game, for example, points, assists, rebounds, and some advanced basketball index like plus/minus values. We will also use a mini data(40\*32),‘NBA League Averages - Per Game’([https://www.basketball-reference.com/leagues/NBA\\_stats\\_per\\_game.html](https://www.basketball-reference.com/leagues/NBA_stats_per_game.html)), as a supplement in the very first part for warming up.

### 2.2 Dataset preprocessing

Firstly, we unify the players’ names in player\_data and seasons\_stats\_data data. Since some of the names in seasons\_stats\_data have special symbols representing All-star player or Hall of Fame winner, we remove those special symbols. Then, we can join those two dataset by players’ name and also their career period. We also use career period when joining,as some players have the same name. Secondly, because our study population is all players after 1980, we filter the data using year after 1980. In addition, 8 kinds of positions including players’ major positions and minor in raw dataset are aggregated into 3 positions by players’ major positions. We also convert the format of height from character into numeric, and create a new variable named ‘decades’, which divides the period of 1980-2017 into 4 10-year period(last one 2010 only has 7 years.)

## 3. Main part

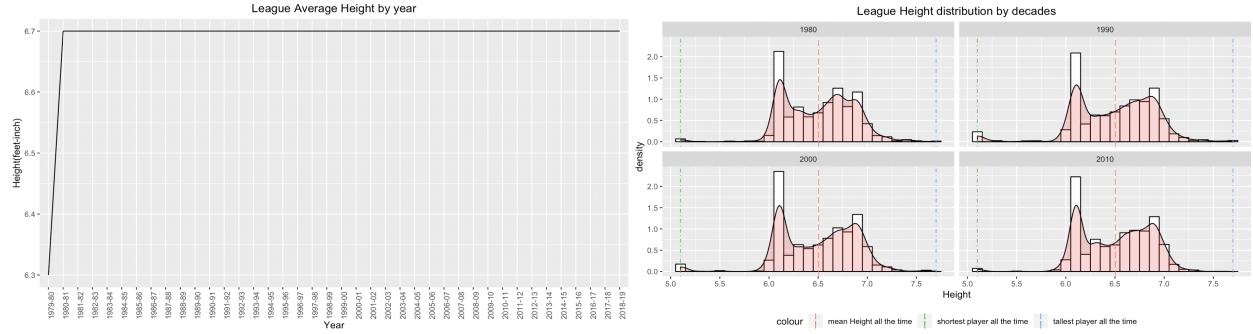
In the main part, we first look at the changes happened in the whole league as a general overview, then we narrow down those changes to 3 positions and compare the different among 3 positions in 37 years. Lastly, we discuss about the top players in 3 positions to see how we define ‘top’ in each decade and how those top players impact the league.

## 3.1 Changes of the whole league

### 3.1.1 bio-stats changes

No matter what kind of sports we are talking about, the physical quality of an athlete is always the key to success, especially for such a highly competitive league. Let's first look at those super basketball players' body condition.

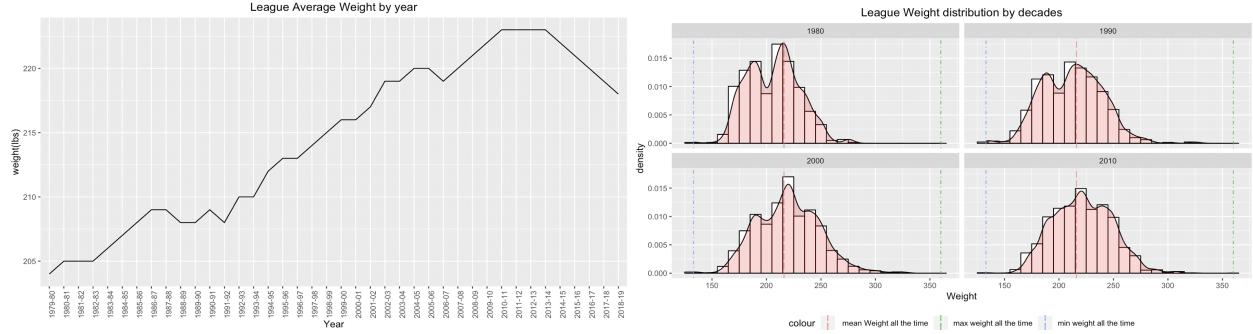
For most people, Height and Weight are biggest thresholds to enter NBA. Because of the better nutrition we have today, people become taller and stronger, then what about those players?



The left line chart shows leagues average height in 37 years. We can see that the average height of NBA players has a rapid increase in 1980, from 6.3 to 6.7, then the average height has stabled for 37 years.

The density plot on the right shows the height distribution of every NBA players in 4 decades. It is clear that the shape of the distribution rarely change in 4 decades. Interestingly, although the mean height of all the NBA players in history is 6.5 and the tallest one is 7.5, there are some shortest players whose height around 5.6, and the number of those relative short players is increasing in 1990 and 2000 decades.

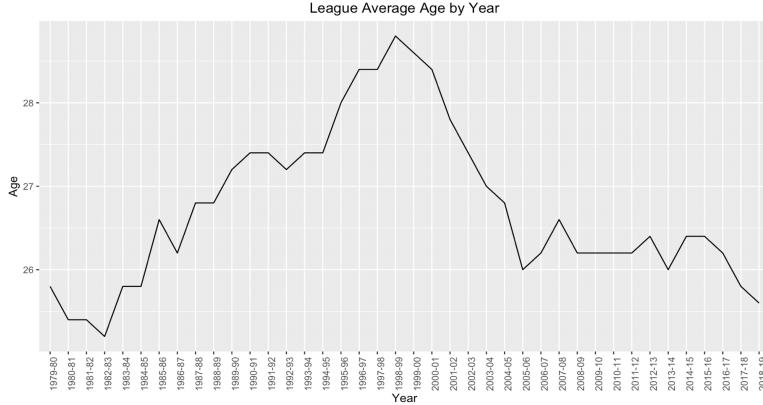
Besides height, weight is also an important physical factor of a good player. Stronger players have absolute advantages on body contact, while too heavy players are not so flexible when moving on the court.



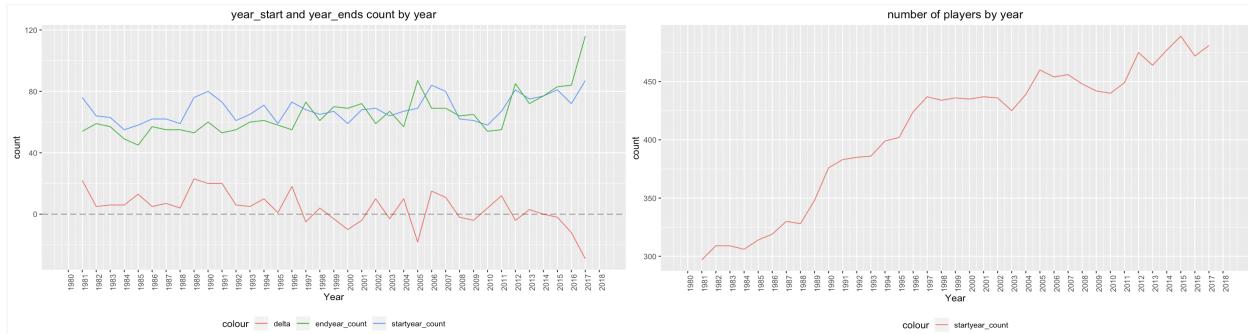
From the left line chart we know that the average weight of NBA players has a steady increase over the first 30 years, peaking at 222.5lbs in 2011, and remained stable for 3 years. In 2013, the average weight started to declined, reaching 217.5lbs in 2018.

One the right side, It is clear that in the decade of 1980, most players weight are lower than 217.5lbs, the average weight of NBA players all the time(1980-2017),while after 1990, the number of players heavier than 217.5lbs gradually increased. In the decades of 2000 and 2010, there are already half of the players weight over than the average weight of 37 years.

Age is another significant factor for Athletes, NBA players' age are often from 25 to 30 with an average career length of 4.5 years. For some old players, although their body are in good shape, they have to retire due to the lack of long stamina and quick Reaction, while some outstanding players like Vince Carter can still be a start up player in his 40s.



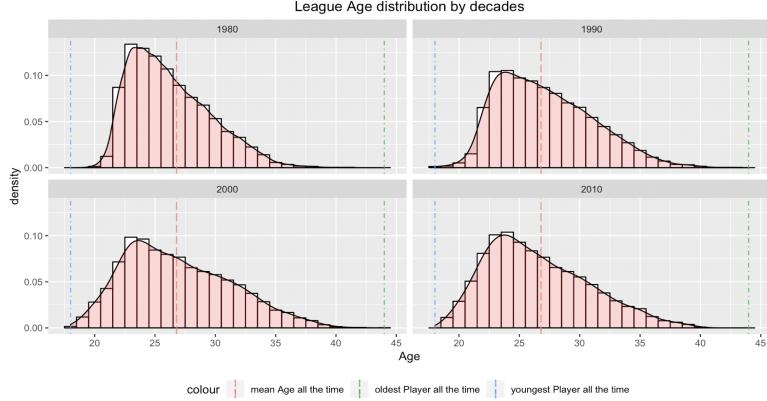
As we can see from the chart, the average age has dropped from 26 to nearly 25 in during the first 3 years, then it constantly rised to over 28.5 in 1999, which suddenly fell down to 26 in 2006. After a 10-year fluctuation by 2016, the average age declined again. When I look at this line chart, I started to ask why there is an apparent up&down trend in the 37 year? To figure out this question, I researched on the total number of players in the league each year and players' start year and end year.



In the left line chart above, the blue line represents the number of first year players(rookie) in every year, the green line shows the number of players who retire in that year, and the red line is the difference between those two numbers, which means the increase and decrease of the total number of players in the league each year. The line chart on the right shows the total number of players for each year.

We can find from the left chart that from 1980 to 1998, the blue line always above the green line, and the red line is above 0, which means the number of people entered NBA is more than people left, so the total number of people in the right chart keep increasing in this period. However, after 1998, the red delta line in the left chart consistently fluctuates around 0 until 2010, meanwhile, both the green line(retire) and blue line(rookie) had a increase trend during this period. In other words, from 1998 to 2010, the total number of NBA players stay the same, while accompanying by a large number of elder retired players and entered young rookies, and this replacement of old to new generation significantly pull down the average age of NBA players.

For more information about the average age in 37 years, we can see the density plot of every players' age in 4 decades below:



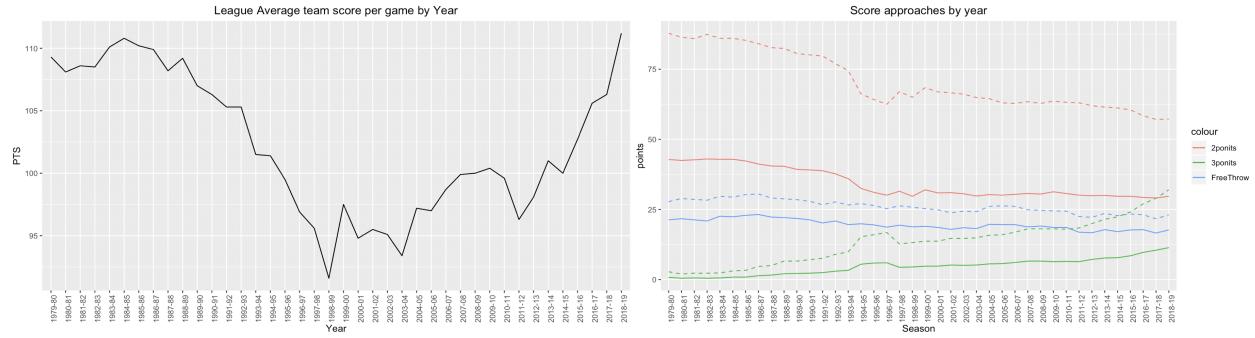
We can find the same conclusion in this distribution plot. In the decades of 1990, as players getting older, and right skewness of the age distribution weaken than before, while after 2000, the right skewness become clearer due to the replacement of old players by young players.

From analysis above, we can conclude that although the average height of NBA players does not change in the 40 years, their weight experienced a huge increase, and the average age become younger after old players' retirements.

Next, let's see the change of bio-stats can bring what kind of influence for the game.

### 3.1.2 Game-stats changes

The most important rule in a basketball game must be the team who scores higher is the winner. When we talk about the game, we first look at the scores.

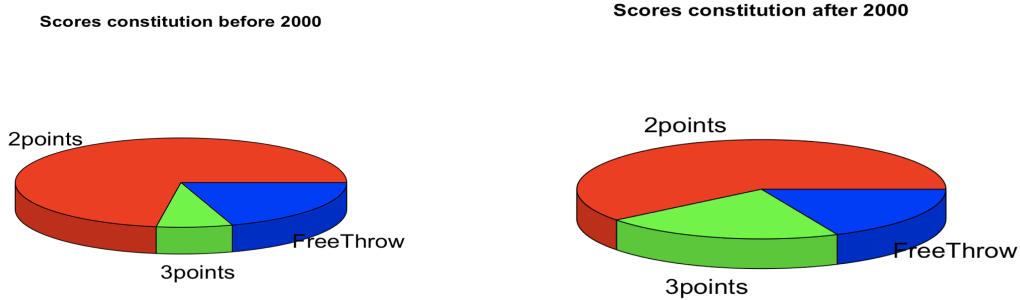


The left line chart above shows how the average points of a team in a game changes, and the right plot decompose those shooting into 3-points, 2points, and free throws. In the line chart on the right, the dash lines represent the average of number attempt shootings per game, and the solid line means the number of scored shooting per game.

It can be seen from the left that the average score per game suffered a big decrease from 1980 to 1999. After a remarkable fluctuation, it shoot up again in 2012, and jumped back to around 110 points per game in the 2018-2019 season. The right chart perfectly explained the reason behind this changes on score. In 1980, when league first introduce 3 points, we can see the green line lies around 0, and few people scored by shooting 3s, even the number of attempted 3 points are very low. Most player scored by 2 points and free throw. The first change happened around 1988, the green dash line has a rapid rise, which means more people started to shoot 3, but the result of this was not good. Because their low shooting percentage of 3 points, the average scores dropped a lot. Then they stopped trying 3 points and switched back to the more efficient 2 points. 10 years later, after the big streak of NBA in 1998, the trend of 3 points came again, more people shoot 3 points, but they failed again due to the low percentage. However, after the second streak of NBA in 2011, the 3 points become unprecedented popular, and the percentage of 3 points shooters also improve a lot, which directly

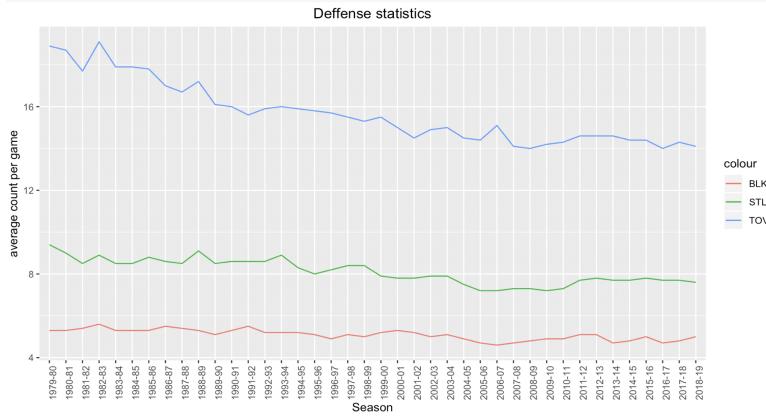
causes the huge jump of average total points per game. Meanwhile, as both the number of attempted 3 points and scored 3 points increased, players shoot less 2 points and less free throw.

We can also how the role of 3 points changes in the 37 years by the two pie charts below.



Those two pie record the composition of total score before 2000 and after 2000. From left to right, we can see the volume of the green part(3 points) nearly triples. Although the volume of the blue part(free throw) only decreases a little, the red part(2 points) shrink a lot.

Defense is also a key part in a ball game. In basketball, we often evaluate the quality of defense by block, steal, and turnover. The higher those technical statistics are, the more competitive of the game, and the better the defense.



We can see that although the number of turnover has decreased in over the first 10 years, the overall defense standard did not change a lot. However, after 1992, all 3 technical statistics gradually fell, especially turnover, which reflects the extend of defense become weaker. Players were not so hustle to fight for the ball as before. On the other hand, players were taught to avoid playing inside the area near the basket with a high risk of turnover. The decreasing number of blocks also confirm the changes that less competitive and intensive in both offensive and defensive plays happened near the basket. Whereas, we can also see the number of steals went up again in 2011. This is the time that many teams began to emphasize on defense, while under the big trend of 3 points and fast break, the quality of defense in the league has a severe drop from 1992.

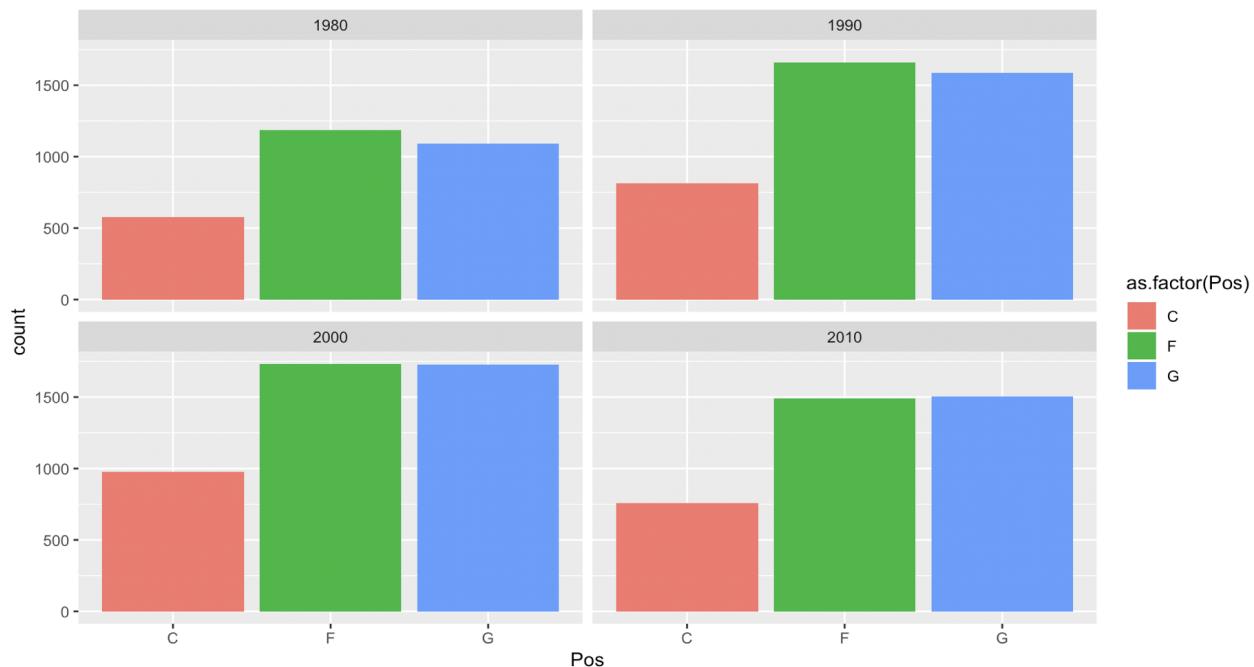
Overall, the improvement of players' physical quality does not promote the intensity of the game, instead, because the Modern basketball encourage more 3 points and fast break, the role of offensive become more important than that of defense.

### 3.2 Changes in terms of 3 positions

Center(C),Forward(F) and Guard(G) are 3 position on the court. Traditionally, Centers are the tallest and strongest, they are good at body contact and attacking under the basket, Guards are the shortest but the fastest, they also have wide range of shooting ability. Forwards are the most well-rounded position, they possess both center's physical strength and Guards' speed. In this part, we will explore how the roles of 3 positions changes in 37 years due to the current big trend of NBA.

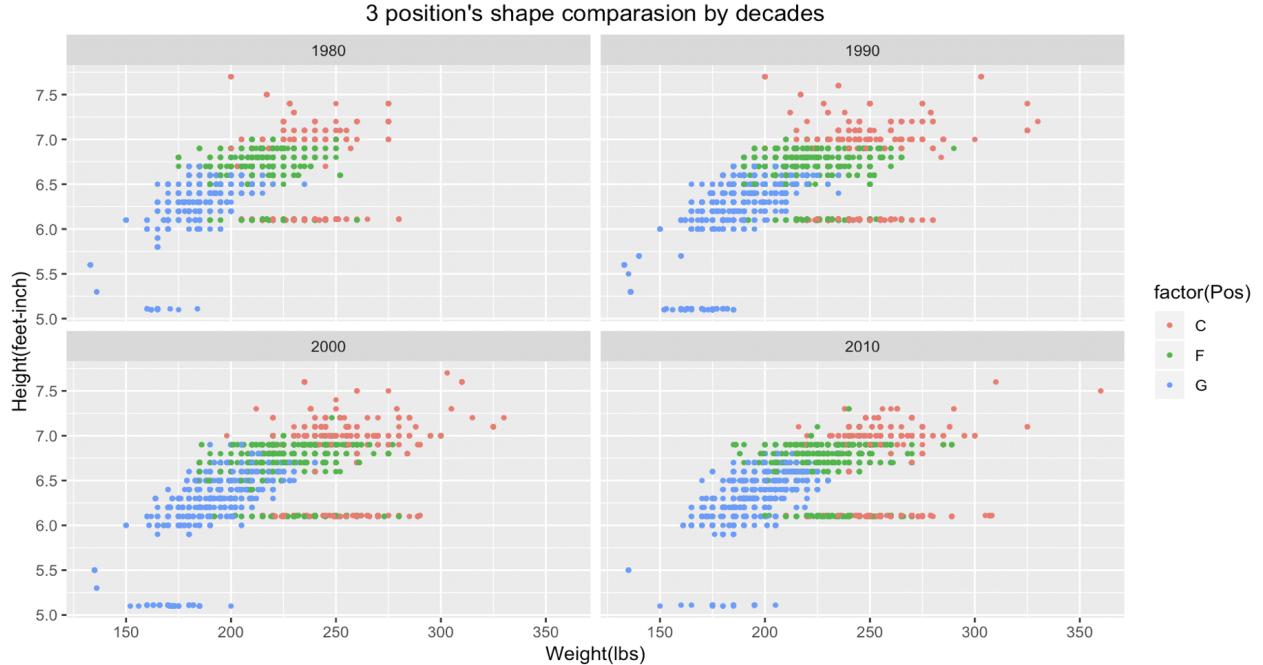
#### 3.2.1 General changes in terms of 3 positions

First, let's see how many players are there for each position in different decades.



The bar chart above shows information on the number of players in 3 position during 37 years. It can be seen that in the first 2 decades, the number of Forward is slightly more than that of guard, and those two numbers are nearly the same in the last 2 decades, while the number of Center are the least all the time. Moreover, after 1990, there is a rapid increase of the number for both G and F followed by a steady growth. The number of Center rised continuously from 1980 to 2000, but it dramatically decrease from 2010. In conclusion, there is always a scarcity of Centers and excessive number of Guards and Forwards.

Another interesting point is how the shape discrepancy among 3 positions changes during this period. We visualize every players' height and weight by a dotplot, and divide them into 3 groups by different colors. Red for Centers, green for forwards, and blue for guards.the x-axis represents weight and y-axis represents height.



From the aspect of weight, in the top left plot, the boundary between guards(blue) and forwards(green) is very clear. There is few guards has height over 6.5 and below 6. However, after 1990, many guards'(blue) height exceed 6.5, some guards even taller than 6.75, and the number of shortest guards also increased. Although the boundary between Forward and Center does not change, interestingly, there are always some relative short center around 6.2 and extreme tall center over 7.25, the number of those outliers has increased sinc 1990. In the decade of 2010, the number of huge substantially decreased, the scarcity of good center become more serious.

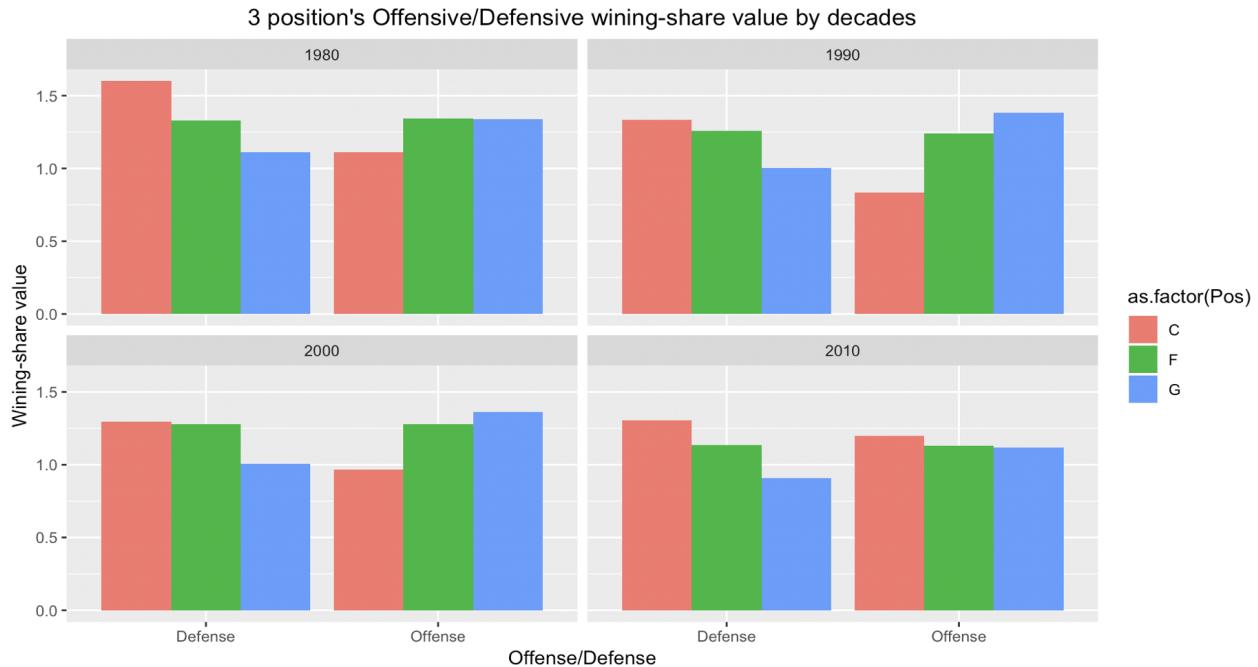
From the aspect of weight, in the decade of 1980, there only a few guards weight over 200lbs, while in the decade of 2010, the average weight of guards is 200. Forwards' weight also gradually expanded. The weight of Centers experienced a fluctuation, peaking at over 300 in 2000, while their shapes shranked to the same level as some powerful forwards.

Overall, both the physical quality of guards and forwards improved in the 37 years. For centers, their shape became larger in the first decade, but seriously weakened after 1990. In the last two decades, we can see many green points overlap with red points, which means the shape discrepancy of 3 position become less apparent than before.

### 3.2.2 game-stats in terms of 3 positions

In the last part, we notice that the shapes of players in differents positions became less different. In this section, we will see how this change influence the offensive and defense in 3 positions.

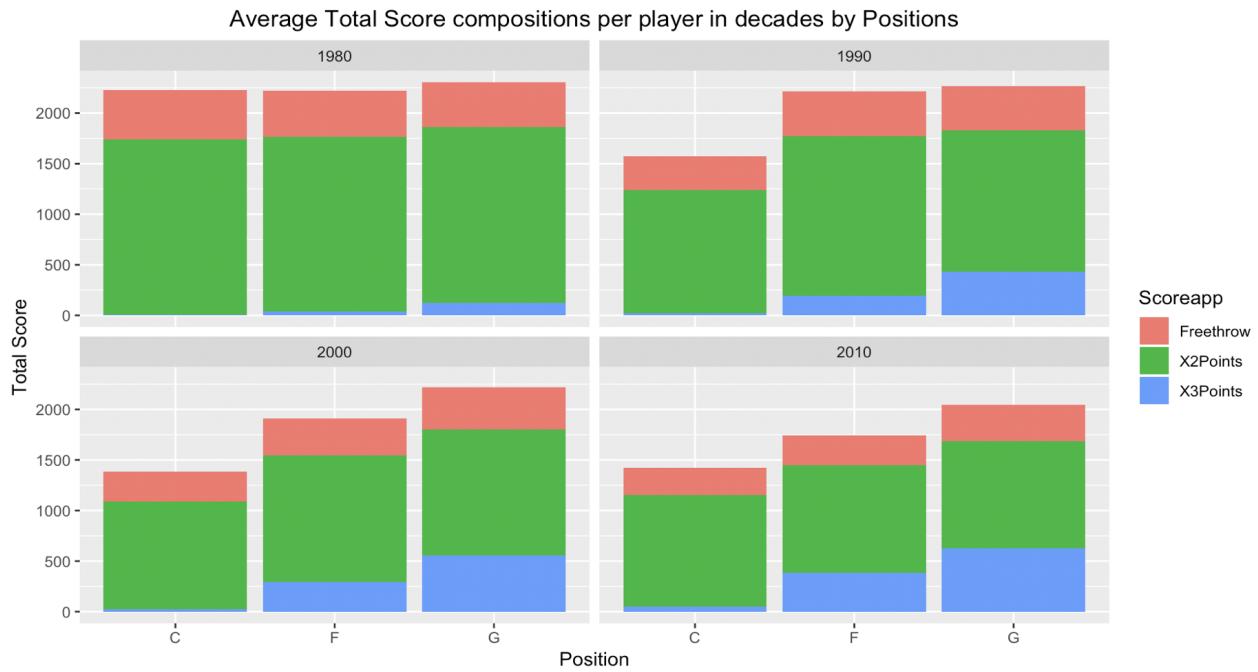
Offensive and defensive wining shares are two popular index to evaluate players' contributions in the Offensive side and defensive side for wining a game. We can use this index to compare the performances of players in different positions.



The bar chart above shows the average offensive and defensive wining-share for 3 positions in 37 years. Bars are filled with 3 colors according to positions.

It can be concluded from the graph that on the defense side, centers has the highest wining share over the 4 decades, which means they play the most significant defensive role in winning a game, although their defensive wining share slightly decrease after 1980. The defensive wining per shares of Forward are stable, which always ranks the second and only declined a little in the decade of 2010. Guards' contributions in defensive side are the least. Conversely, in the offensive side, Guards have the most contribution, and centers' wining-share are the least. However, after the decades of 1990, the offensive wining share of centers started to climb, and amazingly, it exceeded the offensive wining share of both guards and forwards in the last decades. This is a very important and interesting result of in our analysis, in the trend of 3 points and fast break, although it seems that guards who are good at long-range shooting and breakthrough will dominate the game, while the key to win a game is centers on both defensive side or offensive side. The reason for this unexpected result might be the scarcity of tall centers in league. Once a team has a excellent center, it will become the absolute advantage over other teams.

Next, we analyze the changes from the aspect of points and scoring approaches. Basically, there are 3 kinds of scoring ways, 3 points, 2 points ,and free throws. Players in different positions usually have their specialities in scoring.

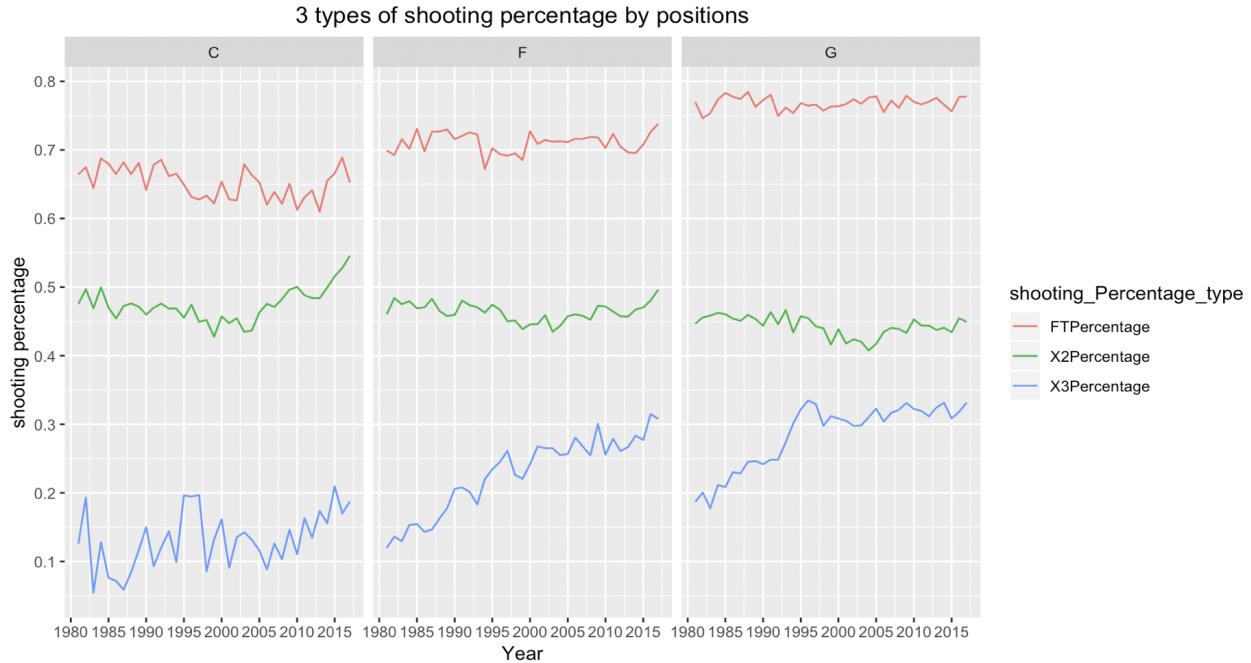


The bar chart above compares the average total points per player in different decades by 3 positions. Every bar in the graph is also divided by 3 parts representing the composition of scores.

It is clear that guards total scores ranks the first over the 4 decades, and the total score difference between guard and forward increased in the last two decades. Forwards score the second most score, their scoring ability slightly decline after 2000. Players who are centers score the least, although they could score as much point as forwards and guards in the decade of 1980, their total scores in a decade plunged in the decade of 1990, and leveled off at below 1500 points per person.

From the aspect of point composition, although the constitutions of points in 3 positions are similar, after 1990, guards and forward shoot more 3 points. In the last decade, for guards and forwards, their average total scores of 3 points are over 4 times as much as that in the decade of 1980. Moreover, in the first 2 decades, there were few centers scored by 3 points, while after 2000, many centers began to shoot 3s.

As a conclusion, influenced by the big trend of NBA, the role of 3 points in offensive become more and more important, most players in the league start to shoot 3s, even for players in big sizes. Meanwhile, the total score of 2 points continuously has declined in the 37 years, and scores of free throws remained the same. Therefore, we can say that, in the nearly 20 years, guards and forwards prefer to shoot 3 points and create chance to get free throw by breakthrough, rather than the middle range shoots.

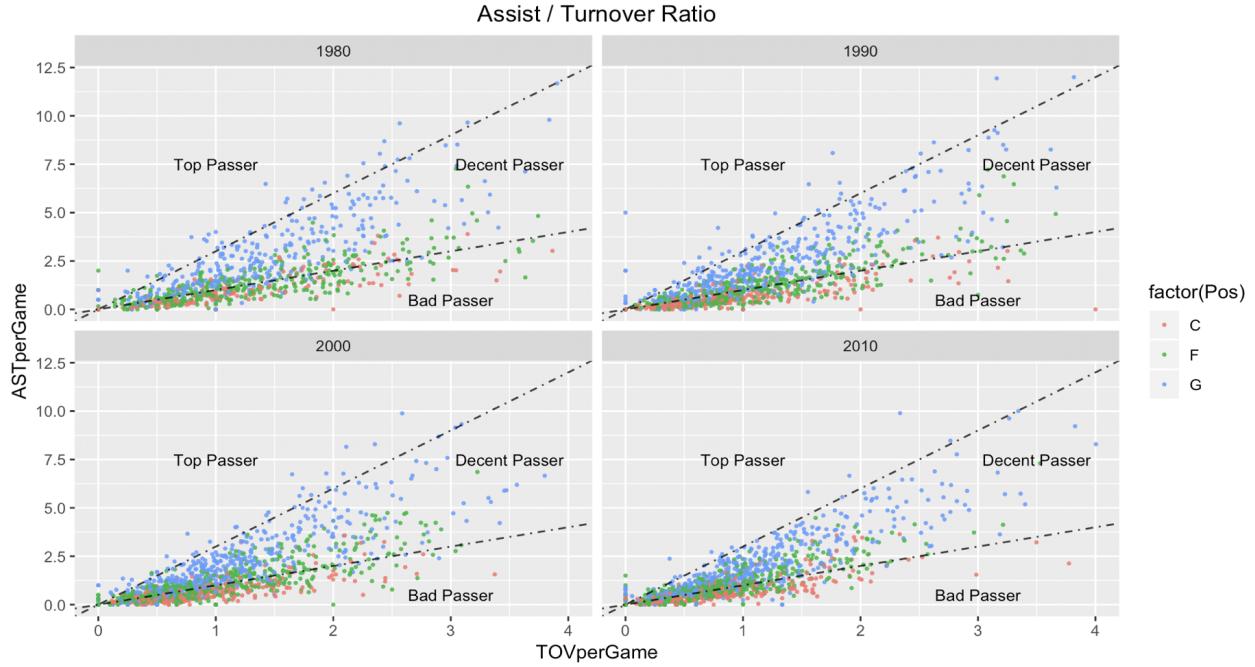


When we talk about scores, we should also talk about shooting percentage. 3 lines in the chart above illustrate each position's 3points, 2 points, and free throw shooting percentage in 37 years.

We can see from the chart that guards have the highest 3 points and free throw percentages, while their 2 points shooting percentage are lower than players in other 2 positions. For Forwards and guards, their 3 points ability has a significant improvement in the 37 years, the gap of 3 points percentage bewteen those two also narrows a lot. Moreover, the 3 point percentage of forwards also exceeded 30 percent, this achievement makes forwards possess excellent shooting ability in both 2 points and 3 points. As for centers, their 3 points shooting percentage also markedly increased from 1995 and 2000, and rised again after 2006. The reason for this phenomenon might be in the past, coaches would not allow centers attempt 3s, and centers only shoot 3 when they were forced by the attacking time limit, and those shoots without sufficient preparations rarely goal. However, infulenced by the trend of 3 points, now coaches will arrange strategies to let big players who are also good at shooting to shoot 3 points, so more and more centers will shoot 3 points in the games, and their 3 points percentage also rise.

In the offensive side, besides score, assist is also an important attacking approach. A brilliant passer not only destroys opponents' defense, but also help their teammates to become better. However, assists often accompany with the risk of turnover, so how to get more assist with less turnover become the key to success, and we have this special index, assist-turnover ratio, to evaluate plays' ability of assist.

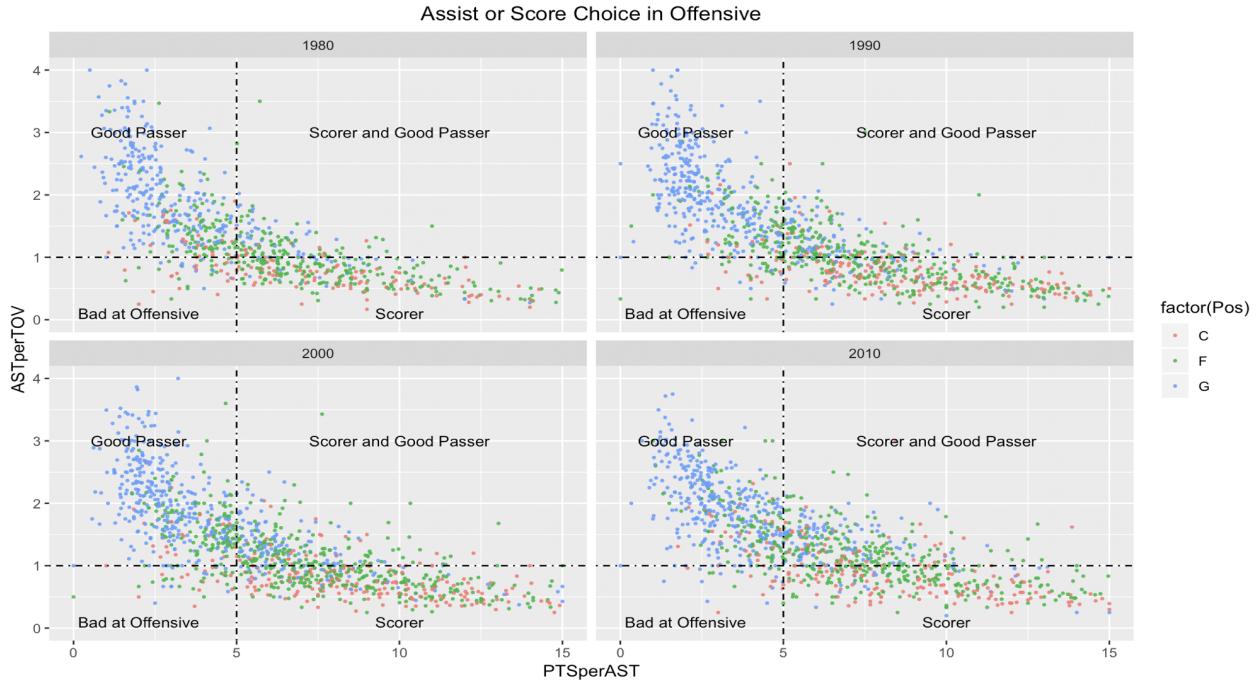
The dot plots below shows players' assist-turnover ratio in 3 positions. Points are colored by position, and charts are listed by decades. We divide every plot into 3 areas by two slope lines(assist-turnover ratios equal 1 and 3). We also define players whose assist-turnover ratios lower than 1 as bad passer, whose assist-turnover ratios between 1 and 3 as decent passer, and whose assist-turnover ratios above 3 as top passer.



As we can see from those plots, gurads have the most assists all the time, and their assist-turnover ratios are often the highest. There are even some blue points(guards) in the area of top passer, while those top passers has almost disappeared in the last decades. In the middle area(decent passer), most of points are blue, but it is not hard to find that many red and grenn points also emerged in this area in the last two decades. Especially in the decade of 2010, many red points have shifted from the bad passer area into the decent passer area, and the number of bad passer in the league decreased a lot compared with the situation in the former decade.

Therefore, we can conclude that guards' pass ability were decreasing over the 37 years, while forwards and center became better at passing, especially in the recent 10 years.

Then how the changes of passing ability impact players choices in offensive? Will there be more big players swithing from scorer to passer because of their improvement of overall passing ability? let's find the answer in the following graph.



This graph shows players assist-turnover ratio as well as the points-assist ratio, namely, how many score players can get when they make an assist. This index perfectly evaluate the players' offensive tendency of whether pass or shoot.(we ignore 311 players who do not have assist in the game) The X-axis represents point-assist ratio, the higher the point-assist ratio, the more likely the players will shoot in offensive rather than pass. The Y-axis represents assist-turnover ratio. We also divide the plot into 4 areas, namely 'scores'(x>5, y<1), 'good passers'(x<5, y>1), 'scorer and good passer'(x>5, y>1), and 'Bad at offensive'(x<5,y<2). If two indexes of a player are both high, then we can say this player is not only good at scoring when offensive, abut also make the rigth decision to pass when needed.

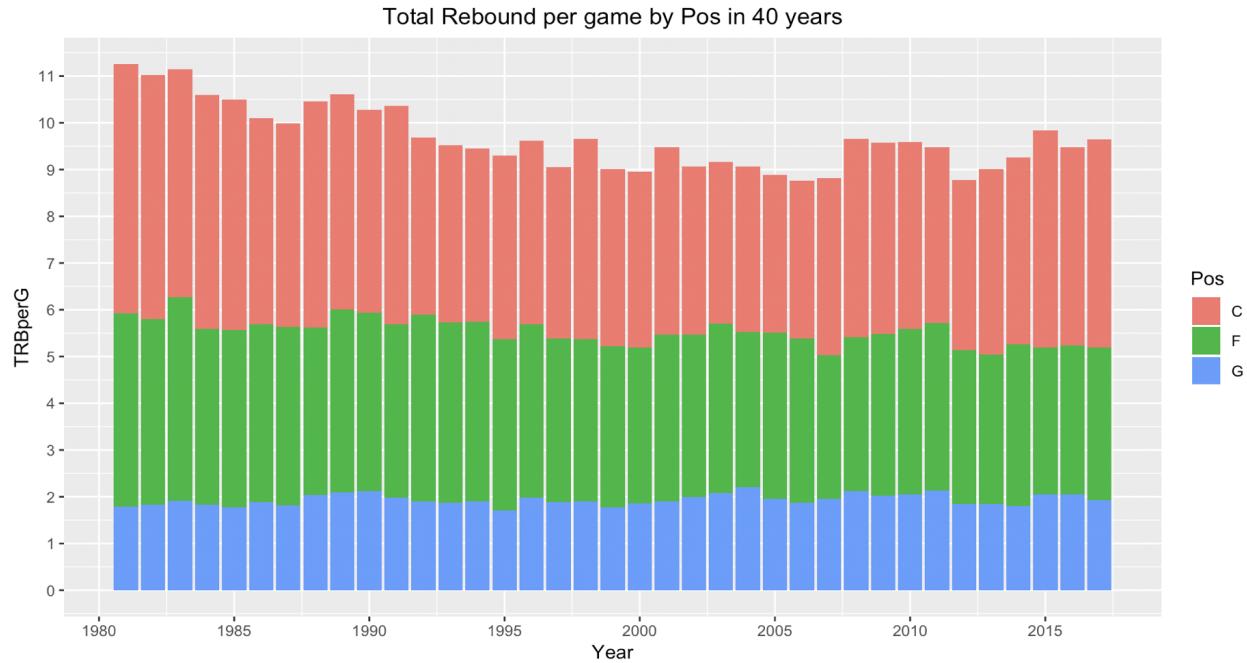
From those dot plots above, we can see that the boundaries among points in different colors are clear. The area of 'good passers'(x<5, y>1) is fulled of blue points(guards), most point in the area of 'scores'(x>5, y<1) are green(forwards) and red(centers), and there are only forwards in the area of 'scorer and good passer'. Wheras, from 1990, more centers and guards also became the type of players who and both pass and score, and the number of well-rounded players gradually increase every decade. In the decade of 2010, there are already many blue points(guards) and red points(centers) in the top right area. Moreover, after the decade of 2000, centers and fowards not only specilized on scoring, many of them also became good passers. Meanwhile, in th area of 'scorer', we can also find many blue points(guards),which means the scoring ability of guards has also enhanced over 4 decades.

Overall, when we talk about players' offensive choices, in the aspect of passing, although guards' assisting ability are the strongest all the time, while forwards and centers also improved their passing ability since 2000. In the aspect of scoring, guards and forwards are better, there were also some top scorer as guards after the decade of 1990. In the last 2 decades, the number of offensively well-rounded player has soared, which is the trendency of the league's development.

After we discuss so much about offensive, let's talk something about defense. After all, good offensive is the key to win a game, but good defense is the key to win a champion.

People always say that the court belongs to team who get more rebounds, in other words, the team getting more rebounds own more chance to offensive, thus more likely to score higher.

Next, we discuss changes about rebounds in terms of 3 positions.

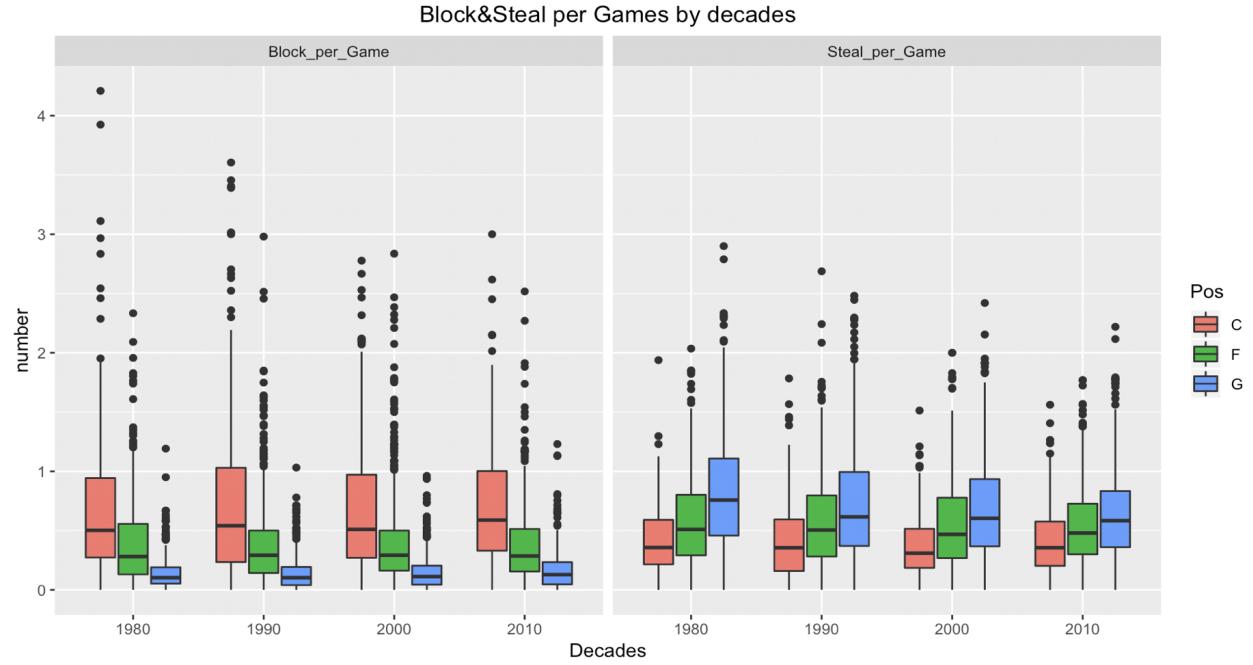


The bar chart above gives information about players' average total rebound per game by years. Bars are divided into 3 parts representing the number of rebounds got by corresponding positions.

From the graph we can find the average total number of rebound per game experienced a decrease over the 37 years. However, the length of blue bar always stay the same, which means guards ability of rebound improved as the percentage of rebound got by guards increased. Contrary, centers and forwards gets less rebounds than before, especially forwards. After the fluctuation of total number of rebounds during 2007 to 2012, it rised again in 2012. The number of rebound gained by guards remained stable after 2012, and its percentae decreased. The number of rebound got by forwards and centers began to increase from 2012.

Overall, guards' ability of rebounds gradually has enhanced in the period between 1980 and 2007, while after 2012, forwards and centers' advantages on rebounds due to their bigger body shape came back.

Steals and Blocks are also popular aspects to measure players' defense. Let's see how those two game-stats changes.



Boxplots above show the average blocks and steals per game of players in decades, different colors represent corresponding positions.

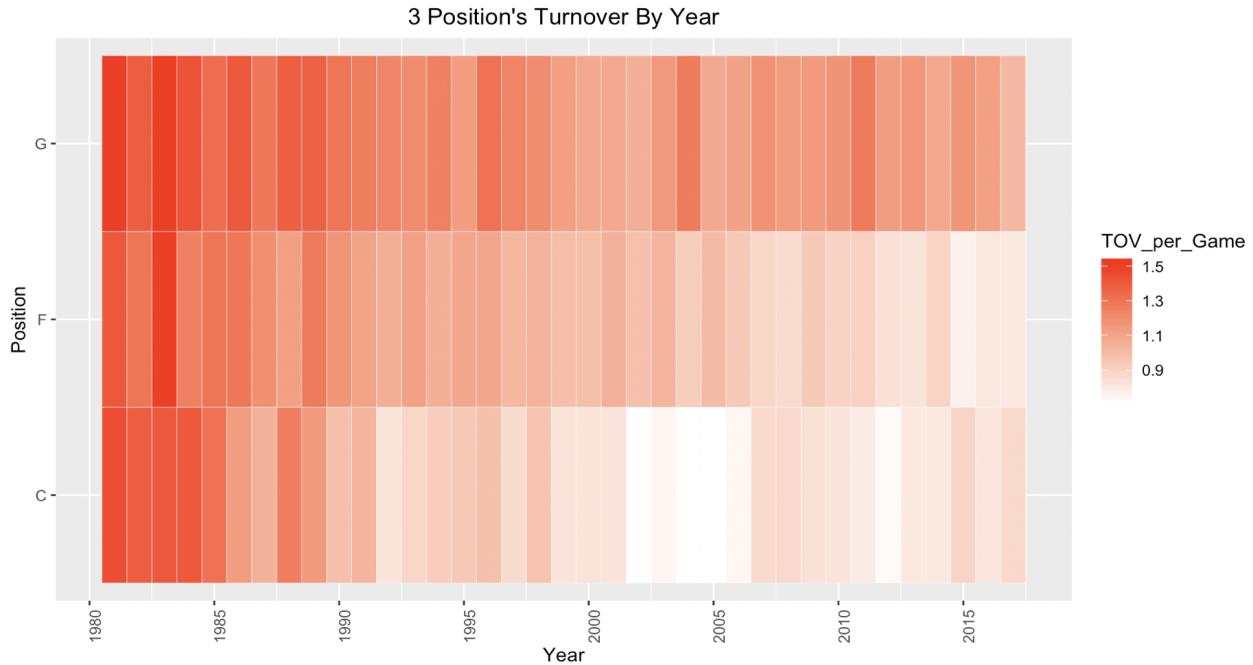
As we can see from the left graph. over the 37 years, centers have the most average block per game, and their numbers of block per game in 4 decades are pretty stable around 0.5, keeping an advantages of blocks among 3 positions. While we can see centers' outliers meaning masters of blocking constantly decreased in the first 3 decades. In the decade of 2000 and 2010, the number of centers whose average blocks per game over than 1 even less than that of forwards. Therefore, although the general blocking ability of forwards does not change a lot, but the number of top forwads who are good at blocking gradually increased. Moreover,some top forwards' blocking ability exceeded that of centers' in the decades of 2000. For guards , because of their height limitation, they ranked the last in all 4 decades, and there only a few guards whose number of blocks per game can reach the average number of forwards'.

In the right graph, it is clear that the average number of steals per game of guards is the highest over 4 decades. However, we can find both the 4th quantile and those outliers of blue boxplots(guards) dropped during this period, which means the number of top defensive players in guards has decreased. Forwards have the second highest number of average steals per game, and the steal ability of both forwards and centers have not changed over 4 decades. Interestingly, in the decade of 1990, there were some forwards having more steals per game more than guards, while we could not find such top forwards latter.

We can conclude that players in 3 positions have their own strength on defensive side, centers often have more blocks, and guards are better at stealing. However, after the year of 2000, as the blocking ability of centers and the stealing ability of guards gradually weakened, those top defenders as forwards became the best defenders in the league.

To win a game, limiting the number of turnovers is another important element, since a turnover means not only lossing a chance to score, but also giving an oppoerunity of a fast break to opponent.

We display the number of turnovers per game created by 3 positions' players over the 37 years in the heatmap below. The darker the color, the higher th e number of turnovers.



It can be seen from the graph that the number of turnovers experience a decrease for all 3 position during 37 years. After 1990, the extend of decrease in turnovers'numbers per games for forwards and centers became more apparent. It is also noticeable that the number of turnovers per game for for forwards and centers are the least in the period between 2003 and 2007, which were close to 0. For guards, their turnover numbers remained stable in 1990 after a consideravle decrease from 1980 to 1990, while their turnovers are the most among 3 positions all the time.

Overall, as the intensity of defense has decreased in the last 20 years, as well as the preference of long-range shooting, the number of turnovers are much less than before, while after 2010, as more centers and forwards attempted to assist, more turnovers were created again.

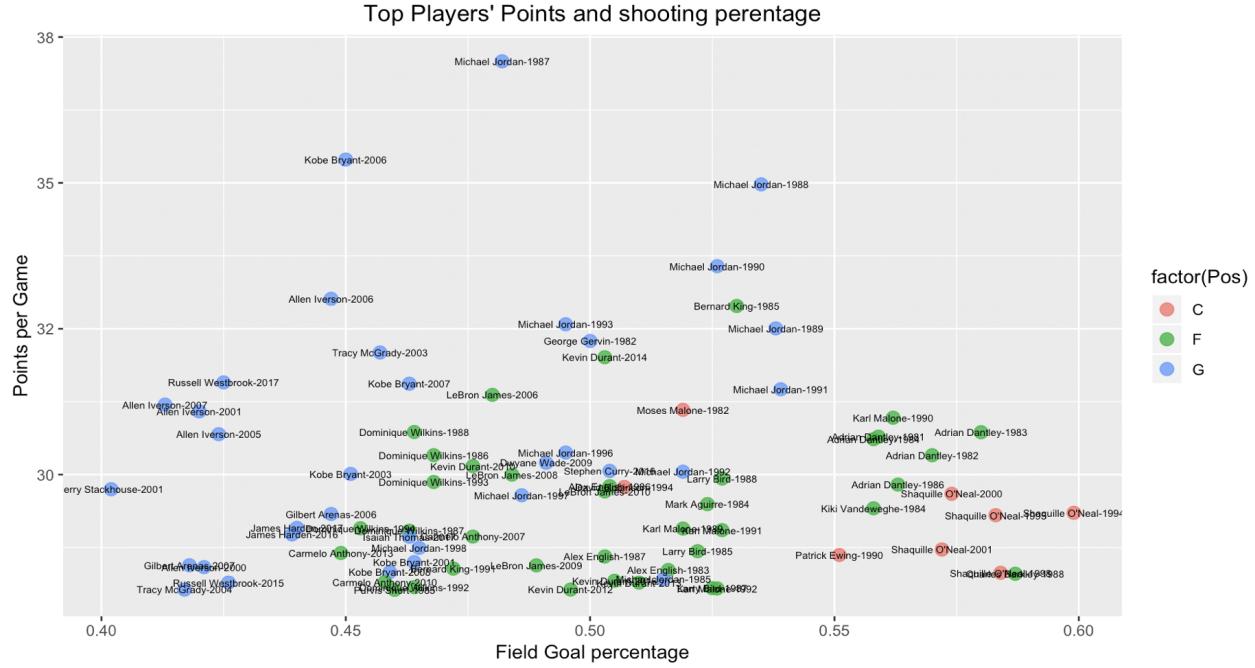
In this section, we have discussed the changes of 3 positions' players in both offensive and defensive sides under the big trend of NBA. On offensive side, 3 points become unprecedeted popular, even players in huge shape start to score by shooting 3s. Moreover, the number of assists in a game increases, centers and forwards also improve their assisting ability to be more comprehensive. On the defensive side, rebounds do not only belong to centers anymore, many guards and forwards also possess the capability to get rebounds. The game has transformed from mainly physical game into high scores and fast break fashion. As a result, the intensity of the game significantly reduced, which leads to weaker defense and less turovers.

### 3.3 Changes of top players

People always love heros. NBA is the place where heroes are born. Every evening, they stand up when teams need them, use their incredible performance to save the city, and win the game. They are so outstanding that enough to change the tendency of the game, while those heroes are also infuenced by the league.

In this part, we will discuss about those top players who dominant the game in 37 years. We compare top players in different positions and analyze the similarities and differences of top players in distinct decades.

Firstly, let's see who is on the leader board of scoring all the time.



In the graph above, we filter players who have average over 28 points with a shooting percentage above 0.4 per game in a season and visualize their performance on the dot plot. Every dot are labeled with the season and player information, and are filled with colors according to the position of the player.

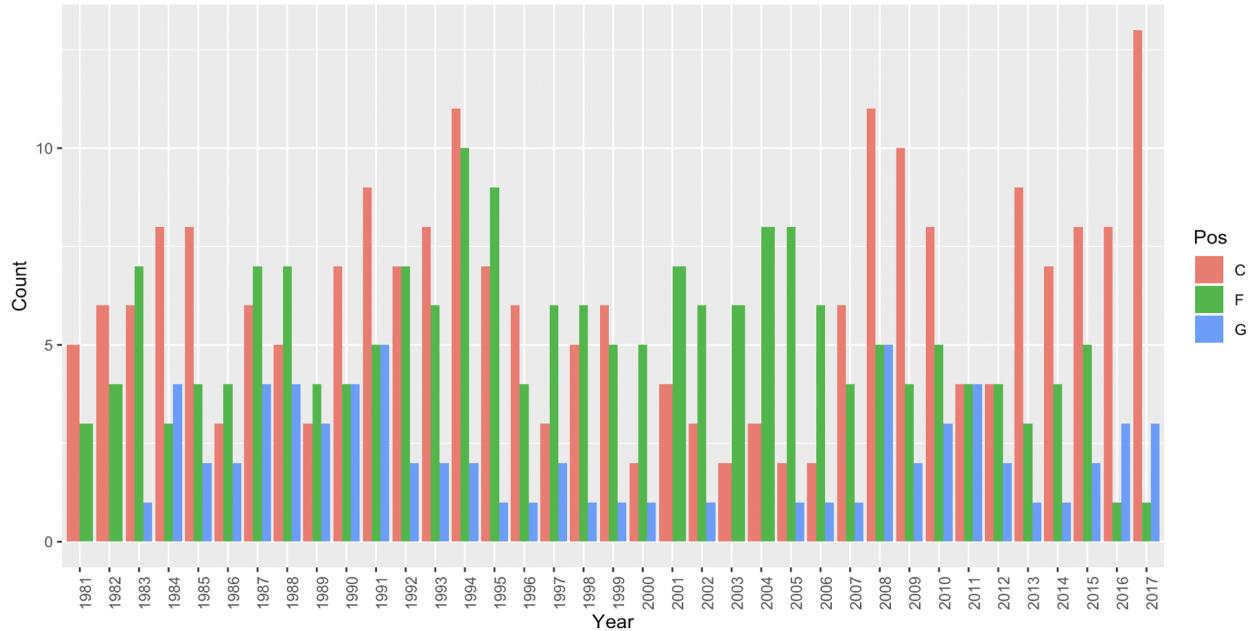
As we can see from the graph, among those top scorers, the number of guards is the most. However, although those top guards score the most, but only a few of them having a shooting percentage over 50 percent. But there is an exception, Michael Jordan, not only did he achieve more than 35 points per game in both 1987 and 1988 seasons(historically, only Kobe Bryant and Michael Jordon had more than 35 points per throughout the season), but also had a shooting percentage over 0.5 in the season of 1985, 1990, 1991, and 1992.(among other guards, only Stephen Curry had shooting percentage over 0.5 in the season of 2016 ). For top forwards, their scores are not as high as that of guards, but many of them can achieve a shooting percentage per game over 0.5 in a season. Forwards like Kevin Durant(2014) and Bernard King(1985) also had points per game over 30 with shooting percentage over 0.5 per game in a season. In this list of top scores, few of them are centers .Actually,only 4 centers have this kind of achievement, but they are all 'Hall of Fame' winners, such as the most famous center in the recent years, Shaquille O'Neal, and 'The Admiral, David Robinson(serviced as an officer in the United States Navy).

In general, in the first 2 decades, the number of top scorers of forwards are the most among 3 positions, while guards became the position having the most top scorers after 2000. The number of top scorers as centers is the least all the time.

To define a top player, it is definitely not enough to only refer to their score. Some players find other ways to help their team to win the game while scoring many points. So we introduce the concept of 'double-double', which means double digits points per game with double digits of other technical stats, such as assists or rebounds. We often give credit to those top players who achieve 'double-double' in a game, and having 'double-double' on their seasonal statistic is a more incredible achievement.

Let's see how the number of 'double-double' in 3 positions changes over 4 decades in the following bar chart.

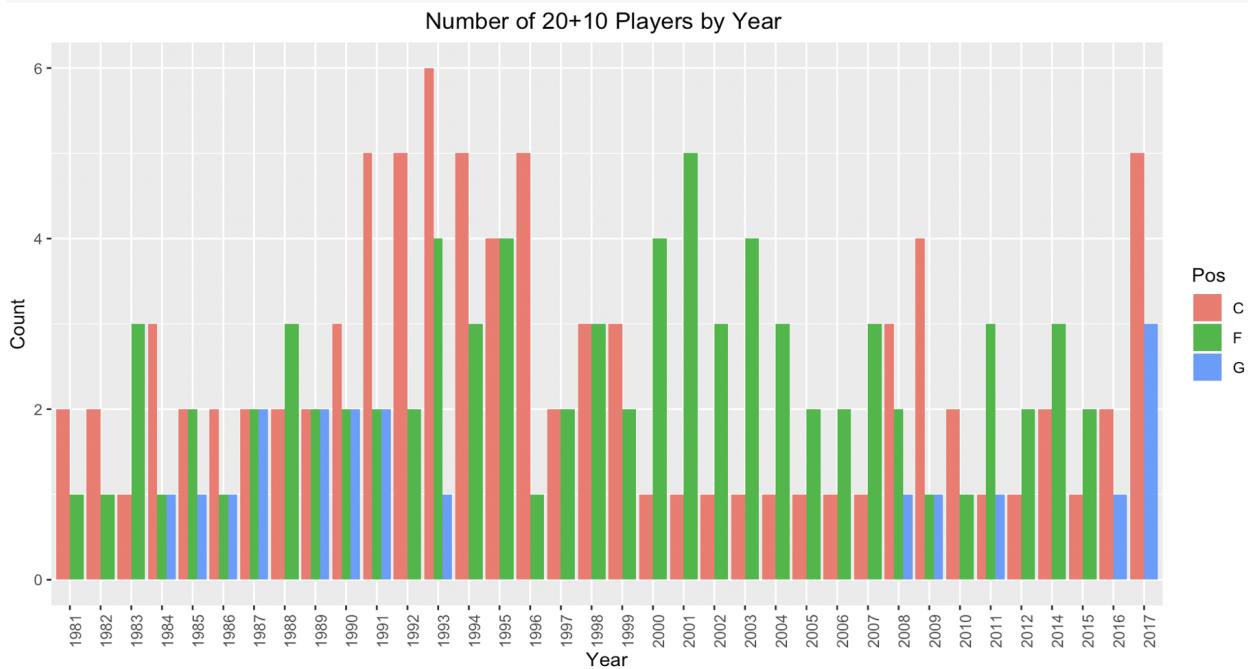
Number of 10+10 Players by Year



We can see from the chart that from 1980 to 1994, among 3 positions, the number of players as centers are the most in most of years. Forwards ranked the second. Few guarding winning this award during this period, even no guards had ‘double-double’ per season in the first 2 seasons in the decade of 1980. The number of players having ‘double-double’ per game in a season suddenly dropped in the period from 1995 to 2006. Interestingly, in this period, the number of forwards who had ‘double-double’ did not change a lot, consequently, forwards became the best to win ‘double-double’. However, after 2006, Centers came back to the number one, and the number of centers having ‘double-double’ per game in season rapidly increased, peaking at 16 in the year of 2018. On the other hand, the number of forwards achieving ‘double-double’ significantly decreased in the last decade, and became similar to that of guards. In addition, more guards owned ‘double-double’ per game in a season than forwards.

We can conclude that if we use 10+10(‘double-double’) to evaluate a player, forwards were dominating in the period between 1995 to 2006, while centers had absolute dominance in the last decade, and forwards even lost to guards in having ‘double-double’ per game in the last decade .

Let’s make our standard more difficult this time, and check how the results will change by using ‘20+10’, namely, 20 points and either 10 assists or 10 rebounds.



It can be seen from the graph that, when we raise the standard, forwards' dominating period shortened to the period between 2000 to 2006. Centers' dominance is the last decades disappeared, instead, we can see another new period dominated by center which is the period between 1990 and 1995. whereas, in the year of 2017, centers began to show their dominance again. In addition, the gap between top guards and top players in other positions narrowed after we raised the standard. Guards also beat forwards in terms of achieving 20 plus 10 statistics per game in a season in the last 2 years.

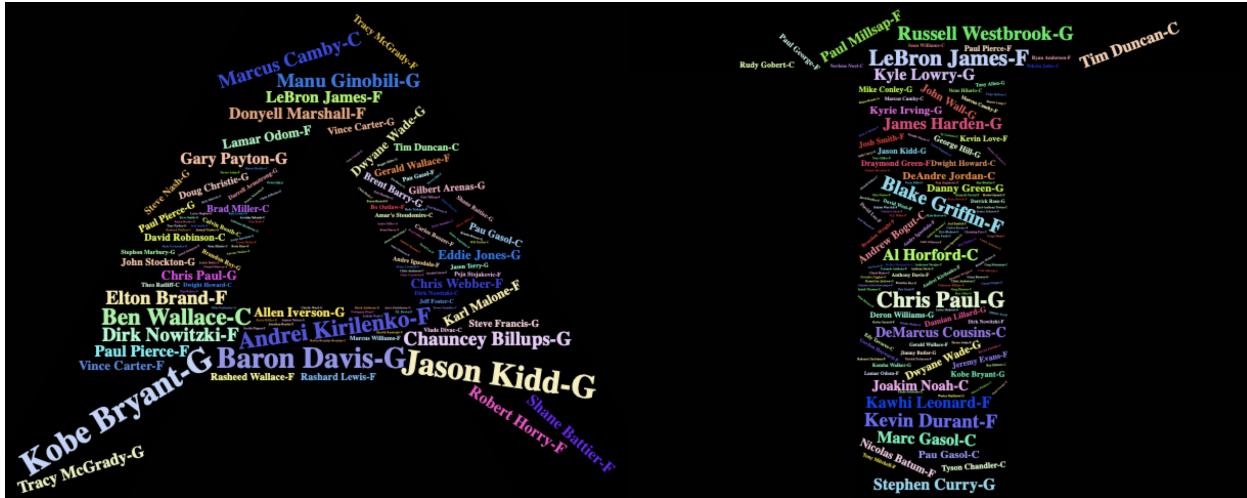
It is more exciting when we make our standard higher again, there are only 3 players achieved a average '30+10' per game in a season.

Year	Player	PTS_per	AST_per	TRB_per	Pos
1982	Moses Malone	31.11	1.75	14.67	C
1990	Karl Malone	30.98	2.76	11.11	F
2017	Russell Westbrook	31.58	10.37	10.67	G

Accidentally, three super heroes are in 3 different positions, it is hard to believe they made such an impossible achievement. More importantly, among them, we can see a player who rewrite the history and create a new record. Russell Westbrook, average '30+10+10' per game in the season of 2017. He just proved that guard can also be so dominating by such a well-rounded performance. NBA, where amazing happens.

Sometime, if we only use common offensive and defensive statistics to measure a player, there will be bias because some contribution cannot be represented by numbers. Therefore, professional basketball analysts create a new index-'Box Plus/Minus', which relies on a player's box score information and the team's overall performance to estimate a player's performance relative to league average. A Box Plus/Minus of 0.0 is league average, +5 means the player is 5 points better than an average player over 100 possessions (which is about All-NBA level), -2 is replacement level, and -5 is really bad.

Now, we use this professional index to choose the top players in 4 decades. We count the total number of games in decades for each players where they had a Box Plus/Minus over 3, and we use those frequent to make a wordcloud.



Graphs above display the greatest players and their positions of all the time in the league by decades. The top left graph displays the great players in the decade of 1980, we can see most of them are forwards and guards, with few centers. Many famous guard players showed up in big shining word, such as Magic Johnson from lakers and the basketball god-Michael jordan. Although the number of top centers is limited in this decade, we can also find legendary guards such as ‘Dream Shake’ hakeem olajuwon and ‘The Sky hook’, kareem abdul jabbar. In the top right graph, the number of top players as guards slightly increased, while the number of top centers still very little. In this decades, those top guards were also famous for their ability to assist, for example , ‘The Gloves’,John Stockton, and ‘Clyde the Glide’,clyde drexler. We also find a 3-point killer in the history, Reggie Miller, which means the era of 3 points has came. In the bottom left graph, even the number of centers slightly increased, but their sizes are much small than that of guards. It is easy to find 3 most noticeable players are all guards. ‘black mamba’, Kobe Bryant, the cold blood killer,he is absolutely the ‘GOAT’,needless to say, Baron Davis, the captain of the team who made ‘Black eight miracle’(the eighth team to beat the first team in the NBA playoffs),and the leader and coach, Jason Kidd. This decade belongs to guards. In the bottom right graph, we can see many fowards names in shining big size. Forwards like Lebron James, Blake Griffin, Kawhi Leonard, and Kevin Durant change the definition of a forwards, or even the traditional impression of a basketball player. They have both huge size and flexiable movement. They can dribble, pass, and shooting. Basically,they can do everything on the court, which we really cannot imagine in the past.

To see how top players in the same position changed in the 37 years, we select 4 representative players in 4 decade for each position and compare their statistics.

Guard:

Player <chr>	height <dbl>	weight <dbl>	Pts <dbl>	Ast <dbl>	Trb <dbl>	x3P <dbl>	Stl <dbl>	Blk <dbl>
Magic Johnson	6.9	215	20	11.6	7.2	0.38	1.9	0.40
Michael Jordan	6.6	195	30	5.3	6.2	0.54	2.3	0.83
Jason Kidd	6.4	205	12	8.8	6.3	1.42	1.9	0.33
Stephen Curry	6.3	190	23	6.8	4.4	3.34	1.8	0.21

It is clear that the shape of the greatest guards became smaller over 4 decades. Both height and weight has dropped from 1980s' Magic Johnson to 2010s' Stephen Curry. 1990s' Jordan has the most prominent scoring ability, average 30 points, nobody in the league can reach this hype. 1980s' Magic Johnson had the highest assist per game, 11.6, the way exceed others. It is hard to see a big guy dominated the league by fatanstanic assists in 1980s. As for 3 points, two guards in the decades of 2000s and 2010s has a large advantage, especially 2010s' stephen Curry, average 3.34 3s, which is nearly 10 times than that of 1980s' Magic Johnson. In defense, 1990s' Jordan have a better statistics on both steal and block, which shows his defense is better than other 3 top guards.

Centers:

Player <chr>	height <dbl>	weight <dbl>	Pts <dbl>	Ast <dbl>	Trb <dbl>	x3P <dbl>	Stl <dbl>	Blk <dbl>
Kareem Abdul-Jabbar	7.2	225	20	2.6	7.2	0.00142	0.71	1.9
Hakeem Olajuwon	7.0	255	22	2.5	11.1	0.02019	1.75	3.1
Shaquille O'Neal	7.1	325	23	2.5	10.8	0.00079	0.61	2.2
Marc Gasol	7.1	255	15	3.2	7.6	0.18040	0.92	1.5

The shape of greatest centers cannot see a big change over 4 decades, while one exception, 2000s' Shaquille O'neal, who weight 100 more lbs than other 3 centers. He is also the most powerful center all the time, average 23 points in his decades, leading the top centers in scoring ability. Interestingly, 2010s' Marc Gasol have an average assist of 3.2 and an averag 3 points of 0.18, which is on the same level as a qualified guard. On the defensive side, Hakeem Olajuwon is undoubtedly the best of all the time, average of 1.75 steals and 3.1 blocks per game, just cannot imagine how horrible will be when matching up such a defender.

Forwards:

Player <chr>	height <dbl>	weight <dbl>	Pts <dbl>	Ast <dbl>	Trb <dbl>	x3P <dbl>	Stl <dbl>	Blk <dbl>
Larry Bird	6.9	220	25	6.5	10.0	0.725	1.73	0.86
Karl Malone	6.9	250	25	3.6	10.1	0.058	1.41	0.78
Tim Duncan	6.1	250	19	3.0	10.8	0.022	0.74	2.17
Kevin Durant	6.9	240	27	3.8	7.2	1.792	1.19	1.05

The shape of fowards also do not change a lot in 4 decades, 2010s durant and 1980s Larry bird are pretty similar, they all have lighter weight with more flexible movements on the court, although 1980s' Bird has more assists and rebounds per game, 2010s' Durants' 3 points ability is much more stronger, 1.792 3s per game, which is also a competitive statistic in the top guards. 1990s' Karl malone and 2000s' Tim Duncan are the type of powerful forwards, they are the solid foundation in the defense side for their team and usually score near the basket. They use their body advantages to grab more rebounds and sometimes give a surprising assist for teammates.

## 4 Conclusion

Throughout our analysis of the game in terms of general and 3 positions, we find many changes happened since 1980. However, all changes actually relate to three topic-'3 points', 'fast break' and 'teamwork'.

Over the decades, the physical game with highly intensive body contact does not exist anymore, instead, players emphasizes more on long-range shooting, teamwork and speed. Games become quicker and smarter.

The boundaries among players in 3 positions are no longer clear. Centers and forwards can also pass and shoot 3s. Although Guards gain advantages under the current trend of 3 points and fast break fashion, the key to win a game is an outstanding center or a powerful forward, because those big guys are really precious in the league nowadays and can dominate the game.