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Original Article

Statistical implications of the pick technique in a basketball match performance analysis

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Abstract
The science of sport applied to basketball has a rather long history, the first studies started at the end of the sixties and the beginning of the seventies (Beals et al. 1971), and over the years especially in the United States, due to the NBA phenomenon, the application of science and of statistics in performance analysis has increasingly taken hold. The analysis on the court, described by this study through video analysis and statistics, is based on the attempt to establish within some elite matches, the real effectiveness, statistically proven, of the technical element of the pick, which today characterizes most of the attacks in Italian Serie A basketball championship, and worldwide too, investigating the most common ones. Basically, the work done deals with the impact on the performance of the picking technique in basketball, taking into consideration the most common pick techniques in elite basketball such as the "Pick and roll, the vertical pick, the horizontal pick, the stagger and the double high pick and roll". The mathematical/statistical representation of the data obtained will help to the project hypotheses. From the results obtained from our study, it's clear that pick and roll is therefore the most used precisely because it's the pick that creates greater difficulty on defense, especially when it creates a "mismatch" (different physical and technical types of athletes facing each other). The successful Pick and Rolls are on average 20 per game and have a standard deviation of 6 so for 68% of the cases the Pick and Roll vary from 14 to 26.
Keywords: Influence analysis, performance, video analysis, basketball picks

Introduction

The idea is to direct technical staff work towards increasingly objective and real performative parameters and not only based on personal choice elements, but on surveys capable of making objective the elements required and deemed performing by the technical staff, and therefore qualifying for the team strategy and least but not last decisive also to plan immediate corrections, for an optimization of the performance. The use of objective data may help in making undoubtedly more targeted corrections on the composition of the training, adapting them to the real needs of the group, and not to personal assumptions. To collect, elaborate, and analyse the data, methods, and technologies used, are taken from video analysis to GPS to inertial sensors, and are expertly used by technical staff together with the support of biomedical and biomechanical engineers, statisticians, and the staff itself, as well as in all the appropriate cases by the medical staff, to produce results that are appropriate to personal needs.

After the notational analysis (C. Reep, UK 1950), the advent of PCs and the various technologies dedicated to the sport has led to greater precision and faster processing of the data collecting, till the upcoming of machine learning (Tian et al. 2019) in addition to enriching the statistical items with further and perhaps more significant elements connected with the performance such as the physical and technical efficiency index, symmetry index and others (ARGS, K-Sport Universal, Stats Perform, Montecchio, Italy, 2015). The data produced in this way by the dedicated technologies have very often subverted the assumptions deemed untouchable by the classical methodology, nowadays in several cases still used, demonstrating their insufficient effectiveness and their significant margin of error that they brought with them. In basketball, in the case in point, for example, interesting elements usually evaluated from a performance perspective were numbers of executed shoots and scored ones, lost and stolen balls and offensive and defensive rebounds and others, today defined as decidedly insufficient and incomplete for the adequate strategic training preparation plan. The science of sport

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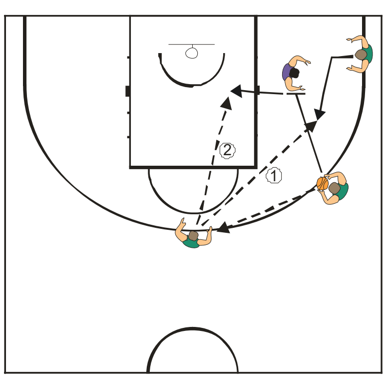
applied to basketball has a rather long history, the first studies started at the end of the sixties and the beginning of the seventies (Beals et al. 1971), and over the years especially in the United States, due to the NBA phenomenon, the application of science and of statistics in performance analysis has increasingly taken hold. Sports science has worked in different and multiple elements of the performance of basketball, such as the evaluation of the anthropometry parameters and their relation with performance prediction and players selection (Garcia et al. 2018, Cui et al. 2019, Pérez-Toledano et al. 2019), in the fitness performance area (Stojanovic et al. 2012, Delextrat et al. 2018), in injury prevention (Taylor et al. 2015, Riva et al. 2016) and in tactical and technical analysis (Garcia et al. 2013, Mandić et al. 2019, Zarić et al. 2020).

The aim of the paper was to analyze with a mathematical-statistical as well as a technical-tactical approach, the use of picks in the basketball team with video analytical methodology, with the final aim of evaluating whether the influence of the correct execution of the analyzed technical gesture has a real impact on the result of the matches. Marmarinos et al. (2016) studied the efficacy of the use of the Pick and Roll in the top-level European basketball teams, the results showed that the most effective type of pick and roll offense was when a shot was attempted after 2 passes from the pick and roll occurrence, followed by the screener's shot when he rolled to the basket. Also, a linear regression analysis showed that that pick and roll effectiveness could predict the final classification of the teams, and teams that perform higher efficiency in picks have a better chance of finishing higher in the rankings. Another analytic approach to the pick was performed from Vaquera et al. (2016) showing that all type of picks showed higher effectiveness in elite games results, mainly, the importance of picks is higher during the last seconds of the ball possession and also the effectiveness was higher as greater was the time pressure. Calvo et al. (2017) propose an evaluation of the mismatch occurring after a pick, showing that when an offensive team encounters a situation of a defensive switch with a mismatch, the shorter the duration the more beneficial to them, for both inside and outside players, the most effective actions are ones that last under five seconds, with the outside positions having a success rate of up to 60%.

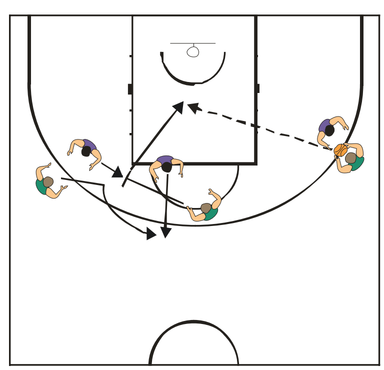
The study was performed taking into consideration 30 matches from the higher level of the Italian basketball championship. Offensive game situations have been evaluated, regarding the types of picks most used in today's elite basketball, that are 5 and precisely: Pick and Roll (PR), Double Pick and Roll High (2PRH), Vertical Pick (BV), Horizontal Pick (BO) and Stagger (STG). The aim was to establish if and how much, the use of this technique may or may not influence action and its conclusion efficiency. From a practical point of view, we have considered all the successful and unsuccessful picks; the effective and well-executed ones that resulted in a scored shot, the picks that were successful but did not allow the construction of an offensive game situation, the unsuccessful ones that led to a wrong conclusion and the badly executed picks with an incorrect conclusion. To support the data in our work, we used the statistical technique of "multiple linear regression with backward stepwise elimination", which allowed us to evaluate how much each predictive variable can influence the final score. Picks are aids that an attacker brings to a team-mate to make it easier for him to evade the defensive pressure of his direct defender and represent a form of collaboration between teammates, to create an obstacle for the teammate's defender to which it is proposed. The goal one wants to achieve by bringing a pick in favor of a partner is therefore to get him an advantage in space or time, to make a shot or another valid action. Good use of a pick, therefore, means performing a valid action to receive the ball in a specific useful part of the court ("comfort zone"). In the use of the picks, then, mainly important is reading the opponent's defense behavior which will suggest to the offensive player the best use of the same ("train, curl, fade-away, ..."). We consider two guiding concepts in the case we analysed:

1) when the pick is set, the picker and the picked player, going out from the pick, always offer two lines of passage to the man passing the ball (Diag.1).

2) take due to account the picker if it's open to receiving the ball due to a "show" movement from his defensive player (doing "help and recover", diag.2).



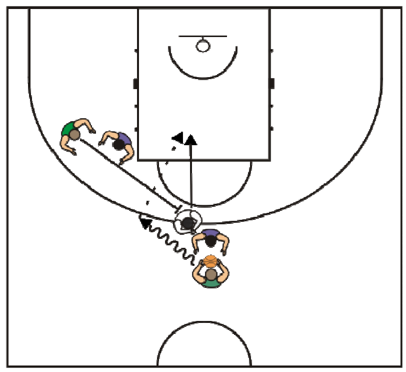
Diag.1. Two lines of passes.



Diag.2. Movement reaction to the "Shaw"

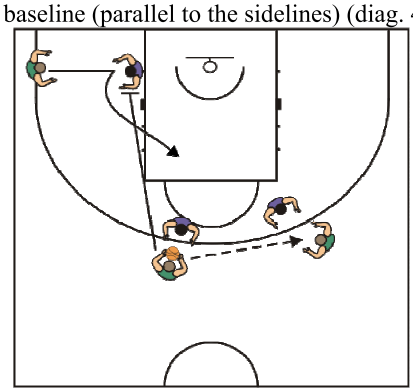
The types of picks taken into consideration are therefore the following: Pick and Roll (PO), Vertical pick (BV), Horizontal pick (BO), Stagger (STG), and Double high pick and roll (2PRH).

Pick and Roll (case: pick between men with the ball)**;** It is a situation where a player, usually the center or big forward, brings a pick in favor of a guard in possession of the ball. It is often carried in the upper area of the attacking field, but not necessarily. The PR is also used tactically in the last seconds of an action, where a situation of offensive disharmony arises to obtain a possible and quick advantage for a quick shot. Over the last few years, it has become one of the most used game solutions in the Italian Basket league, and not only, both at the beginning of a game and as an "escape" in technically complicated moments as mentioned above. This derives from the fact that the defense today produces a strong pressure and aggression with great use of physicality, making it difficult for the attacker to free himself with the use of only the individual technique of one versus one (1v1), and therefore they need help, to do so, in this case, a pick. This collaboration, if well-executed, also creates technical problems for the defenders who, to defuse the potential of the attack, find themselves in a condition called "mismatch", where the small defender comes to defend a very bigger player and vice versa for the other defender as well as other defensive issues. The pick on the ball is one of the two collaborations that create greater defense difficulties (diag.3).



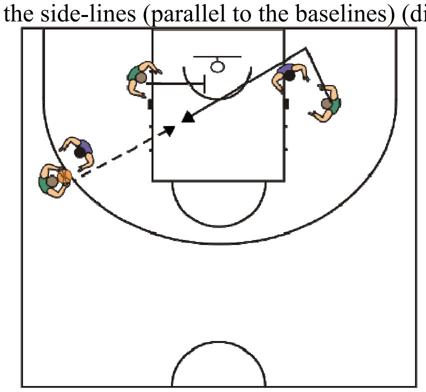
Diag.3. Example of Pick and Roll

Vertical pick; Pick set towards the baseline (parallel to the sidelines) (diag. 4).



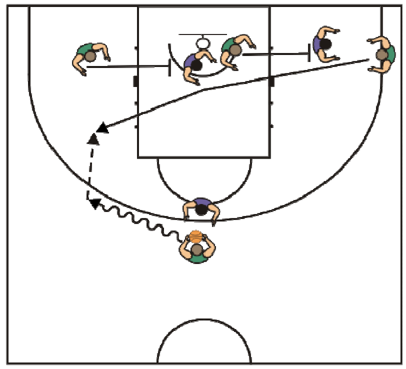
Diag.4. Example of Vertical Pick

Horizontal pick; Pick set towards the side-lines (parallel to the baselines) (diag. 5).



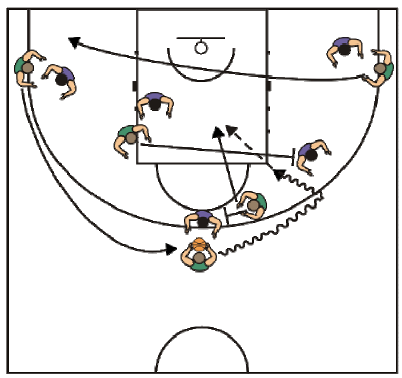
Diag.5. Example of Horizontal Pick

Stagger: Sequential picks, two usually, set by two players, usually the two Bigmen, but not necessarily, favouring a third player, in successive times, but close together and especially on different lines (trajectories), which makes it differ substantially by the double pick in "series", to favour the reception of the ball in favourable conditions and good substance with an advantage (diag.6).



Diag.6. Example of Stagger

Double High Pick and Roll; The player with the ball uses a first high pick from his partner and then also uses the second (diag.7).



Diag.7. Example of double high pick and roll

Material and Methods

Thirty (n=30) games of a team of the Italian Serie A basketball championship of the last year have been taken into consideration, to evaluate how much, the variables of the picks considered were predictive of the final result. For each type of pick, PR, BV, BO, STG, and 2PRH, we have analysed 6 different variables: successful picks, failed picks, successful picks with scored shot, successful picks with failed shot, failed picks with a successful shot, and unsuccessful picks with an unfulfilled throw. As an objective, it was verified how the variables deriving from the analysis of the picks were, overall, predictive in relation to the final score. In this case, the multiple linear regression model was used. The multiple linear regression theory responds to the objective of studying the dependence of a quantitative variable *Y* on a set of *m* variables explanatory quantitative $X_1,\ldots, Xm$, called regressors, using a linear model. $Y = f(X_1,\ldots, Xm) + \mathcal{E} = \beta_o + \beta_1 X_1 + \ldots + \beta m\, Xm$. The function *f* depends on parameters that determine the influence of every single regressor on the value of Y. In the formulation of the multiple regression model, the linearity holds concerning the parameters. The relationship that binds Y to $(X_1, \ldots, Xm)$ is therefore not expressible by an exact mathematical function, therefore in equation (2.1), a random variable is added which summarizes the effect on Y of all those factors not included in the function *f*. The term $\beta_o + \beta_1 X_1 + \ldots + \beta m\, Xm$ represents the systematic component of the model, and the random variable $\mathcal{E}$ is the error component of the model. The parameters (to be calculated) of the model are β_o (the intercept), and $\beta_1, \beta_2, \ldots \beta m$ (the regression coefficients). The R2 of the linear multiple models (index or determination coefficient) varies between 0 and 1. R2 measures the fraction of the variability of Y due to its linear dependence on the regressors. The analyses were performed using the SPSS 13.0 software. Pearson's (linear) correlation coefficient (also called Bravais-Pearson) between two random variables or two statistical variables X and Y is defined as their covariance divided by the product of the standard deviations of the two variables:

$$\rho_{xy} = \frac{\sigma_{xy}}{\sigma_x \sigma_y}.$$

The correlation coefficient can also be represented as:

$$r = \frac{\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^{n}(X_i - \bar{X})^2}\sqrt{\sum_{i=1}^{n}(Y_i - \bar{Y})^2}}.$$

Or:

$$r = \frac{1}{n-1}\sum_{i=1}^{n}\left(\frac{X_i - \bar{X}}{s_X}\right)\left(\frac{Y_i - \bar{Y}}{s_Y}\right)$$

When:

σ_{xy}, is the covariance between X and Y

σ_x, σ_y, are the two standard deviations of populations.

$\bar{X}$ Average variable X

$\bar{Y}$ Average variable Y

s_x Standard déviation X

s_y Standard déviation Y

The coefficient takes values between -1 and +1.

If:

$\rho_{xy} > 0$, the variables x and y are said to be directly correlated, or positively correlated.

$\rho_{xy} = 0$, the variables x and y are said to be uncorrelated.

$\rho_{xy} < 0$, the variables x and y are said to be inversely correlated, or negatively correlated.

In the case of independence, the coefficient assumes a zero value, while the opposite conclusion does not apply: in other words, the correlation is a necessary but not sufficient condition for independence. The Pearson indices of n variables can be presented in a correlation matrix. It is a double-entry table, which is a square matrix of size [n, n] having the variables understudy in the rows and columns. The matrix is diagonal because the correlation index of a variable with itself is unitary, and is symmetric. In fact, it is true that:

$\rho_{xx} = 1$,

is that

$\rho_{yx} = \rho_{xy}$.

Results and Discussion

In the tables (Tab.1,2,3,4,5), the average, the standard deviation, and the CV (coefficient of variation, i.e. the ratio between the standard deviation and the average) are indicated, for each of the variables considered.

Tab.1. P&R data

	P&R					
	successful	**failed**	**successful picks with scored shot**	**successful picks with missed shot**	**failed picks with scored shot**	**unsuccessful picks with unfulfilled throw**
Total	1214	456	605	450	105	264
Average	20.23	7.60	10.08	7.50	1.75	4.40
St.dev	6.61	4.25	3.71	3.63	1.75	2.71
CV	0.33	0.56	0.37	0.48	1.00	0.62

Tab.2. Vertical Pick Data

	Vertical					
	successful	**failed**	**successful picks with scored shot**	**successful picks with missed shot**	**failed picks with scored shot**	**unsuccessful picks with unfulfilled throw**
Total	878	43	172	191	3	20
Average	14.63	0.72	2.87	3.18	0.05	0.33
St.dev.	6.38	1.09	1.81	2.40	0.22	0.60
CV	0.44	1.52	0.63	0.76	4.40	1.80

Tab.3. Horizontal Pick Data

	Horizontal					
	successful	**failed**	**successful picks with scored shot**	**successful picks with missed shot**	**failed picks with scored shot**	**unsuccessful picks with unfulfilled throw**
Total	311	24	79	96	4	10
Average	5.18	0.40	1.32	1.60	0.07	0.17
St.dev.	2.64	0.64	0.98	1.24	0.31	0.42
CV	0.51	1.61	0.75	0.76	4.46	2.46

Tab.4. Stagger Pick Data

	Stagger					
	successful	**failed**	**successful picks with scored shot**	**successful picks with missed shot**	**failed picks with scored shot**	**unsuccessful picks with unfulfilled throw**
Total	427	35	115	117	4	13
Average	7.12	0.58	1.92	1.95	0.07	0.22
St.Dev.	4.84	1.12	1.50	1.66	0.31	0.49
CV	0.67	1.94	0.79	0.83	4.46	2.23

Tab.5. Double P&R Data

	Double P&R					
	successful	**failed**	**successful picks with scored shot**	**successful picks with missed shot**	**failed picks with scored shot**	**unsuccessful picks with unfulfilled throw**
Totale	183	57	81	65	12	27
Media	3.05	0.95	1.35	1.08	0.20	0.45
Dev.Std	2.91	1.10	1.54	1.32	0.42	0.62
CV	0.95	1.15	1.14	1.22	2.46	1.30

The analysis is given to us by a total of 60 team events where the final score has an average of 82.58 and a standard deviation of 11.47 and this means that the final score varies approximately between 71 and 93 points per game. The successful Pick and Rolls are per game on average 20 and have a standard deviation of 6 so for 68% of the cases the Pick and Roll vary from 14 to 26. The unsuccessful Pick and Rolls have an average of 7.6 and a standard deviation of 4.6, here it's important to note that the standard deviation is higher than half the average and this means that the successful Pick and Rolls undergo considerable variation from game to game. Successful Pick and Rolls with achieved shots have an average of 10.10 and a standard deviation of 3.6, varying from 7 to 13 per game.

The Pick and Roll successful with the wrong throw are 7 on average per game with a standard deviation of 3.6, therefore, varying from 4 to 10. The Pick and Roll failed and shot made are very few per game and the unsuccessful with scored shot are about 4 on average with a standard deviation of 2 and therefore are from 2 to 6 per game. The vertical, horizontal picks, the stagger, and the double high pick and roll are almost all successful, but you can see how it's more important, to achieve a shot conclusion, than how much a pick and roll has been successful rather than another type of pick.

We have always to underline that going out more open from a pick set put the shooter in a better time and psychological condition to shoot, which means normally a higher score in the shooting. Pick and roll is therefore the most used precisely because it's the pick that creates greater difficulty in defense, especially because it creates a "mismatch" (different physical and technical types of athletes facing each other).

Tab.6. Multiple regression

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,809(a)	0,655	0,298	9,612
2	,809(b)	0,655	0,321	9,451
3	,809(c)	0,655	0,343	9,299
4	,809(d)	0,654	0,362	9,163
5	,808(e)	0,653	0,38	9,033
6	,808(f)	0,652	0,397	8,91
7	,807(g)	0,652	0,413	8,79
8	,807(h)	0,651	0,428	8,676
9	,806(i)	0,65	0,442	8,568
10	,806(j)	0,649	0,455	8,467
11	,804(k)	0,646	0,465	8,39
12	,801(l)	0,642	0,472	8,332
13	,798(m)	0,636	0,476	8,302
14	,792(n)	0,627	0,476	8,3
15	,786(o)	0,617	0,475	8,314
16	,780(p)	0,608	0,474	8,319
17	,770(q)	0,593	0,466	8,38
18	,761(r)	0,579	0,46	8,428
19	,758(s)	0,574	0,465	8,391
20	,752(t)	0,565	0,465	8,39
21	,743(u)	0,552	0,461	8,426
22	,726(v)	0,527	0,442	8,568
23	,722(w)	0,521	0,446	8,538
a Predictors: (Constant), Double Pick 4, Vertical successful, Stagger 4, Horizontal 3, Double Pick 2, Horizontal 1, Stagger 1, Vertical 3, Horizontal 4, Vertical 4, P and R failed, Stagger 3, P and R 2, Horizontal 2, Stagger 2, Double Pick 1, Double Pick 3, Vertical 2, Vertical 1, P and R 1, P and R 3, Stagger failed, Double pick failed, Horizontal successful, Stagger successful, Vertical failed, Horizontal failed, P and R 4, Doppio pick successful, P and R successful				
w Predictors: (Constant), Double Pick 2, Horizontal 1, P and R 2, Vertical 2, Vertical 1, P and R 1, P and R 3, Double pick successful				

In this table (Tab. 6) the multiple regression R with backward stepwise elimination is reported, which goes to quantify how much all predictive variables, i.e., all the picks analysed, affect the outcome. From this analysis, we can correctly explain the 29.8% of the outcome and if instead, we consider the multiple linear regression with backward stepwise elimination we can explain the 44.6% of the outcome. Taking into consideration the incorrect ones, that we can read in the 1st column, we can instead explain 72.2%. The difference between correct and incorrect is that the first considers the number of predictive variables and is a very conservative index, while the second one does not take into account the number of variables but only how much all the variables explain the final outcome. We are concerned with the incorrect index as it explains the final score regardless of the number of predictive variables. The concept of multiple linear regression with backward stepwise elimination starts from the assumption of having a certain number of variables, in our case 24, and a dependent variable, which for us is the final score, which seems to depend on the distribution of the pick type and from the outcome of the pick. We do not consider all 24 variables, we eliminate them one at a time and observe as "R" which is the approximation index, varies. The algorithm stops when the decrease in R is significantly high, that is when the further reduced model explains the dependent variable significantly worse.

Tab.7. shows the results relating to multiple linear regression with BSE

Coefficients (a)								
		Unstandardized Coefficients		**Standardized Coefficients**	**t**	**Sig.**	**95% Confidence Interval for B**	
		B	**Std. Error**	**Beta**			**Lower Bound**	**Upper Bound**
Model	**P and R 1**	1,15	0,339	0,371	3,394	0,001	0,47	1,831
	P and R 2	-1,429	0,325	-0,45	-4,393	0	-2,081	-0,776
	P and R 3	1,154	0,598	0,206	1,931	0,059	-0,046	2,354
	Vertical 1	1,562	0,654	0,241	2,386	0,021	0,248	2,876
	Vertical 2	-0,883	0,509	-0,186	-1,733	0,089	-1,905	0,14
	Horizontal 1	2,635	1,163	0,225	2,265	0,028	0,299	4,97
	Double pick successful	1,939	0,747	0,491	2,597	0,012	0,44	3,438
	Double Pick 2	-4,119	1,578	-0,473	-2,61	0,012	-7,287	-0,951
a Dependent Variable: final score								

The model excludes 16 variables; this means that the final score can be modeled considering only 8 variables. In the beta column and the Sig. column, an estimator of the partial correlation and the relative significance are reported respectively. The analysis of the table shows that the final score is positively dependent on the R 1 pick and roll from the vertical 1, the horizontal 1, the successful double pick and roll, and the unsuccessful pick and roll but with the shot made. While the final score is negatively dependent on the R 2 pick and roll, the vertical 2, and the double pick and roll 2.

Conclusion

Our aim was to verify how the fundamental of the pick has an impact on the final score of each race. Out of 24 variables, the statistical model of multiple linear regression with backward stepwise elimination (BSE), considered only 8 variables to be fundamental. The final score is therefore positively dependent on the successful pick and roll with a successful shot, on the successful vertical pick, on the successful horizontal pick, on the double successful high pick and roll, and on the unsuccessful pick and roll but with a successful shot. On the contrary, it's negatively dependent on the successful pick and roll with an unfulfilled shot, on the unsuccessful vertical, and the double high unsuccessful pick and roll, which means that the offensive action wasn't at the end successful. Our analysis has focused mainly on the study of the performance possibilities considering the statistics concerning the use of the fundamental pick and therefore on its realization capabilities based on the final score of each game taken into consideration. For an analysis linked to the outcome and not therefore basically linked to the quantity of score, it's probably better to use a much more complex logistic regression which will allow us, with the study of multiple variables, to further attempt to predict the outcome, probably even more precise. Technically speaking the important outcome, we can offer with this research is certainly that setting a good pick means a larger work on the same fundamental dedicating a larger space to teach it not only in a dynamic way but underlining the specific technique to set it n a more profitable way.

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Validation: Izzo R., Cejudo A., D,Elia F.
Formal analysis: Izzo R., Hosseini C.
Investigation: Righi E., Cejudo A.
Resources: Giovannelli M., Righi E., Hosseini C.
Data curation: Righi E., Cejudo A.
Writing, original draft preparation: Izzo R., Giovannelli M., Sisti D., Hosseini C.
Writing, review, and editing: Izzo R.

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