ISSN : 0974 - 7435 Volume 10 Issue 7

2014

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(7), 2014 [2109-2116]

Mechanical analysis-based basketball shooting technological elements impacts on hit rate

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ABSTRACT

In basketball, shooting is unique way to get scores in basketball game, shooting frequency and hit rate decides game winning or losing. Whether shooting technical motions are correct and standard or not will directly affect field-goal percentage, to improve field-goal percentage, it should fully grasp shooting technological basic elements. The paper mainly adopts document literature, theoretical analysis, comparative analysis and other ways to summarize basketball shooting technological basic elements impacts on field-goal percentage, and focused on analyzing release height, release angle impacts on ball hit rate when shooting, aiming point and ball rotation impacts on hit rate by mechanical analysis, theoretical analysis, comparative analysis and other ways, theoretically explores field-goal percentage influential basic factors, which provides theoretical basis for basketball education and athletes practical application.

KEYWORDS

Field-goal percentage; Technological elements; Biomechanics; Basic factors; Release angle.

INTRODUCTION

Basketball game is a kind of antagonistic technological event that decides game results with scores. Field goal is the final pursuing of athletes gaining scores in basketball game, so high or low of field-goal percentage decides competitiveness winning or losing to a certain degree, its position in basketball game is irreplaceable, which is always one problem of every athlete and coach concerns.

Researches on how to improve field goal percentage have never been interrupted, some domestic scholars put forward their own opinions and theories on how to improve field-goal percentage that made certain contributions to Chinese basketball undertakings, from which Xu Yan and others (2012) made three-dimensional video analysis of basketball athlete shooting techniques by adopting documents literature, observation method as well as sports biomechanical analysis methods, analyzed athlete each main sports joints motion features, shooting hand motions and ball motion features, got that only well handled with upper and lower limbs exertion, release points height and angles as well as ball releasing instant motions relations when shot then could really improve shooting hit rate[1]. Wen Zhong-Bo (2013) in brief discussing basketball game athlete psychological quality impacts on field-goal percentage, he pointed out psychology impacted on hit rate during game, and proposed some kinds of athlete psychological training methods, and advocated to organize psychological course tutorial theory to athlete and university student[2]. Fan Liu-Dong and others (2011), researchers based on observing athlete APAS images, make statistical analysis of releasing opportunities, ball release angle and hit rate as well as other kinematics parameters descriptive statistics, single factor variance analysis, Pearson product moment correlation when made jump shot of basketball in middle distance, research result built certain basis for basketball middle distance jumping shot technical training and researching.

The paper will state basketball shooting technical basic elements impacts on field-goal percentage, and mainly adopts mechanical analysis, theoretical analysis, comparative analysis to analyze shooting release height and shooting angle impacts on hit rate, aiming point and ball rotation impacts on hit rate. Theoretically provide some practical suggestions in game and training.

BASKETBALL HIT RATE IMPORTANT INFLUENTIAL FACTORS MECHANICAL ANALYSIS

In reality, shooting can be divided as one-hand shot and two-hand shot two types, as Figure 1. One-hand shot is relative general, while two-hand shot mostly appears in women's middle and far distance shooting. Firstly, practical application tells us that two-hand shot consumes longer time than one-hand shot, it nearly is 0.1-0.3 seconds more, adopt two-hand shot is very bad in basketball such intense competition technological game. Secondly, two-hand shot mostly puts the ball right above the forehead, it is prone to obscure shooters' visions, affects shooters perception and judgment on surrounding environment, and it is difficult to change and prone to be block shot by opponents. According to above two reasons, the writer suggests to adopt one-hand shot.

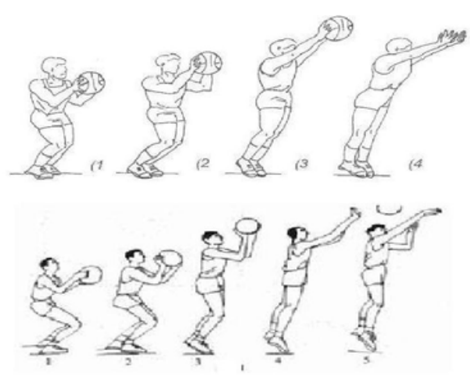

Figure 1 : Two-hand shot and one-hand shot comparison

Rebound aiming point mechanical basis

Momentum conservation law is rebound aiming point shot mechanical principle, if ignore basketball and rebound energy loss, then basketball before and after hitting rebound included angle with rebound are approximately the same, adding that hoop area (6358.516cm²) is around fifteen times basketball area (415.265cm²), so aiming points allows certain error, the error needs to be grasped by athlete with accurate sports perception through numerous training.

By investigation, aiming point in the heart of athlete has five types: 1) hoop front edge; 2) hoop back edge; 3) imaginary hoop central point; 4) imaginary hoop center line point right above 20cm; 5) the whole hoop. Here mentioned front edge, back edge take athlete index finger as reference point.

When shooting, it is back spin; the writer thinks aiming point should be hoop back edge. If it takes hoop front edge as aiming point, it will occur to three cases: 1)Shooting exertion is slightly small, ball doesn't contact with hoop; 2) Ball just touches hoop, due to it is back spin, it will be popped up from hoop after touching hoop; 3)Shooting force is slightly bigger, ball touches back edge of hoop and pops into hoop. According to above analysis, when aiming point is hoop front edge, hit rate is 33.3%. There are three cases when aiming point is hoop back edge: 1) Shooting exertion is slightly small, ball doesn't contact with hoop back edge and drops into hoop; 2) basketball just touches hoop back edge, ball rebounds into hoop 3) When shooting, ball excessive deflects from hoop, ball cannot enter into hoop. According to above analysis, hit rate on the condition that aiming point is hoop back edge is 66.7%. When aiming point locates in other three cases, due to imaginary points are not easy to aim when shooting, it is not fit for shooting aiming point.

When take hoop back edge as aiming point, ball forward spin and back spin also have certain impacts on hit rate. By analyzing, field goal percentage by back spin suffered resultant force after ball contacting with hoop is larger than forward spin. Therefore author suggests that it should try to let ball to fast back spin when shoot in middle and far distances, so that will improve hit rate as Figure 2 and Figure 3.

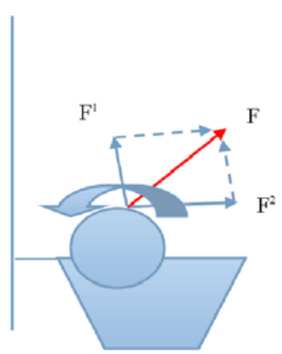

Figure 2 : Force situation of Forward spin contacting with hoop

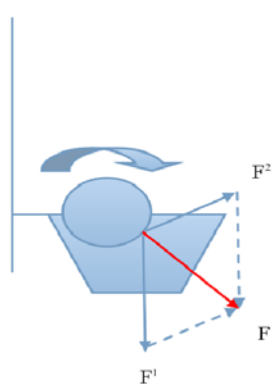

Figure 3 : Force situation of back spin contacting with hoop

Ball rotational mechanical analysis

When shooting, after basketball releasing, basketball suffers gravity, air buoyancy and air resistance three kinds of forces when moving in the air, air buoyancy and air resistance are very little with respect to gravity that can be ignored, so it can think that basketball air motion trajectory is oblique projectile motion, oblique projectile motion each parameter is up to sum total of each kind of element that shooters shooting instant before releasing ball and releasing instantaneous act on ball, its trajectory equation (1):

$$\mathbf{H = v \times \sin\theta / 2g \quad L = v \times \cos\theta \times v \times \sin\theta / g} \tag{1}$$

Shooting motion let basketball to rotate in the air, so basketball motions in the air is c compound movement that oblique projectile and basketball surround sphere frontal axis to make rotation, therefore shooting motions basketball movement trajectory is different from general oblique projectile movement. Basketball back spin is generated when shooting, shooters lower limbs pedal the ground, waist, abdomen, and upper limbs by virtue of each joint chain transmitting, ball releasing instant wrist bends forward, index finger acting on the back bottom part of basketball.

Basketball back spin effects and mechanical analysis in shooting:

High speed back spin can effective overcome air resistance, it is beneficial to keep basketball relative stability in the air, which is very important for middle and far distances shooting motions. When basketball moves slowly in the air, air to sphere surface friction force is smaller, basketball spherical surface and adjacent airflow have a small gap, and we call it spherical surface layer. The existence of spherical surface layer lets sphere moving direction front and back regions to have insignificant pressure differences, airflow still can keeps steady airflow after passing through basketball it has little impacts on basketball. When shooting in middle and far distances, basketball speed is larger, basketball surface and airflow friction force increase, and causes spherical surface layer being damaged, when airflow gets through sphere peeling point (as Figure 4, F1 is stress, F2 is lift force, M point is peeling point, V is ball speed), it generates a flow line that has larger differences with original airflow, let sphere back region to generate larger laminar flow eddy zone, basketball front and back pressure differences are larger that cause sphere suffering resistance so that it diminishes basketball running height and distance, which is bad for middle and far distances. If basketball back spins at high speed when shooting in middle and far distances, due to air exists viscosity, basketball surface is not smooth, when basketball spins, it drives basketball surface adjacent gas particle to generate a puff of air circulation that in the same direction of basketball spinning direction. Air circulation and airflow make interactive effects and can weaken sphere front and back laminar flow eddy, it causes basketball surrounding airflow changing, effective diminishing air to ball resistance, it is beneficial to control basketball running trajectory and improve hit rate.

High speed back spinning basketball can let basketball to suffer a lift force (refer to Figure 4 F2), basketball lift force existence can enlarge basketball movement radian, increase basketball incident angle, enlarge hoop exposed surface and improve field-goal percentage. Therefore, it is clear due to basketball back spinning existence, it causes basketball upper side airflow speed to be big but flux is small, while upper side airflow speed is small but flux is big by unequal basketball up and down airflow volume and flow speed. According to Bernoulli's equation $: P + \rho gh + 1/2\rho v2 = \text{const ant}$, ρ is air density、g is gravity accelerated speed, the two are constant values, h is fluid height, h changes can be ignored with respect to atmospheric height. Therefore, it is clear that v and P are in inverse proportion, theoretically shooting distance gets further, basketball release speed would be faster. Flying basketball upper side (as Figure 5's A point) with respect to lower side (as Figure 5's B point) point is low pressure region, therefore it generates a upward lift force for basketball, pressure differences get bigger then basketball lift force would get bigger, flying basketball parabola radian would get bigger, radian gets bigger and then incident angle would get bigger, incident angle gets bigger then basketball exposed area will get bigger so that increase basketball odds of entering into hoop. By above analysis, it is clear that shooting instant high speed back spinning can improve hit rate.

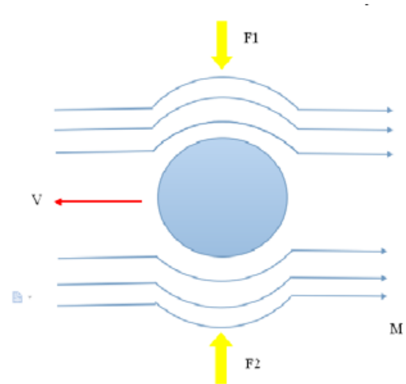

Figure 4 : Magnus effect

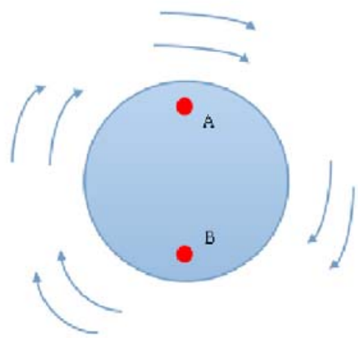

Figure 5 : Back spin up and down two terminal speed pressures

Basketball forward spinning generation generates due to shooting motion when ball released, shooters index finger acts on the front bottom part of basketball, forward spinning effects and mechanical analysis are as following:

Forward spin similarly is beneficial to basketball to keep its relative stability when flying in the air, causes can refer to 2.5.2 relative statements;

When make quick attacking, it suggests to use forward spin to act on similar force to ball, for basketball speed, forward spin is the fastest, non-spinning ball is secondly, back spin is the slowest, while basketball flight distance and radian size as well as speed size ranking orders are on the contrary. Though forward spin will suffer downward pressure in flight, considering forward spin are mostly used in close range shooting, so its influence can be ignored.

SHOOTING RELEASE HEIGHT AND RELEASE ANGLE MECHANICAL ANALYSIS

Basic conditions for basketball shooting into hoop

When shooting, incident angle size decides ball hit rate, according to shooting instant, basketball parabola, we know that incident angle is up to release angle when shooting.

1) Shooting minimum incident angle defining

To easy to understand, we adopt geometric graphics to analyze, as Figure 6 shows, AB is hoop diameter (0.45m), CD is basketball diameter (0.25m), here we assume that basketball flies in the horizontal direction, the hoop rotates upward X angle to EF with a center of a circle, by Figure 6, it is clear that EG must be larger than CD so as to let basketball to enter into hoop, according to formula (2):

$$\mathbf{Sin\alpha = \frac{EG}{EF} = \frac{0.25}{0.45}} \quad \mathbf{(2)}$$

According to calculation, it is clear that basketball minimum incident angle α =33°45′, incident angle must be larger than 33°45′, and then basketball can be shot into the hoop.

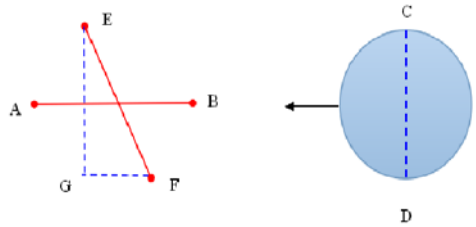

Figure 6 : Incident angle when ball enters into the hoop

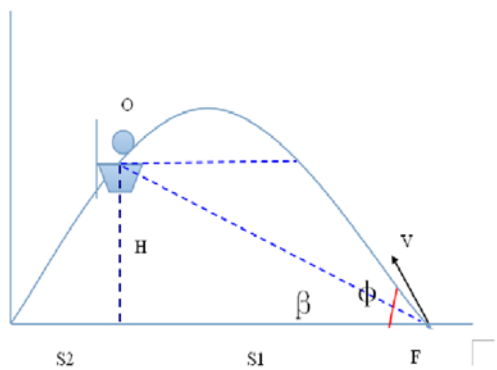

Figure 7 : Projection angle and incident angle relations

2) Projection angle and incident angle relations

As Figure 7shows, shooter shoots in F point at initial speed V, and projection angle α, H is difference between shooter release height and hoop height, S1 is horizontal distance between shooter and hoop, β is shooter and hoop lean angle. If ignore air resistance, according to parabola formula (3):

$$\mathbf{H = tg\phi \bullet S - \frac{gs^2}{2V\cos^2\phi}} \quad \mathbf{(3)}$$

For basketball entering into hoop's incident angle, it can solve derivation (4):

$$\mathbf{\frac{dH}{dS} = \frac{d}{dS}(tg\phi \bullet S - \frac{gS^2}{2V^2\cos^2\phi})}$$
$$\mathbf{= tg\phi - \frac{gs}{V^2\cos^2\phi}} \quad \mathbf{(4)}$$

Basketball located in hoop O point coordinate $S_2 = \dfrac{2V^2 tg\beta\cos^2\phi}{g}$, input S_2 into formula (4), by calculating, then can get (5):

$$\mathbf{\phi = Arctg(tgQ + \frac{2H}{S_1})} \quad \mathbf{(5)}$$

According to formula (5), it can get projection angle and incident angle relations, when shooting and incident angle is minimum, shooter minimum projection angle should be : $\phi = Arctg(tg33°45' + \frac{2H}{S_1})$

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According to above deduction, it can know that in order to let basketball to be shot into the hoop, incident angle should be larger than 33°45′, projection angle should be larger than $Arc(tg33°45' + \frac{2H}{S_1})$, from which H is difference between shooter release height and hoop height, S_1 is horizontal distance between shooter and hoop.

Release height and shooting distance impacts on projection angle

According to above analysis of projection angle and incident angle, we know field-goal percentage also suffers shooting height and shooting distance impacts. In following TABLE1, according to calculation, we list when release height range in 2-2.9m, shooting range in 4-7m, minimum projection angle changes. By TABLE 1, we get that when incident angle is minimum incident angle 33°45′that remains unchanged, take shooting distance 7m, release height 1.05-0.15meters as examples, minimum projection angle is gradually diminishing from, 44°05′ to 44°05′, 4m and 5m have similar cases. If shoot with fixed projection angle, release height and incident angle are in direct proportion as Figure 8. Therefore we can get conclusion :1) if shooting distance is unchanged, release height gradually increases then shooter can arrive at similar hit rate at smaller projection angle; 2) With shooter shooting incident range increasing, corresponding hit rate has promotion.

TABLE 1: Shooting distance and release height as well as projection angle relations

S\H	1.05m	0.85m	0.65m	0.45m	0.25m	0.15m
4m	50°02′	47°35′	44°14′	41°48′	38°24′	36°38′
5m	47°13′	45°19′	42°55′	40°17′	37°32′	36°09′
7m	44°05′	42°25′	40°22′	38°35′	36°33′	36°33′

S= shooting distance, H=3.05- release point height

As Figure 8 shows, combine with TABLE 1, it can get conclusion:1) if incident angle is 33°45′ that is unchanged, then with release height increasing (0.45m to0.15m), minimum incident angle tends to be around 36°. When shooting release height is promoted to 2.6m-2.9m, different projection distance projection angles are approximately the same; 2) release height remains unchanged, then with shooting distance gradually increases, minimum projection angle gradually diminishes. On the contrary, shooting distance gradually gets smaller, minimum projection angle gradually gets bigger. When shooter is shooting, projection angle is inverse proportional to incident angle, as Figure 9.

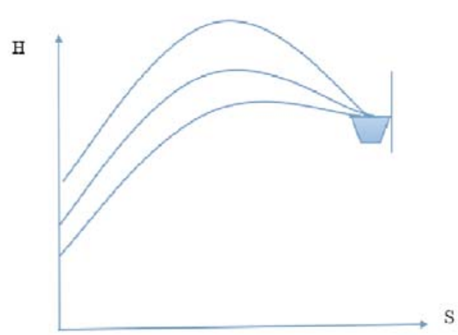

Figure 8 : Shooting height and incident angle relations

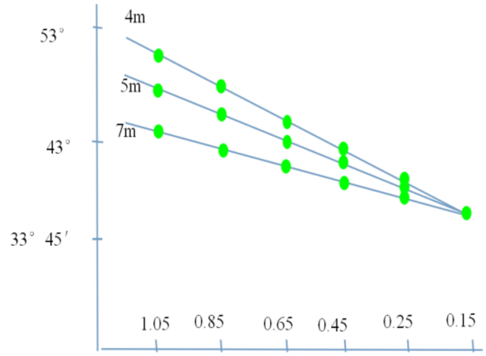

Figure 9 : Projection angle and release height relations

Influence analysis of hit rate when incident angle is unchanged, projection angle diminishes

According to analysis, when height as 1.83m shooter makes set shot, release height is in 2.1m-2.2m, when makes jump shot, release height is in 2.7m-2.9m, when shooter is in shooting distance 5m, incident angle 33°45′, according to above formula (5) calculation, it can get set shot projection angle $\varphi=45°18'$, when makes jump shot, projection angle $\phi'=37°33'$. Jump shot release height is higher than that of set shot, and basketball flying parabolic trajectory is relative shorter in the air, basketball suffered external force impacts are smaller, so jump shot is relative stable by comparing to set shot.

CONCLUSION

The paper makes analysis and statement of basketball shooting percentage influential technological factors, and makes mechanical analysis of shooting influential important technological factors, by analysis, we learn that back spin after ball contacting with hoop, its suffered resultant force let basketball hit rate to be bigger than that of forward spin, so when shoot in middle and far distances, it should try to let ball to back spin in high speed, so that will improve hit rate. In addition, we also focus on departure angle and incident angle impacts on hit rate, and carries out mechanical analysis, in the hope of providing references for coaches and athletes.

REFERENCES

[1] Chen Jian, Yao Song-ping; Application of Connected Analysis to Analysis of Statistical Data of Basketball Technique. Journal of Shanghai Physical Education Institute, **33(5)**, **(2009)**.

[2] Wang Luning et al.; Development of a Computerized System for On-the-spot Technical Statistics in Basketball Matches. China Sport Science, **19(3)**, 37-40 **(1999)**.

[3] Mao Jie, Shan Shuguang; Basketball Technology Statistical Software Development. Journal of Wuhan Institute of Physical Education, **46(2)**, 70-73, 87 **(2012)**.

[4] Zhang Lei; Analysis on Foul in Man's Basketball Final Phase in 10th National Games. China Sport Science and Technology, **42(1)**, 50-52 **(2006)**.

[5] Fu Fan-fei, Yu Zhen-feng, Zhang Quan-ning; Analysis of offensive turnover in period of men's basketball final matches at 10th National Games. Shandong Sports Science & Technology, **28(2)**, 24-25 **(2006)**.

[6] Yang Yue-qing, Rao Han-fu, Len Ji-lan; A Study on the Improvement of Computer Statistic Software for Basketball Games. Journal of Hubei Sports Science, **22(2)**, 204-205 **(2003)**.

[7] Li Ji-hui; Research on the Current Situation and Developing Strategy of Chinese Track and Field Coaches. Journal of Shenyang Sport University, **25(2)**, 63-66 **(2006)**.