ISSN : 0974 - 7435 Volume 10 Issue 20

2014

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(20), 2014 [11799-11805]

Research on free throw shooting skills in basketball games

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ABSTRACT

This study makes modeling research on key skills of free throw in basketball games, which are of great significance for enhancing the capacity of free throws. By curvilinear motion model assumptions, three shots models are set up; by model analysis, more accurate idea of free throw shooting is proposed and basketball free throw motion track is studied; by continuously enhancing free throw shooting skills, the accuracy of free throw is improved.

KEYWORDS

Basketball games; Free throw shooting skills; Modeling.

INTRODUCTION

In basketball games, free throw shooting is one of the most basic techniques, and one or two scores made by free throws often can determine the outcome of the game. In America's NBA and in China's CBA games, it is often seen that a team would lose the match just because of one or two scores. The famous Hack-a-Shaq is used against players who are bad at free throws, so you can make the other side get the lowest chance of scoring and make the ball in your possession. It is often seen in the last few minutes of the Professional Basketball League game that the team with lower scores may use Hack-a-Shaq against the player in the other team who are bad at free throws, so the team with lower scores will greatly increase the chance to win. Hack-a-Shaq is often used in NBA games to turn the tables, but if every basketball player's free throw skill is good, then the Hack-a-Shaq will automatically collapse. If every player can do two successful free throws, it will greatly increase the team's chance to win. Free throw shootings are therefore very crucial in games, so it is necessary to go through scientific training to improve basketball players' free throw skills and hit rate. This paper undertakes studies on free throw shooting skills in basketball games.

RESEARCH OF FREE THROW SHOOTING WITH MODELINGS

Raising questions

In many large basketball games like the NBA and the CBA, the outcome of the game is often decided by hit rate of shootings, while in hit rate of shootings, the speed and angle are very important factors. This paper studies the most fundamental shooting in basketball games: the free throws shooting. In this study, the penalty spot is indicated by P, and the center of the basketball rim is indicated by Q. According to the standards for the dimensions of the basketball court and basketball rim, the horizontal distance between P and Q is L and L =4.60m, the height of Q is H and H=3.05m, the diameter of the basketball is d and d=24.6cm, the diameter of the basketball rim is D and D=45.0cm. According to the practical situation, the shooting speed v is between 7.0-9.0m/s, and the shooting height h is between 1.8m-2.1m.

Modeling assumptions

In free throw shootings, the basketball shooting spot and the center of the basketball rim will form a vertical plane, and the moving track of free throw shooting is always within the plane. This study only considers the situation of "needle threading", and does not consider situations including the ball rebounding into the rim, or the ball touching the rim, or the influence of air resistance in the game, or the balls' rotation.

Analysis of the questions in the study

The movement of basketball in the air is affected by many factors, so it is necessary to carry out detailed analysis of the issues and to simplify the abstract questions. The ball and the rim can be studied as material points, and the relationship between β (angle of the ball entering the rim) and α (the angle of shooting) can be determined depending on different shooting speed v and the shooting height h. This study only considers the situation in which the ball enters the center of the rim without touching it, because the rim is slightly larger than the ball, and in the shooting the centre of the ball can be deviated, but in this case it can still be ensured that the ball will fall into the rim.

Establishing modelings

Modeling 1

In this study, the basketball can be seen as a material point motioning obliquely upwards. Establish the following axes: make the position of the center of the ball at the moment the ball leaves the hands as the original point O, make the horizontal direction of the center of the ball as the x axis, and vertical direction as the y axis, establish the x, y equation, and get the horizontal moving track of the ball. The center of the rim happens to be hit by the ball, and that means the point Q is on the track of the ball, from which we can derive the angle and speed of the ball. Start timing at the moment the ball leaves the hands, and at that time t=0, while moving in the air, the ball can make uniform linear motion in horizontal direction in the speed of $v*\cos\alpha$ and upward projectile motion in the initial speed of $v*\sin\alpha$ (upward). So the speed of the ball in both directions at the time t are v_x, v_y and:

$$\begin{cases} v_x = v\cos\alpha \\ v_y = v\sin\alpha - gt \end{cases}$$

The coordinates of the center of the ball at the time t are:

$$\begin{cases} v = vt\cos\alpha \\ y = vt\sin\alpha - \frac{1}{2}gt^2 \end{cases}$$

Eliminate the t in the equation above and we can get the equation of the moving track of the center of the ball:

$$y = x\tan\alpha - \frac{g}{2v^2\cos^2\alpha}x^2$$

The parabolic map of the moving track of the center of the ball is shown as Figure 1:

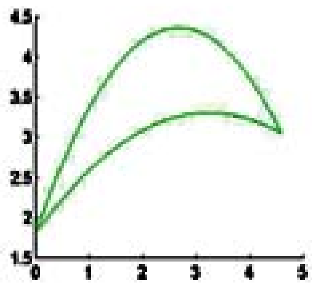

Figure 1 : The parabolic map of the moving track of the center of the ball

Because center of the ball must hit the center of the rim $Q(L, H-h)$

So: $\tan\alpha = \dfrac{v^2 \pm \sqrt{v^4 - 2gHv^2 + 2ghv^2 - g^2L^2}}{gL}$

To make it make sense, this condition must be met:

$$v4 - 2gHv^2 + 2ghv^2 - gL \geq 0$$

That is to say: $v \geq \sqrt{gH - gh + g\sqrt{H^2 - 2Hh + h^2 + L^2}}$

So $v_{\min}$ (the minimum v):

$$v_{\min} = \sqrt{gH - gh + g\sqrt{H^2 - 2Hh + h^2 + L^2}}$$

Derived from the above, we know that g, H, L are constants, the minimum shooting speed is related to h (the height of the ball), and $v_{\min}$ decreases with the increase of h, indicating that short athletes need more speed in shooting than tall athletes.

In the condition that the ball can be guaranteed to hit the rim, we must also pay attention to β, which can be derived from the derivative of the parabolic equation $y = x\tan\alpha - \dfrac{g}{2v^2\cos^2\alpha}x^2$ in the center of the rim $(x = L)$.

$$\tan\beta = \tan\alpha - \frac{Lg}{v^2}$$

And that means: $\beta = arc\tan\alpha(\tan\alpha - \dfrac{Lg}{v^2})$

Modeling 2

Considering the size of the ball and the rim, it should be noted that even if the center of the ball hit the center of the rim, if the angle β is too small when the ball enters the rim, the ball would touch a point on the rim (such as point A) and fail to fall into the rim.

The basic condition under which the ball would not touch the rim during the flight is as follows:

$$\sin\beta > \frac{d/2}{D/2} = \frac{d}{D}$$

Put $d = 24.6cm$ and $D = 45.0cm$ into it, then:

$$\beta > 33.1551^{\circ}$$

Modeling 3

Because the ball is smaller than the rim, the ball can still get into the rim when the center of the ball is not in the center of the rim. Now let's discuss the maximum deviation of angle and speed.

QC is the equation of the moving track of the ball, and the distance between the equation and A cannot be less than $d/2$.

So the maximum deviation of the ball is:

$$\Delta x = \frac{D}{2} - \frac{d}{2\sin\beta}$$, It is the length of CO

When the ball hits the rim, the coordinates of the center of the ball is within $(L \pm \Delta x, H - h)$

So: $$\frac{g}{2v^2\cos^2\alpha}(L + \Delta x)^2 - (L \pm \Delta x)\tan\alpha + H - h = 0$$

When $v = v_0$, $L \pm x$ is the range of the abscissa of the center of the circle, solve the equation of α, and get α_0, so the maximum deviation is: $\Delta\alpha = \alpha - \alpha_0$

When $\alpha = \alpha_0$, $L \pm x$ is the range of the abscissa of the center of the circle, solve the equation of v, and get v_0, so the maximum deviation is: $\Delta v = v - v_0$

Solve questions with the modelings

Under modeling 1, according to the minimum speed $v_{\min} = \sqrt{gH - gh + g\sqrt{H^2 - 2Hh + h^2 + L^2}}$

and $\tan\alpha = \frac{v^2}{gL}$

Getting the minimum speed and the corresponding angle of the shooting with different heights of players, shown as TABLE 1:

TABLE 1 : The minimum speed and the corresponding angle of the shooting with different heights of players

$h(m)$	$v_{\min}(m/s)$	α **(Degree)**
1.8	7.6789	52.6010
1.85	7.6386	52.3098
1.9	7.5985	52.0185
1.95	7.5585	51.7238
2.0	7.5186	51.4293
2.05	7.4788	51.1314
2.1	7.4392	50.8338

According to the data above, the minimum speed is higher than $7.0m/s$, so we only need to discuss the shooting speed $v = 8.0 \sim 9.0m/s$

The shooting height is between $1.8 \sim 2.1m$.

Then according to the formula $\tan\alpha = \frac{v^2 \pm \sqrt{v^4 - 2gJv^2 + 2gjv^2 - g^2L^2}}{gL}$, calculate the shooting angle in which the center of the ball can hit the center of the rim with different heights and speeds:

The shooting angle in which the center of the ball can hit the center of the rim with different heights and speeds, shown as TABLE 2:

TABLE 2 : Hitting the center of the rim with different heights and speeds

$v(m)$	$h(m)$	α_1 **(degree)**	α_2 **(degree)**
8.0	1.8	62.4095	42.7936
	1.9	63.1177	40.9188
	2.0	63.7288	39.1283
	2.1	64.2671	37.4014
8.5	1.8	67.6972	37.5061
	1.9	68.0289	36.0060
	2.0	68.3367	34.5201
	2.1	68.6245	33.0441
9.0	1.8	71.0697	34.1333
	1.9	71.2747	32.7614
	2.0	71.4701	31.3874
	2.1	71.6561	30.0107

Under modeling 2, according to $\tan\beta = \tan\alpha - \frac{Lg}{v^2}$, we can know that the incident angles are different with different shooting angles. The corresponding relationship is as the following TABLE 3:

TABLE 3 : The incident angles are different with different shooting angles

$\alpha_1(\circ)$	$\alpha_2(\circ)$	$\beta_1(\circ)$	$\beta_2(\circ)$
62.4095	42.7936	53.8752	20.9218
63.1177	40.9188	55.8214	20.1431
63.7288	39.1283	57.4959	19.6475
64.2671	37.4014	58.9816	19.3697
67.6972	37.5061	67.8199	19.3814
68.0289	36.0060	68.6121	19.2722
68.3367	34.5201	69.3347	19.2795
68.6245	33.0441	69.9990	19.3886
71.0697	34.1333	75.1701	19.2987
71.2747	32.7614	75.5635	19.4202
71.4701	31.3874	75.9325	19.6191
71.6561	30.0107	76.2784	19.6191

According to the above we know that $\beta > 33.1551^\circ$, because β_2 is always smaller that 33.1554°, we can surrender it, and the shooting angle can only be α_1, and the incident angle is β_2.

According to modeling 3, we can get the maximum deviation between Δx and Δv, shown as TABLE 3.

TABLE 3 : The maximum deviation between Δx and Δv

$v(m/s)$	$h(m)$	$\alpha(\circ)$	$\beta(\circ)$	$\Delta\alpha(\circ)$	$\Delta\beta(\circ)$
8	1.8	62.4095	53.7520	-0.7902	0.0503
	1.9	63.1177	55.8214	-0.7556	0.0540
	2.0	63.7288	57.4959	-0.7268	0.0571
	2.1	64.2671	58.9616	-0.7035	0.0597
8.5	1.8	67.6972	67.8199	-0.6089	0.0698
	1.9	68.0289	68.6121	-0.5941	0.0713
	2.0	68.3367	69.3343	-0.5805	0.0727
	2.1	68.6245	69.9990	-0.5678	0.0741

9	1.8	71.0697	75.1701	-0.4920	0.0790
	1.9	71.2747	75.5635	-0.4848	0.0799
	2.0	71.4701	75.9325	-0.4762	0.0808
	2.1	71.6561	76.2784	-0.4689	0.0817

Analysis

Analysis of the flight path of the ball in free throws

In free throws there are usually three parabolas: high radian, middle radian and low radian ones. From this study we can know, using middle radian parabola in free throw shootings can get the highest hit rate, while the hit rate is low using high and low radian ones. It is mainly because that when the parabola radian is high, its flight path is long, and it is difficult to control the angle and speed, and when the parabola radian is low, its flight path is short, the angle is small, so the hit rate is low too.

Analysis of the shooting angle and speed

The shooting angle in free throws is the angle formed by the ball and the horizontal direction at the moment when the ball leaves the hands. The shooting angle directly affects the radian of the ball whiling moving in the air and the angle it hits the rim. If the shooting speed is the same and the shooting angle is small, then the radian of the ball is low; if the shooting angle is big then the radian of the ball is high. So to ensure the ball hit the rim accurately, the shooting angle and speed have to be reasonable.

Analysis of the use of strength

The effort in free throw shootings is a process of integrated and coordinated effort of various parts of the body. Under normal circumstances, when the shooting distance is short, we can use less intensive integrated physical exertion. The small muscle groups in fingers and wrist are the main parts of exertion in shootings. When making free throws, it requires not only the muscles and joints in various parts of the body to make coordinated effort, but also to master the order and strength of the muscle, so that the efforts can be fully made and be the most labor-saving, it is also very favorable for mediating integrated exertion, so that the shooting action can be accurately completed.

Analysis the follow actions of the arms when and after the ball leaves the hands

In free throws, the movements from the shooting to the follow-up should be coherent and complete, both smooth and soft, for it is very important for improving hit rate. At the moment the ball leaves the hands, the arms, wrists, and fingers of the player shoud be fully stretched, the shaking of the wrists should be gentle and not too strong to avoid the spin of the ball. The shooting motion is correct when the wrists and fingers forms the gooseneck shape.

RESEARCH RESULTS

(1) Free throw shooting is the combination of multiple action links, in order to have a higher hit rate of free throws, we must get standard free throw shooting skills, which requires basketball players to master the principle of free throw shooting, and to constantly practise in their daily training to form good free throw shooting styles.

(2) Any movement is essentially a linked, complex, and proprioceptive conditioned reflex, which is what we call dynamic stereotype of motion. Accurate free throw shooting action is the prerequisite to improve free throws. Added with constant repetition, the conditioned reflex can be formed. In daily training of basketball players, they should first acquire the correct free throw shooting action, and establish and strengthen the proprioception of action, which is also known as the sense of the muscle. Why? It is mainly because in the forming of conditioned reflex, the impulse conduction of the muscle plays a very important role, and without the conductioned impulse, we cannot strengthen the conditioned stimulus, or form the conditioned reflex, or master the skills of movement. The second the players need to do is to continuously increase the frequency of practice.

METHODS TO ENHANCE FREE THROW SHOOTING SKILLS

① In the teaching of free throws shootings, we should guide the actions of students, tell students that at the moment the ball leaves the hands, the elbow of the shooting arm should be raised as high as possible, the wrist should actively aim at the direction doing downward pressing or flipping, the four fingers should send the ball in the direction along the tip of nose and the forehead, and the index and middle finger should pluck the ball with gentle strength. Especially avoid to press the wrist, otherwise it will effect the shooting angle, and thus will effect the hit rate of free throws.

② In free throw shootings, we not only need to adjust the shooting angle, but also needto accelerat the shooting speed, which is to say, while accelerating the shooting speed, we also need to consider factors including the shooting angle, strength and method, as well as targeted of for integrated comprehensive strain training to ensure in shooting radian should be adjusted to the middle radian, because the research above has obtained that the moving track with middle radian has the highest hit rate.

③ Free throw shootings also have high requirements for players' standing position. The legs should keep separate instead of standing together, so the player can move in all directions. Some basketball players hold the ball in their right hands, and their right feet should be closer to the free throw line than the left feet and point to center of the rim. In practice, the player should adopt the same position in every free throw shooting to form the dynamic stereotype of actions.

④ In the practice of free throws, the ball should be hold cautiously. For players using one single hand in shootings, the tip of the index of the shooting hand should contact the center of the ball's plane, and the of the thumb of the shooting hand should be stretched and form a 60-degree angle with the index; the other hand should hold one side of the ball, with fingers fully open to the greatest degree.

⑤ In free throws, the player should slightly bend the knees instead of excessively, for too much physical activities would increase the possibility of missing the free throws.

CONCLUSION

This paper studies the skills of free throw shooting in basketball games, first it discusses the process of using modelings to study free throw shooting skills, including raising questions, modeling assumptions, questions analysis, establishing modelings, solve questions with the modelings and analysis, and then come to a conclusion and proposed methods to enhance basketball players' free throw shooting skills. From this research we know that the free throws shooting skills are effected by factors like the shooting angle and speed, and if we want to improve the hit rate of free throw shootings, we should give targeted training of free throw shooting skills to players to ensure they master free throws shooting skills that are the most correct, and can improve the hit rate to the greatest extent, which is the gentle and smooth shooting actions and the middle radian of the shooting path. This is the action with greatest hit rate that this research finds out. When giving training to players, the coach should master the scientific training method to correct and guide the incorrect actions of players in free throw shootings. Make players form conditioned reflex through repeated free throw shooting trainings, to guarantee greater accuracy of free throws in fierce games, to ensure the scores which are more easily earned, and thus to increase the chance to win of the team.

REFERENCES

[1] Dou Hongbin; The experimental research of image training in the teaching of basketball free throw skills, Journal of Xinxiang University (Natural Science Edition), **6**, **(2010)**.

[2] Zhang Tianxi; The analysis and control of players' tension and stress in free throws of basketball games, Science & Technology Information, **32**, **(2010)**.

[3] Yuan Xiangyue, Jia Hongxiang; Analysis and discussion on influencial factors of hit rate in basketball free throw shootings and new training methods, Business Conditions, **35**, **(2013)**.

[4] Shao Yongqing, Zhao Fang; Main influencial factors in basketball free throw shootings and training methods, E-magazine In the New Era of Education (Teachers' Edition), **10**, **(2014)**.