Analysis of Movement Mechanics in Three-Point Shooting

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Abstract — The field of basketball integrates modern science and technology. Advanced shooting actions and accuracy rates are based on correct and reasonable shooting. Therefore, in this paper, the authors analyzed principles of shooting technique and action structure to help the athletes to master and be proficient in using the technique, innovate the skill and improve shooting accuracy. Therefore, this paper analyzed mechanics factor of the shooting technique and results of the research on teaching, training and competition, so as to improve the accuracy. With the results, the authors hope to analyze factors affecting the accuracy of shooting, improve feasibility and effectiveness of the analysis and explore effective ways to improve the shooting rate.

Keywords - Shooting Percentage; Motion Mechanics Analysis; Air Resistance

I. INTRODUCTION

Modern basketball is developing towards high speed, high altitude and high skill [1]. The one who once many times obtained the Olympic champion of the US men's basketball team and got world champion of Serbia and Montenegro men's basketball team is the representative of comprehensive players with both physical quality and skills. Throughout the Athens Olympic Games and the world basketball championships in Japan, general development trend of current world basketball players is faster, taller, with comprehensive techniques and of high accuracy. These outstanding basketball players have their own unique skills and tactics in the style of play [2].

II. DEVELOPMENT OF SHOOTING TECHNIQUE

Shooting is the player with the ball using all the correct way, the ball from the top of the rim into basket used by the various methods of action in general cumulative score depends on how much the game outcome and shot. The attacking team used various techniques and tactics to create more and better shooting opportunity to get the shot score; the defensive team played an active defense. Therefore, the shooting has become the focus of attack and defense, basketball is the most important basic technology [3].

With the development of basketball, the shape and function of the athletes are improved, and the technology of the basketball is developing. The shooting method is more and more, the shooting rate is increasing, and the evolution of the shooting technique is a sign of the basketball movement from one stage to another [4]. With the continuous development of basketball, as Basketball Offensive and defensive focus shooting technique also appeared some new trends and characteristics, summed up as: fast, high, long and variable, full, accurate six words [5].

Fast. Mainly shooting the ball from defense, can use the vagaries of footwork and seize the opponent a momentary lapse, use of time and space of brief gap quick shot; in a ball or dribble pull-up jumpers, most of the ball, knees bent, lift ball, jump a few moves one cohesion, in one fell swoop; shot quickly, mostly using the jump vacated just close to the highest point of the moment shot [6].

High. Increase the shooting height, the modern basketball game is widely used not only jump, but also increase the jump shot position. If the master shot, shot back, dunk difficult moves.

Far. Due to the development of the defensive tactics of the defender control shooting area expand, on 5-6 meters shooting is difficult to find the ideal opportunity to shoot. As a result, some of the outstanding pitcher has been to extend the effective shooting area to 7-8 meters away. In view of the rules, in the hoop center distance 6. 25 meters outside shooting hit to three points, but also promotes the development of the technology of long distance shooting. Good command of long-range shooting technology, makes the point of attack increased, caused a great difficulty for the defender.

Variable. Because the players control the ball, the ability to control the ball and the strength of the strength, the ability to bounce, and the flexibility of the body, and thus greatly improve the shooting skills and strain capacity. One is performance in the transfer, transport, breakthrough technology and shooting the ingenious combination; second in jump shots, encounter defenders cover, can in the air change avoids the defense for shooting [7,8].

Comprehensive. In the modern basketball game, the tactical system has the new development, in the position attack, mostly uses the big scope to cross the transposition, the continuous movement attack [9]. Tactical change, breaking the division of the team's clear division of restrictions, so that the front, the internal and external responsibilities of the increasingly narrow. It also promotes the development of the technology of shooting. In order to adapt to the new tactics, the technology is becoming more and more comprehensive, the players can use a variety of ways in different position, distance and angle [10].
Accurate. Due to players to master the high, fast and far, and comprehensive shooting skills and strong physical condition as the foundation, in the game despite the defender of blocking shots, interference is very fierce, and game shooting rate and the score is still growing up in a high level of international competition, shooting rate generally in more than 50%, averaging also reached more than 90 points [11].

III. SHOOTING MECHANICS ANALYSIS

Shooting is one of the most important techniques in basketball. It is the only way to score. It is the most important technology in basketball technology, and it is also the core of basketball tactics. No matter what kind of attack tactics are ultimately to be attributed to the shooting score, while the purpose of defense is to limit the opponent's shot, so as to create more scoring opportunities [12]. So in a sense, basketball is a sport that limits the opponent's score. Therefore, the shooting rate is a critical technical indicator.

If we can make use of the principle of sports biomechanics to analyze the factors affecting the shooting rate, improve the feasibility and effectiveness of this analysis to explore the effective way to improve the shooting rate, we can enrich the existing basketball training theory and method to improve the athletes' understanding of the shooting process, guide the basketball training, improve the shooting rate, to guide the basketball teaching and training.

Shooting technique refers to the process of coordinating and coordinating the body parts in the body. Force aggregation from shooting the ready position began, by the leg force and along the direction to the basket hit the stretch, especially by stretching the spine of the inertia promote lower limb, trunk and upper limbs, coherence, coordination, the various parts of the body muscle strength of the final accumulation of arm, wrist and finger position and to the extension of the arm and wrist flip and shake and flexion of the fingers plucked action will cast ball. Because the shooting technique is composed of multiple action steps, in order to let the players master the accurate shooting skill as soon as possible, the following is analyzed from the angle of motion mechanics.

The rotation of the ball in the basket has two types: the front and the back. Before or after the ball is the index finger pointing to the reference point to the reference point for the players. Ball rotation type depending in the act of shooting, the first rotation occurred mainly in moving between the underhand cast hollow ball and moving underhand throw cricket. After the rotation occurs mainly in the long-range shooting (including hook shot) and moving master cast hollow ball, cricket. Some people also put forward the problem of side spin of basketball. Under normal circumstances, in the basket on the right side of the shot, the ball should be in accordance with the sagittal axis left. In the basket on the left side of the shooting, the ball should be in accordance with the sagittal axis right-handed. That is to say, in the rim on the right side of the shot, the ball should be along the clockwise rotation; in the basket on the left side of the shooting, the ball according to counter clockwise rotation.

Generally speaking, basketball is carried out in the interior, so the basketball players in the basketball in the middle of the basketball players to play the role of basketball, basketball in the air is only subject to 3 forces, namely gravity, air resistance and air buoyancy. Since the latter two forces are less than the gravity, it can be considered that the basketball is to make an approximate oblique motion, and the motion parameters of the oblique motion are determined by the sum of the various elements of the force exerted by the players in the ball before and in the moment. Because of shooting action caused by basketball in spin in the air to form a composite motion, that is, in the oblique throwing a translational motion at the same time also in around the sphere coronal axis do rotary movement, so the basketball in the air running track with general oblique projectile motion of different. Basketball in the air after the rotation is mainly due to the shooting, the athletes leg strength, limbo abdominal strength and the strength of the upper limb with human joint chain transfer, through the wrist flexion and finally fore finger acting on the underside of the sphere rear of, mainly used in the long-range shooting and travel between master cast hollow spheres and cast to play cricket.

The function and mechanics mechanism of the post rotation in the basket are as follows:

The ball is able to overcome the air resistance and remain relatively stable in the air, and it is very important to keep the ball in the air at high speed. As we all know, the air is applied in the ball table and the friction force is small, that is, there is no significant difference between the two parts of the sphere, that is, the flow of the ball is not significant.
As shown in Figure 1, when the distance shooting, the ball table and the friction of the air flow greatly increased, the spherical layer was severely damaged, when the air flow through the ball will produce a large deviation of the flow direction, so that the rear area of the ball to produce a large flow area, so that the ball before and after the pressure difference between the two parts, resulting in a large sphere of resistance, reducing the length and height of the ball flight, especially not conducive to long-distance shooting. If in the far to shoot the ball through an appropriate force applied to the sphere, the ball in flight process backward rotation: due to the effect of air viscosity, and the surface of the sphere is not absolutely smooth ball rotates in, will drive a layer of gas particles near the surface of the ball body, and ball rotates in the same direction air circulation. The interaction between the air circulation and air flow, weakening or destroying the flow of the sphere in the rear area of the sphere, so that the air flow around the sphere is changed, so that the air can effectively reduce the resistance, so that the ball to maintain a more stable flight state, is conducive to control the ball and keep the ball in the direction of the ball, improve the shooting.

As shown in Figure 1, basketball after the high-speed rotation can make the basketball to get a lift, the lift to improve the ball in the air flight radian, increasing the angle of incidence, expand the basket sudden appearance, improve shot hit rate is very important. Because of the above reasons, in the rotation of the sphere, the ball on the lower part of the gas flow and velocity range, the upper air circulation and streamline of the air flow direction, flow velocity larger but less traffic. Similarly, the lower sphere is opposite, and the slow flow of traffic.

According to the fluid mechanics of Bernoulli's principle:

\[ p + \rho gh + \frac{1}{2} \rho v^2 = C \text{on} \tan t \]  

(1)

The air density P and the gravity acceleration g are both constant, and the variation of the height of the fluid h can be neglected. So, \( p \) decreases with the increase of \( v \), and the \( p \) decreases with the decrease of \( x \). As shown in Figure 2, the top of the flight of the A point relative to the lower B point of the formation of the gas flow rate is low, while the B relative to the A gas flow and high pressure area, so that the direction of the upward force, that is, the higher the lift, the greater the lift, the greater the lift, the more quickly the ball, resulting in a parabolic curve, the incident angle increases, the increase in the incidence of the basketball into the basket [18].

Because of the strength of the lower limbs of the athlete and the combination of the force of the waist and the upper body of the lower part of the ball, the force of the ball is caused by the force of the ball. This situation occurs mainly in March when the cast hollow ball and shooting, cricket.

The role and mechanics mechanism of the pre - rotation of the basketball in the shooting is as follow. The forward rotation of the ball is in favor of keeping the ball relatively stable when the ball is in the air. The author in the experimental observation found that athletes in shooting using the same strength, the size of the basketball movement speed is in turn before spin to the ball, not spin and spin to the ball, the size of the flying distance of the ball, arc is the opposite, so fast in athletes often use moving underhand shot. Although top spin, the ball will be a pressure, which will shorten the in basket level above the flight altitude and flight distance, but taking into account the top spin is mainly used for near shot point of moving shooting, ball in time of flight and flight distance is very short, so the pressure effect on the ball and little.

Hypothesis: \( H \) - Shot height, \( V_0 \) -Shot speed, \( \theta \) - Incident angle, \( \alpha \) -Angle of entry, \( L \) -Shooting distance, \( h=3.05-H \)
There is a certain relationship between the various factors when the shooting distance is constant. L certain time ball in the air, such as not considering the air resistance, then the ball horizontal velocity:

\[ V_{\text{level}} = V_0 \cos \theta \]  

Vertical velocity:

\[ V_{\text{vertical}} = \sqrt{V_0^2 \sin^2 \theta - 2gh} \]  

\[ \tan \alpha = \frac{Lg}{V_0^2 \cos^2 \theta} \]  

Therefore, when the shot is certain, the higher the shot is to reduce the angle and speed of the shot to ensure the appropriate input.

When the shot height is changed, the relationship between \( V_0 \), \( \theta \) and \( L \) has a certain relationship.

\[ V_{\text{level}} = V_0 \cos \theta \]  

Vertical velocity:

\[ V_{\text{vertical}} = \frac{Lg}{V_0 \cos \theta} - V_0 \sin \theta \]  

\[ \tan \alpha = \frac{Lg}{V_0^2 \cos^2 \theta} - \tan \theta \]  

So the more the shot distance is required, the more the shot angle is required to increase the horizontal velocity, and the error caused by the change of \( V_0 \) and \( \theta \) is more and more.

The relationship between the input angle and the angle of the shot is shown below:

\[ \tan \theta = \tan \alpha + \frac{2h}{L} \]  

Therefore, when other factors are constant, \( \alpha \) increases with the increase of \( \theta \).

When shot from the L and the height of the H, \( \theta_m \) - Minimum velocity angle:

\[ \theta_m = 45^\circ + \frac{1}{2} \tan^{-1} \left( \frac{h}{L} \right) \]  

The entry point is an important factor affecting the ball into the basket. Reasonable input angle will greatly improve the shooting rate. When the ball through the hoop gravity center is "hollow into the basket". In theory, the highest percentage of hits is 90 degrees in the basket. The maximum allowable error range, with the decrease of the curvature of the shooting, the angle of the input is also reduced, and the range of the error is reduced, which reduces the shooting rate. So when the basket angle to reduce the number of times to shoot the ball can not hit it? Basketball radius of two 12~13cm, the basket of the radius of =22.5cm, set \( \alpha \) to shoot the minimum into the basket, then \( r, R \) has a relationship:

\[ \sin \alpha = \frac{r}{R} \]  

When \( r \) takes an intermediate value, \( \alpha = 32^\circ 39' \). We can see from the angle of the input to the 32°39', when the error has dropped to zero, if the angle of the basket and then decreases, the basketball will have to touch the edge of the ball box and can not be directly into the box. And the upper limit of \( \alpha \) is obviously 90. Let E as the allowable error, the error E is changed when the \( \alpha \) is changed into the basket.

\[ E = R \sin \alpha - r \]  

The range of \( \alpha \) is 32°39' to 90° degrees, so the E increases with the increase of \( \alpha \). It can be concluded that the allowable error should be increased \( \alpha \). However, due to the increase of \( \alpha \) when the ball is required to increase the initial speed and angle should be corresponding increase, which will undoubtedly increase the difficulty of shooting.

IV. CONCLUSION

The paper analyzed mechanical characteristics of various segments of the process of throwing a basketball from the shot to the basket and discussed factors that affect efficiency and probability of different shots.

Shooting technique contains a variety of laws of human motion, in which the content of motion mechanics plays a decisive role. Coaches and athletes should pay great attention to it in basketball teaching and training to make full use of the mechanics and work together to actively explore and utilize scientific law of shooting.

The act of shooting is composed of multiple segments. Therefore, to master the technology of shooting, one should pay attention to function of the technology and coordination of the operation, and pay attention to comprehensive effect of the technology.

It is suggested that teaching and training of basketball should be based on technology of shooting, and other techniques and tactics should be developed. Coaches should strictly require athletes to work hard from actual conditions to master techniques such as pass, dribble, breakthrough and fake action in shooting training, which is conducive to training of athletes with changeable consciousness. Coaches should also strengthen psychological quality of the players.
and lifestyle training to help the players to improve accurate shooting ability in the game.

REFERENCES


