

A Biomechanical Analysis of Basketball Shooting

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Abstract — Shooting technology as the core technology in the basketball game, from the point of view of biomechanics, basketball shooting skill is a very effective means to improve the shooting percentage of basketball shooting. The details of basketball shooting were analyzed by the methods of aerodynamics, biomechanics, sports science and statistics. Through the analysis of shooting action, based on the mathematical and physical methods as auxiliary means, analysis of human shooting motion arm trajectory, shooting direction, angle, shooting efforts, and shooting rate between the relationship, from the relationship between time, speed, distance and other physical quantities are analyzed and calculated, to improve the method of shooting skills were the summary of the research and the practice.

Keywords - biomechanical; shooting skill; basketball

I. INTRODUCTION

Basketball is a sport that scores determines its results, and shooting skill determines score percentage which means shooting skill determines the result of a basketball game to some extent. As a result, basketball players needs to put much effort on training shooting skill and try their best to stop opponents to score in a game. Therefore shooting technique is one of the core technics in basketball movement, players in the game use various techniques and tactics to create more space to make shots and score. There are so many factors to influence score percentage, such as mental state, shot selection, the level of physical training and shooting techniques, but shooting technique is the main factor to determine score percentage. Specifically, Shooting hand movements, basket aiming points, the whole body coordination and index finger determines whether shoot technology is reasonable or not and score percentage. However, regardless of changes in the shooting techniques, any senior shooting action and its accuracy is established on the basis of the correct and reasonable and fundamental shooting technique [1, 2, 3].

In this paper, through taking record of successful shooting movement and shooting action, and record every shooting action structure characteristics in two dimensional space, and make use of integrated aerodynamics, sports biomechanics and statistical probability to analyze the shooting action and shooting aiming point selection, diversity and its effects on shooting percentage[4, 5].

II. PROBLEMS AND METHODS

Shooting is a complex action, it includes the way of handling the ball, the method of hand movements [6], the coordination of upper and lower limbs, and aiming point. Each part has an effect on final shooting percentage, so people need to practice every part hardly so as to maintain a high score percentage [7, 8].

A. The phase of Handling the Ball

Whether the ball is firmly in control during the whole process of shooting the ball and finished shooting is really important. To make a successful shot, one should make his five fingers separate, pull wrist back and hold the bottom of the ball with the above parts of his hand, keep palm empty, fingers bent slightly, and the bending and spherical radian should be the same, keep the gravity line of the ball almost in the vertical plain between index and middle fingers, elbow adduction, face the basket, carry the ball upon his shoulder. Before shooting, another hand should hold the other side of the ball [9].



Figure 1. Gesture of handling the ball

B. The Phase of Finishing Shot

Two feet stand before and after in distance of half a foot, the foot which is in the same side of the shooting hand should be in the former position against the other foot, two feet should be apart in a width of the width of shoulder [10]. Knees bent, put the center of gravity between the two feet, all the soles of your feet should touch the ground, and forefeet gives power to body. Power passes through the limb,

ankle, knee, hip, waist to the shoulder, elbow, wrist, fingers. Then use fingers to accomplish a shot. While shooting, elbow should be aim at the basket. Shoulder, elbow, wrist, fingers and the ball should be in the same plane, thus when the ball is thrown towards the basket, the ball is in the same plain with the plain when players handle the ball. At the same time, this correct motion method also facilitates shooting since it helps force pass through the whole body to fingers and wrists, as a result players maintain enough power to finish shooting. Finger movement is a key to shooting, ball speed, shot angle and rotating are all for fingers to control, which is to say, fingers dialing the ball movement determines whether the ball will be in the basket [11, 12].



Figure 2. Gesture of shooting the ball

C. Knees Action while Shooting

When shooting, the athlete on the motion of lower limbs, organic cohesion and cooperation is to complete shooting action is the important premise of high quality. By the basic principle, the sports biomechanics in the lower limbs stretching in fast, to reduce the height of the ball by the movements of the elbow flexion, on the one hand, increased the working distance of shooting action; On the other hand, strong tensile in advance as a junior active muscle movements[13,14]. His arms bend your knees, exhibition. Three action links in the contraction of skeletal muscle and bone leverage amplification function, make the basketball vertical upward movement for a long distance, get a speed up. In order to make the ball moves after certain parabolic curve, the moment when the ball away from the hand, the entire torso to do at full stretch to make it has the high point. This will make the shoulder ligament on the forward movement of the muscle contraction speed and powerful, is located in the shoulder joint to the distal finger can obtain larger acceleration, to produce a push forward above the effective action, can effectively enhance the power of the ball moves when. The biomechanics analysis showed that strengthen the athletes shoot, lower limb movement on the coordination of training, to improve the athletes when shooting the ball, to complete shooting action to provide strong guarantee of high quality.



Figure 3. Knees action while shooting

Bend your knees down squat movement characteristic and its influence. According to the analysis of the anatomy and mechanics principle, the correct basic standing position is: two feet before and after the left, right, or open, and shoulder are the same as wide, his right foot before, and knee relaxed slightly curved, upper body slightly forward, right hand palm the ball on top of right shoulder forward, left hand, your right elbow joint natural prolapse, make the arm muscle, slightly elongated, reserve the elastic potential energy. Facing the basket, neck muscle relaxation, body center of gravity between two feet, this basic standing position, every link up function can be produced by the inertia falls within the bearing surface in total center of gravity. Kneel down movement is through the leg extensor group of state under tensile loading, increase the distance when shooting the ball run, to provide good body position and shooting state. By comparing 3d image analytical technology, knee during the shooting, the knee joint Angle and the shot distance, the relation between found that athletes when shooting the ball to his left knee flexion Angle is 163.1° , instant right knee flexion Angle is 161.8° , bend your knees ground at the same time the center of gravity low knee Angle of left knee is 130.6° , right knee was 95.7° when can get the best shooting distance. From the perspective of biomechanics analysis shows that knee flexion is too big, can give a extensor group of large load, speed and other part of the body and the influence of fit; Bend your knees too small and not fully stretched and muscle group, influence of the elastic potential energy reserves, thus influence and power, the body can't get good vertical speed. Statistics show that athletes left and right knee Angle variation of 34° respectively to 163° and 77° , 163° when athletes can get the best body power state, at the same time also can do full preparation for cooperate to complete upper limb movements [15, 16]. Because every athlete's physical quality and different height, different athletes best squats depth of knee flexion Angle and the body will be slightly different, but the scientific grasp the Angle of knee flexion range will provide training of basic movements of athletes with scientific basis [17].

D. The Choice of Aiming Point

According to whether the basketball hit the rebounding shot aiming point can be divided into two categories, namely the aiming point the hoops and rebounding aiming point. Due to the rebound aiming point range has certain limitations, the Angle of shot plus basketball energy loss in the collisions with rebounds and absorb each other, leading to run after the ball is in contact trajectory is relatively complex, so the athletes now specifically used to play hoops is less, the action is more commonly used for moving low hand, master shot and the ball basket on both sides of the shooting Angle range in 30 ° to 45 ° and rebounding positive distance field.



Figure 4. Aiming Point

Use rebounds aiming point shooting mechanics principle of conservation of momentum, if see basketball and rebounding as elastic rigid body, ignore their momentum loss, play basketball board with the rebound Angle should be approximately equal before and after, plus the area of the basketball (415. 265 cm²) only the rim area of 1/15 (6358. 517 cm²), so the aiming point allows a certain error, the error depends on the athletes after training in one thousand to form a precise movement of consciousness to grasp. The author found in the experimental observation, spin the ball before and after the ball after plate basketball running track will be different, after playing board before the ball would have a blunt on the movement, then spin the club there is a downward movement, so the aiming point for low hand play cricket than the aiming point shooters play cricket slightly lower distance is farther the hoops, likewise, is far less how much depends on the athletes' proprioception to adjust.

III. RESULTS

(1) Shooting compliance order are passed through bottom-up, in the form of. Ball moves when, therefore, the ground of lower limbs athletes strength, the waist abdomen strength, and upper body strength mechanical chain transmission through the human body, through the wrist down, finally the index finger on the sphere, resulting from the lower part of the former the transitivity of force in the process of from bottom to top, for shooting arm fully extended rapidly, so as to get the best shot arc. Ball moves,

affected by gravity in the process of the air, its orbit to form a parabola. The kinematics principle shows that the ball is in a horizontal velocity for uniform motion in a straight line, vertically do initial speed for on vertical movement. Basketball in the process of flight kinematics equation is:

$$S = v_0 \cos \theta t \quad (1)$$

$$H - h_1 = v_0 \sin \theta t - gt^2 / 2 \quad (2)$$

, respectively for the initial speed and Angle of basketball; H as the height of the basket, $H = 3.05$ m; shoot height; S for the flying distance of basketball; G for the acceleration of gravity.

The flying distance of basketball with Angle, speed, height and other factors are closely related. Simultaneous (1), (2) available:

$$S = [v_0^2 \sin \theta \cos \theta + v_0 \cos \theta \sqrt{v_0^2 \sin^2 \theta - 2g(H - h_1)}] / g \quad (3)$$

Using (3) the type of basketball air flight distance and shot release speed and Angle dependency for numerical calculation. Basketball under the condition of different initial velocity, air flight distance S dependence on shot-putting Angle theta relationship is shown in figure 4.

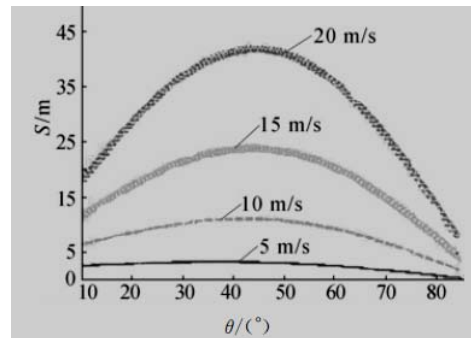


Figure 5. Basketball Flight Distance Curve along with the Change of Shooting Angle Theta

(2) the calculation results show that in hand under the condition of fixed speed, shooting the ball flying in the process of increase with the increase of the distance S with hand speed, namely S and where v_0 into positive correlation; If to a constant speed, the distance of the ball's flight with the increase of Angle increases after the first decreases, and when the Angle of about 45 ° with the longest distance of the ball's flight. So to make the shot distance far, should improve to speed, must increase upper limb force of the ball. In addition, the sphere of the parabola form surface must agree with the ball surface, the entire action is required in the sagittal plane of the human body, such making that the body movement of each link unification in sagittal plane flexion, and for each joint movement of muscular activity and the consistency of joint movement provide strong conditions in addition, also calculate the basketball air flight distance S with the basketball

Sell Angle theta and highly h1 dependencies, the result is shown in figure 5 and 6. Calculation results show that the shooting Angle and shoot height have larger influence on the flying distance of basketball.

(3) Arm at full stretch a shot, can make the ball away from the control of the ball long before hand, is beneficial to control the ball's flight, and raising the point. The shooting arm fully extended is also added to the effect of ball time t. By the formula:

$$S = \frac{1}{2}at^2 \quad (4)$$

$$v = at \quad (5)$$

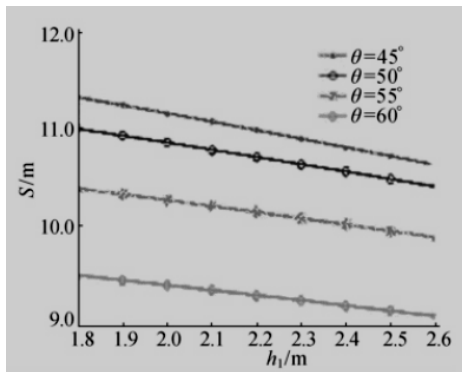


Figure 5. Basketball Flight Distance Curve along with the Change of Shooting Angle Theta

Then it would be easy to get the formula as:

$$v = 2s / t \quad (6)$$

Visible ball to speed v is proportional to the range of the ball S, and the effect of the ball is inversely proportional to the time t. Statistics show that shot when the arm fully extended rapidly, the ball moves close to linear moment your right elbow joint Angle, make the working distance of the ball S peak, is advantageous to the control of the ball, raised a point of the ball. Due to the working distance of the ball must be, quickly at arm's length in the shortest time through a certain distance, improve the movement speed of shooting.

(4) the aiming point for the shooting also can appear after three possibilities: 1) the field strength is small, the basketball right into the basket without touch along the center made; 2) after the shot to power just touch along, because the ball is in the air after the ball, the ball after touch along the spiral rebound after just playing to the basket and made; 3) could force large (or small) and after and along the no contact and can't be made, so at the basket along the shot after shot 66.7%, when the aiming point for other points, because a void point in the field is very difficult to play the role of target and meaningless, so not as shots aiming point.

(5) Knee stretching movement characteristic and its influence. Knee stretching in the direct effect is to make the body upward acceleration, auxiliary upper limbs strength to complete shooting action. Statistics show that the average velocity of shots at around knee joint is 26.6 rad/s and 94.7

rad/s, average around knee stretching rate of 29.3 ° and 76.2 °, the body can be in the best state of power. At this point, the average angular velocity and stretching rate of the right knee is nearly three times in his left knee, control the average angular velocity of the knee joint and stretching amplitude difference is bigger, the stretching force of athletes are heavily dependent on right leg extensor group of the rapid shrinkage of implementation. According to the principle of kinematics analysis shows that the athletes when shooting in the same rhythm, since after the body off the ground in the pedal only by gravity.

By summarizing these results, we can easily get some conclusions as follows:

(1) One hand shoulder shot knee adduction is the basket is a normative, scientific, it is accord with human body anatomy and kinematics, dynamics characteristic, and conform to the biological mechanics principle.

(2) The study found that if the shot from close range is increased by the intensity of exercise, and close shooting is still not high, even if the long-range shooting score, action technology is also not stable; Should strengthen the waist abdomen strength, upper body strength and appropriate finger strength training, increased shooting when the waist abdomen and upper limb muscle elastic potential energy reserves, so as to control the ball bearing and ball to time; Moreover in the process of long-term training should be based on the characteristics of the players and match the actual situation, according to the situation of energy consumption in the process of game at the same time, timely adjust individual shooting Angle, to speed and the point height, form suitable technical style.

(3) In the wrist flexion at the same time, and the index finger force set out at the end is accord with human body movement mechanics principle. , index finger and metacarpal is one of the longest, so, the longest and the working distance to dial out to the ball from this side, is helpful to accelerate the speed and accuracy of basketball accuracy.

(4) Scientific shooting skills should not depend too much on upper limb joint acceleration, should strengthen the lower limbs stretching force, improve jumping ability, on the premise of ensure accuracy to action to improve the height of the point, and then improve the shooting.

(5) Due to the lower level of fatigue will increase as the game time, the fall in jump height and speed, should be appropriately increase the proportion of upper body strength, and to ensure that the speed, when the shooting Angle and minimum height, ensure the balance between these three is the key to the basket

IV. CONCLUSION

Shooting skills contains a variety of laws of human movement, among them, the movement mechanics content plays a decisive role.

While shooting, elbow should be aim at the basket. Shoulder, elbow, wrist, fingers and the ball should be in the same plane, thus when the ball is thrown towards the basket, At the same time, players also need to use fingers to control

and shoot the ball, therefore players will have a better feeling and ensure a higher score percentage.

The aiming point should be the trailing edge of the basket, because after releasing the shot, ball is spinning in the air. Considering the parabolic trajectory and three possible cases that the ball may go into the basket, when aiming at the trailing edge of the basket, the score percentage will be 66.7%, much higher than aiming at other points of the basket.

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