

THE BIOMECHANICAL ANALYSIS OF THE STABILITY OF SINGLE-HAND OVER-SHOULDER SHOOTING

Jia Fang-ye

Shandong Sports College, Jinan, Shandong Province, P. R. China 250000

INTRODUCTION

Shooting is the ultimate aim of all the techniques and strategies in the basketball game, and the percentage of shots made (hits) in a basketball game determines the result of the game. All excellent players both abroad and at home get famous for single-hand over-shoulder shots. The single-hand over-shoulder shot is also an essential basic aspect of training in basketball teaching. So, much emphasis should be put on **this** action. In order to increase the accuracy of shooting, the shooting action itself needs to be correct and appropriate besides other basic techniques, while a correct and appropriate action can only be established and mastered through hard training under strict technical standards. The biomechanical analysis of the stability in single-hand over-shoulder shooting has been conducted in this paper.

METHODS

Data used in this study were obtained in two ways: (1) experiments, and (2) literature. Biomechanical theories were used to analyze the effects of the single-hand over-shoulder shooting action.

RESULTS AND ANALYSES

RESULTS

The total number of shots and shots made by 17 athletes on our college basketball team before and after normalized training in single-hand over-shoulder shot are given in Table 1. Each player shot 10 times.

Table 1. The number of shots made before and after normalized training (10 shots per capita)

Number of shots made	0	1	2	3	4	5	6	7	8	9	10
Number of athletes before training						6	7	3	1		
Number of athletes after training						1	2	4	5	3	1

In Table 2 the scores of the topmost three players in the national class-A league basketball matches in 1996-1997 are listed.

Table 2. The statistics of the scores of the highest three players in the class-A league basketball matches in 1996-1997

Player's name	Total score	score by single-hand shoulder shooting	Percent (%)	Position
Hu Wei-dong (forward)	816	674	83	No. 1
Gong Xiao-bin (mid-forward)	732	513	71	No. 2
Liu Yu-dong (mid-forward)	697	473	68	No. 3

THE REQUIREMENTS OF A STANDARD SHOOTING POSTURE

Shooting is a technical action that requires accurate and harmonious forces. This requirement has two meanings: one is sufficient strength, which is a prerequisite for a necessary height and distance of the ball; the other is accuracy, which is a guarantee for a high percentage of hits. A standard shooting posture is the satisfaction of this requirement and is essential to a successful shooting.

A standard shooting posture is one that utilizes physical strength most appropriately, effectively and economically, and helps ramify new, highly difficult, complex and practical techniques. It again has two implications: the first is a basic shooting posture, which is reflected by the harmony among the lower limbs, the body and the head; the second is the correct holding method of the hand and the correct posture of the corresponding arm.

a. Standing Posture

A standard standing posture, according to anatomical and biomechanical theories, should be as follows: the athlete stands astride with the feet in about the same distance as the shoulders. The foot of the ball-holding side steps a pace forward; the knees are slightly bent, with the ankle-bending muscles and knee-stretching muscles kept in appropriate tension. The feet parallel each other toward the basket; the chest and abdomen slightly contract

in order for the arm-stretching muscles to slightly stretch and store sufficient plastic potential energy; the head is upright toward the basket, and the neck muscles should avoid excessive tension. The weight center of the body falls between the supporting surface of the feet.

This posture has two effects. First, the appropriate establishment of the weight center and supporting surface can provide a steady mechanical condition for the shooting action, and every link from the lower limbs to the body is in a tense state like a pressed spring, thus having sufficient force. Second, all the above-mentioned links conducted bending and stretching movements perpendicular to the ground so that the momentum of each link falls on the same supporting surface as the weight center, and the recoiling force by the ground is concentrated on one point, reducing force disintegration to the minimum.

b. Ball-holding Method of the Hand and the Posture of the Arm

The ball-holding method is an essential part of the basic shooting posture, and greatly influences the improvement of shooting skills. Experience and theoretical analysis have shown that a standard holding method in single-hand over-shoulder shooting should be as follows: the five fingers part naturally to form a concave shape, with the fingers mildly surrounding the lower-back portion of the ball; the palm should be empty in order for the weight of the ball to fall on the fingers; the fingers should avoid excessive tension and too heavy grasp of the ball; the wrist of the ball-holding side lightly turns back, and the forearm turns forward, with the shoulder, elbow, wrist and the forefinger on an arrow-like surface straight toward the basket.

Such a ball-holding method can allow for maximum contact area between the fingers and the ball, thus guaranteeing sufficient stability. In addition, as the contact surface is above the bases of the fingers, the hand can accurately sense the ball, thus acquiring better control and regulation of the ball.

The shoulder joint is in a degree of about 110-120°, and the elbow joint about 90°. The muscles of the forearm relax naturally, and in the meanwhile the other hand slightly lies against the side of the ball for balance.

Figure 1 demonstrates the correct posture of single-hand over-shoulder shooting.

(Figure 1)

Figure 1. The correct posture in single-hand over-shoulder shooting

It can be seen from the analysis above that the force of every link — the lower limbs, the body, and the upper limbs — is exerted on the ball in the same direction. It is the harmony of these forces that allows for sufficient strength and **an** accurate direction.

BIOMECHANICAL ANALYSIS OF THE SHOOTING ACTION

A standard shooting posture not only lays firm foundation for getting appropriate mechanical condition, but it also facilitates the establishment of refined differentiation centers for actions on the cerebral cortex.

A standard shooting posture provides the condition for the simplification of a movement direction in that it unites the movements of all the links of the body and limbs in an arrow-like surface, and the muscles of all the joints lie on the same side of the body. In the process of shooting, a recoiling force is generated by the ground when the legs push on the ground and the knees stretch. With the extension of the body, the forces generated by the rapid, full stretching of the shooting arm and by the pulling action of the wrist combine and pass on to the ball, and make the ball fly out.

Such a transmissive force-exerting process requires the rapid and full stretch of the shooting arm, **i.e.**, the completion of "the golden arc." "The golden arc" is the moving track of the elbow joint, and was posed by a famous physicist after careful **calculation**. The position of **the** elbow joint after the ball leaves the hand has direct influence on the formation of such an arc. The moving track of **the** elbow should be right upward, and the flying track of the ball should parallel the line of vision (See Figure 2).

Figure 2

Figure 2. The harmonious force exertion process in the single-hand over-shoulder shooting (in the sequence of the action)

This action has three important results: (1) to concentrate the harmonized forces on the wrist and fingers, and then on the ball; (2) to control the flying of the ball and to raise its starting point by fully stretching the arm and lengthening the staying duration of the ball at the hand; (3) to speed the shooting action by rapidly stretching the arm.

According to the momentum theory, the change in the momentum of an object, when stricken by an outer force, is equal to the impulse of the force, i.e.,

$$m(V_t - V_0) = F * t,$$

where m is the mass of the object, and V_0 and V , the speeds of the initial state and the final state, respectively, F the force, t the time.

The total force an athlete exerts on the ball can be supposed to be constant when he stands at a certain distance, m is constant, and V_0 is zero relative to the athlete; therefore, we get

$$V = \frac{F*t}{m}$$

It can be seen that the starting speed of the ball is in proportion to the impulse and is in inverse proportion to the mass, and the elongation of the staying time at the hand will raise the speed of the ball, which is realized by the full stretch of the arm.

From the equations

$$S = a t^2, \text{ and } V = a t,$$

where S is the working distance of the ball, a the acceleration, t the time, and V the starting speed, we get

$$V = \frac{2s}{t}$$

It is obvious that the leaving speed of the ball is proportional to the working distance and inversely proportional to the contact time. The full stretch of the arm maximizes the working distance, thus not only improving the control of the ball, but raising the starting point as well. In addition, as S is constant, the full stretch of the arm in the minimum period will raise the starting speed.

CONCLUSIONS AND PROPOSALS

CONCLUSIONS

The normalized training of single-hand over-shoulder shooting can enhance the formation of an athlete's contesting skills and raise the percentage of hits.

Normalized single-hand over-shoulder shooting is very competitive and the most common means of hits in excellent athletes, and is a keystone aspect of training in shooting teaching.

PROPOSALS

Normalized single-hand over-shoulder shooting is consistent with the rapid-going requirements of modern basketball game. Therefore, it is necessary to make the athletes establish a good interior sensitivity through hard training.

New, highly difficult technical actions are urgently expected to ramify from this essential shooting action in order to face the challenge of the "faster, higher and more accurate" tendency of the basketball game.

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