BIOMECHANICAL ANALYSIS OF FOUR SHOOTING TECHNIQUES IN ICE HOCKEY

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The purpose of this study was to analyze four shooting techniques used in ice hockey. Under the experimental conditions, the shooting techniques, performed by high performance male Chinese ice hockey players were filmed and analyzed from the viewpoint of Sports Biomechanics. These included the pulling shot, reflection shot, flick shot and the hitting shot. The results showed that each kind of shooting technique had a distinctive motion structure and technical feature. In competition, correct choice of shooting methods is one of the important factors for improving shooting average.

KEY WORDS: ice hockey, shooting technique, biomechanics

INTRODUCTION: Ice hockey is an official event in the Winter Olympics. The side that attains the highest score decides the result of the competition. Consequently, the shooting technique is the most important factor, affecting the outcome of competitions. Up to the present time, there is little quantitative research on biomechanics concerning the four shooting techniques in ice hockey. Therefore, the study was chosen for the purpose of providing kinematic characteristics of different ice hockey shooting technique in order to make this information available to ice hockey players for their improvement.

METHODS: Under the experiment conditions, film was taken in the ice hockey center of Chinese province of Heilongjiang. Three top hockey players, identified by their initials, W. B. (75kg, 1.81m), G. X. (82kg, 1.83m) and W. L. (71kg, 1.76m), all of whom had won the Best Shooting Prize several times in the national and international games, were selected to perform the four shooting techniques.

A high-speed camera (model: SX–16K) was placed 1.2m high from the ice plane and 28m away from the player who was performing, and the lens direction was vertical with the motion plane of the player's lower hand (the hand holding the lower part of the stick). The filming frequency was 72 frames per second and was checked through the internal time-occurring instrument irradiating the edge of the films in every equal time regularly. The data was obtained from the ST-87 DATA COLLECTING SYSTEM and was screened twice.

The subjects were asked to perform each shooting technique,(pulling shot, reflection shot, flick shot and hitting shot) in front of the hockey gate. The distance between the player and the gate was 8.4±0.3cm, and each shooting method was used 3 times by every subject (that is, each shooting technique was performed 9 times).

For the convenience of analysis, each technique motion was divided into several motion stages. Pulling shot motion was divided into drawing stage and pushing stage. Drawing stage was the period from the beginning of motion to the moment that the puck arrived in front of the center of gravity and pushing stage was the period from the end of drawing stage to the moment puck departed. Reflection shot motion was divided into waving backward stage, waving forward stage and launching stage. Waving backward stage was the period from the beginning of stick's move to the biggest displacement backward and waving forward stage was the period from the end of waving backward stage to the moment stick connected with the puck, and launching stage was the period from the end of waving forward stage to the moment puck departed. Flick shot motion only includes raising stage. Hitting shot motion was divided into advanced waving stage, waving forward stage, deformation stage and batting stage. Advanced waving stage was the process of stick's waving backward. The waving forward stage was the period from the end of advanced waving stage to the moment stick blade beat ice. Deformation stage was the period from the end of waving forward stage to the moment stick blade touched puck and batting stage was the period from the end of

deformation stage to the moment puck departed.

RESULT AND DISCUSSION: The time history of velocity curves from the center of gravity of the athletes in four shooting movements is shown in figure 1 to 4. The shape of the V-T curve in pulling shot was an oblique line and in flick shot was a parabola. In reflection shot and hitting shot, there were two wave crests and one trough: the first wave crest was made because of the waving in advance and the second wave crest was formed by brandishing the stick forward quickly. The V-T curve of the lower hand's center of gravity and that of the end of the staff were similar to that of the body's center of gravity. At the launching stage in reflection shot, the velocity of wrist's center was falling from beginning to end, but the lower hand velocity was not only retarded but also increased in earlier stage owing to the wrist's crook. In hitting shot, the second wave crest of lower hand's V-T curve arose at the end of stick's elastic deformation, and the velocity was falling for the whole batting stage. Comparing the V-T curve of the body center of gravity with that of every link above the lower hand, it was found that the momentum transference existed in reflection shot and hitting shot. That was to say, the body's momentum was delivered to the end of the lower hand, thus to increase the shooting velocity. According to the results of this experiment, the motion of the puck in pulling shot and flick shot was uniformly accelerated approximately. In this way, the instantaneous velocity of the puck departing from the stick in pulling shot and flick shot was decided by the initial velocity, the average acceleration and the displacement. The equation, in which, V_i = the initial velocity (the instantaneous velocity of the puck at the start of the motion), V_f = the final velocity (the instantaneous velocity of the puck at the end of the motion), d = the displacement the puck had undergone, a = the puck's acceleration, are as follows1:

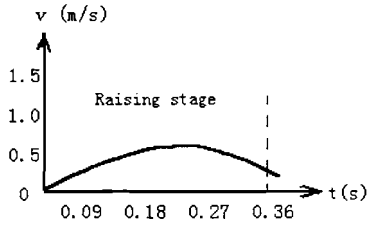

Figure 3 V-T curve in flick shot

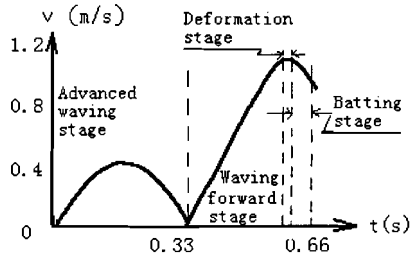

Figure 4 V-T curve in hitting shot

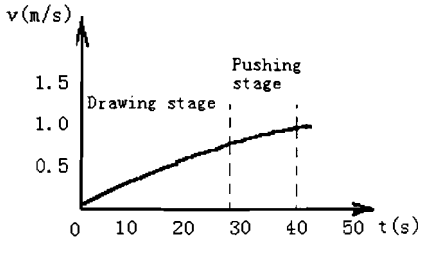

Figure 1 V-T curve in pulling shot

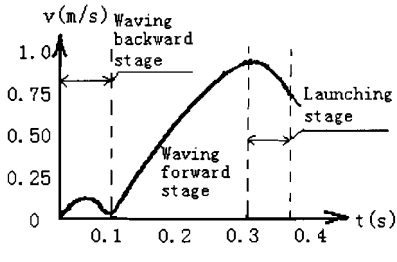

Figure 2 V-T curve in reflection shot

Table 1 Parameters of Four Shooting Techniques

	Pulling shot	Reflection shot	Flick shot	Hitting shot
Holding coefficient	2.52±0.14	2.35±0.16	2.54±0.17	2.09±0.14
Displacement of center of gravity (cm)	29.4±4.3	13.6±9.2	-2.5±0.2	37.1±4.8
Motion time (s)	0.39±0.05	0.35±0.04	0.35±0.02	0.65±0.03
Contact time (s)	0.39±0.05	0.06±0.01	0.35±0.02	0.04±0.01
Puck's average acceleration (m/s^2)	53.13±9.57	304.59±86.40	42.06±10.20	666.94±182.18
Puck's velocity of departure (m/s)	20.88±1.37	18.58±1.92	14.68±2.93	24.01±1.89
Puck's angle of departure (°)	13.2±3.7	12.6±3.5	24.8±6.7	9.7±0.4

Holding coefficient was the length of stick divided by the distance of two hands. Puck's average acceleration was puck's velocity of departure divided by the time of stick acting puck.

$$V_f^2 = V_i^2 + 2ad$$

Therefore, the bigger holding coefficient was needed in the two shooting techniques to increase the displacement of the puck, and the motion time should be shortened to multiply the average acceleration of the puck. The instantaneous velocity of the puck, departing from the stick in reflection shot and hitting shot was decided by the impulse (the product of the force acted by the stick and time during which the force acted). This also referred to the initial momentum (the product of the initial velocity of the puck and the mass of the puck). The equation, in which, F = the force acted by the stick, t = the time during the force acted, V_i = the initial velocity of the puck, V_f = the final velocity of the puck, m = the mass of the puck, are as follows1:

$$Ft = mV_f - mV_i$$

Each segment's accelerating and braking successively could bring about the whipping of the lower hand for the purpose of increasing the impulse of the force acted by the stick.
Usually people think that the stick was swung backward 30-50cm away from the puck in reflection shot 2. and 3., but the result of the experiment proved that the waving distance of the stick back from the puck was 12.6±2.3cm in reflection shot. This kind of shooting technique called for a sudden motion. Although bigger distance of waving backward can increase the batting force in a certain extent, it is disadvantageous for player to put forth his strength suddenly, 4.
The surveying results of these four shooting techniques are shown in table 1. For the contact time of stick acting puck among the four techniques, the result of the pulling shot was the most and its velocity was bigger, correspondingly, this kind of shooting was beneficial to control puck's direction and was suited to middle or long distance, 5. The motion time and batting time in reflection shot were all shorter and for this reason. This kind of shooting was unexpected for the opponents and was suitable in short or middle distance. In flick shot, the departing velocity was the smallest and the departing angle was the biggest, therefore the flick shot was practical only for short distance. On account of the biggest velocity and the smallest angle of departure, the hitting shot was applicable for long distance.

CONCLUSION: Differences in shooting techniques have different biomechanical patterns, and respectively fit different distances. In competition, the correct choice of the shooting

method is one of the important factors in improving shooting average.

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