BIOMECHANICAL ANALYSIS OF RIGHT SIDEDSTRIDE IN JAVELIN DELIVERY

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The purpose of this study was to analyze the technique of javelin delivery using a rightsided stride. This study provided important data for more accurate analysis of the technique of javelin throwing with the right-sided delivery stride. The performance of 10 Chinese elite javelin throwers were filmed and then, some relevant parameters were analyzed. Based on these measurements, it was found that the right foot turns outward when contacting the ground, while the right knee is slightly flexed in the delivery stride. However the strength of the right leg depends on extension of right hip rather than that of right knee.

KEY WORDS: delivery stride, technique structure, javelin, throwing

INTRODUCTION: Some research has been conducted on the delivery stride of javelin throwing. However, further analysis and more specific tests on the performance of the right side in the delivery stride is limited. The delivery stride usually initiates with the left foot contacting the ground. It is well known that javelin throwing is different from throwing techniques in other sports. For most sports involving throwing technique, the delivery stage is completed with two-foot support. However, in javelin throwing, the motion of landing and extending the right leg is completed with the left foot touching the ground only. This was the factor that distinguishes javelin throws from others. In addition, equal effort is devoted to the working of hips. In this study, detailed analysis of the stride structure was conducted. Reasonable technique in the delivery phase of javelin throwing would provide information for coaches and P.E teachers.

METHODS: In May, 1995, Chinese national track and field championships were held in Taiyuan, Shanxi province. The delivery stride of the first 6 male javelin throwers and the first 4 females were recorded by a high-speed camera (Chun-Feng, China). The camera was placed on the right side of the throwing area with a height of 1.25 m and a distance of 25 m to the throw movement. The filming frequency was calibrated as 96 frames per second. The film materials were then digitized and analyzed on a motion analysis system (JTK-I, China). Digital wave-filter was employed to smooth the original data. The kinetic parameters of the 4th stride of the throw were obtained for analysis.

RESULTS AND DISCUSSION: The results revealed that a thrower's right foot contacted the ground in the delivery stride belonged to one of the of the following approaches:

1) the heel of the right foot land the ground first;
2) the sole and lateral border land first;
3) the front part of the sole land first; or
4) the whole sole reach the ground simultaneously.

Most athletes adopt the second approach. At the end of delivery stride phase, if the right heel reaches the ground first, the right leg usually stays straight. The could help to extend the trunk to its full length. However, its disadvantage lies in susceptibility to influence the motion by reduction of the speed. The second approach usually requires the right leg to touch the ground flexes slightly, which is accepted by most throwers. The third one usually calls for the right leg to touch the ground bent, in order to maintain or increase the horizontal speed. This is inclined to move the upper part of the body too early and limit the distance in the final phase.

When the right foot lands first, the angle formed between the right toe and the direction of the throw was around 45°. At the end of extension of the right leg, the right toe was in the throwing direction. This indicated that in the course of extending the right leg, the right toe rotates towards the throwing direction. Hence, when the right foot touched the ground, the

thrower should try to reduce the angle between the toe and the throwing direction. By examining photographs of these experienced athletes, it could be found that when the crossover step finished and the right foot landed on the ground, the body and right leg were almost in one line and the body leaned backwards. From table 1, it could be found that the angle was 61±4.7° for males and 64±1.7° for females. The result indicated that the lower limbs lead to the upper ones and the projection line of the body's center of mass was behind the touchdown point, causing braking. This braking was unfavorable for speeding up horizontally; enabling for the upper body to make forward movement ahead of time, which resulted in shortening of delivery stride. To reduce braking, the right foot must prepare for the shock absorbing motion to follow. The shock absorbing range of the ankle joint was narrow; after the right foot touched the ground, as knee flexion was mostly used to absorb shock. Therefore, with landing of the right foot, the right knee joint should produce a certain angle. Table 1 showed that at the touch down of the right foot touches, the angle of the right knee was 177±8.6° for males and 166±9.9° for females. This result indicated that this factor could be attributed to knee flexion in order to take advantage of the succeeding motions.

Table 1 Trunk Orientations and Knee Angles at the Instants of Touchdown during the Delivery

		Right foot touchdown		Left foot touchdown	
Thrower	Throw distance (m)	Backward tilt of the trunk	Right knee angle	Left knee angle	Angle between the right forearm and the javelin
F1	61.82	62°	158°	173°	81°
F2	63.06	63°	176°	172°	69°
F3	61.32	66°	156°	177°	78°
F4	60.16	64°	172°	172°	77°
Mean±SD		64 ± 17°	166 ± 9.9°	175 ± 3.2°	76 ± 5.1°
M1	65.82	66°	169°	164°	86°
M2	70.94	59°	163°	157°	78°
M3	77.04	64°	169°	176°	58°
M4	72.54	61°	172°	173°	51°
M5	70.98	64°	175°	175°	64°
M6	70.62	53°	177°	165°	91°
Mean±SD		61 ± 4.7°	177 ± 6.8°	168 ± 7.5°	70 ± 18°

Note. the angle of backward lean refers to the angle of the line between the seventh cervical vertebra and the perineum.

The instantaneous motion structure, from the moment of the right foot touching the ground to prior to the standing, was to pull the left hip forward while extending right hip. So as not to change the initial exertion when the right foot touches the ground, the performer should not brake and should push the central gravity of the body forward swiftly. This was accompanied by landing of the left foot without delay. At the instant of the left foot touching the ground, the right foot no longer exerts force and the process of extending is totally completed.

After the right foot touches the ground, with the central gravity of the body moving forwards, the right knee remains flexed at a certain angle. When the direction of the right foot turns to that of the throwing direction, the right foot begins to exert force. The sole purpose of the right foot's exertion is to quicken the horizontal movement of hips and lower body, speed up the landing of left foot and to forces the right hip in order to rotate to the throwing direction. It also prolongs the action of the muscle groups of the right side body, keeps the body leaning backward, and enlarges the mechanical distance. How, then, does the right foot exert force to meet these requirements? If the knee is extended at that moment, the central gravity of the body will move upwards and can produce upwards acceleration, enabling the legs not to move forwards quickly and the hip's forward motion will also be delayed. Because the horizontal (forward) velocity is decreasing, while that of the upper part of the body is

comparatively increased, the mechanical posture is destroyed, which is obviously incorrect. Therefore, it can be seen that, when the right foot lands, its extension is complete, but the right knee still keeps a certain angle of flexion: for males 168±7.5°, for females 175±3.2°. This indicates that when the right foot is exerting force, the angle of the knee joint remains unchanged. So, for the right foot, the only way of exerting force is to extend the hip and the ankle. On the premise that the right knee keeps a certain angle of flexion, the extension of the right hip can accelerate the forward speed of the hips. At the same time, it can rotate the right hip to the throwing direction and push the left hip forward; the landing of the left foot then is quickened. Because the horizontal speed of the right hip is increased, the muscle groups of the right side of the body are pulled tense, and sufficient elastic energy is stored. With the acceleration of the hips, the upper body remained behind the lower body, which is good for enlarging the acceleration path. Therefore, the main function of the right foot's exertion was to extend the right hip.

The angle between the forearm and the javelin in this study showed that right arms of most subjects were nearly straight when subjects were holding the javelin in the delivery stride. In some cases, the right arms of subjects bend slightly. At this moment, the part of the javelin was a little over the head itself. This study showed that the angle between the right forearm and the javelin were between 51° and 91°; for males, and it was between 70±18°, and 76±5.1° for females.

CONCLUSION: In the delivery stride of javelin throwing, the main direction of touchdown for the right foot is on the lateral border. When the right foot touches down, the right knee flexes to absorb shock, and the toe tries to locate in the direction of the throw. The main role of the right leg action is to extend the right hip.

REFERENCES:

China Track and Field Association Press (1995). *Practical Track and Field Technique Course.* Beijing, China.

Hebei Education Press (1989). Hebei Education Press Sports Statistics, Hebei, China.

People's Sports Publishing House (1984). *Track and Field*, Beijing, China.

People's Sports Publishing House (1990). *Sports Biomechanics*, Beijing, China.

People's Sports Publishing House (1994). *Advanced Track and Field Course*, Beijing, China.

Javelin, Beijing, China.