

3-D KINEMATICAL ANALYSIS ON LEFT LEG TECHNIQUE IN THE LAST EXERTING IN JAVELIN THROWING

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Javelin throwing is a kind of event that has a completely different personality and philosophy from the heave thrower, with almost unrestricted approach run. Approach speed and timing transition of body segment play an important role to performance. Through approach, for the elite world javelin throwers, the speed that the body and javelin obtain is 7-8 m/s before exerting finally. Through exerting, the speed of weight of the body is lowered to less than 3 m/s, and javelin obtain 21 m/s above speed. Therefore, through exerting oneself finally, the speed of javelin is increased rapidly, left side planting movement enabling momentum transmit and increase javelin speed. Hence, left leg technique play a important role During transition, the planting of the left leg have a key function, through "whip" technique, the speed of lower big part of the body gradually transmit to upper small arm, via hand, to javelin at last. This study investigated left leg contribution to javelin throwing during the last thrust phase. Eight female javelin throwers were taped during selective competition of X III Asian games in 1998. The subjects were videotaped at 50 frames per second. By analyzing left leg technique, the consciousness of left side supporting and stretching should increased, more and more coaches and athletes will pay more attention to stretching phase of left side supporting technique. The posture of the left foot falling to the ground has influence on left leg supporting technique to certain degree. Home outstanding women javelin throwers should make a little enlargement inside of angle that button up at left foot planting. Home outstanding women javelin throwers have a big buffer degree, hence make the left shoulder, left hip supported not enough. They should enhance the cowgirl muscle the cluster carrying the constringency of left shoulder crest of left shoulder; they should enhance the cowgirl muscle anti-carrying contracting training.

KEY WORDS: javelin throwing, last exerting, left side supporting, left side stretching

INTRODUCTION: Javelin throwing is a field event that requires speed and strength. It demands javelin throwers develop the whole body power and transfers the speed of body to javelin as much as possible. Most studies on biomechanical aspects of javelin throwing were based on data collected during competition. Miller and Munro emphasized the importance of period just preceding releasing to performance, and examined the contributions of body position to javelin performance earlier in 1983. But not talked about body segment such as left leg's contribution to performance. Antti Mero, and Paave V, Komi researched in 1994 and found that knee angle during final foot contact. In their research, 11 female's knee angle were $177 \pm 5^\circ$ at beginning, $163 \pm 11^\circ$ at minimum and $166 \pm 11^\circ$ at release. Roger Bartlet et al, evaluated release parameters for javelin throwers in 1996, they found that the amount of front knee flexion after final foot stride was $12 \pm 6^\circ$.

How much body speed transfers to throwing apparatus is largely depend on planting effect of the left leg. Seeing from the biomechanical angle, the action of javelin throwing has the characteristics of whipping, but the athlete has been won a fast speed during approach, the rigid rooting is impossible to attain. Supporting leg has two kinds of techniques with buffering and stretching, so the expression of left-leg supporting seems to be not completely. The left leg technique correlated to performance tremendously. This study is try to find out the contribution of the left leg to the speed of mass and javelin transmitted.

METHODS: The subjects were female ($n=8$) javelin throwers who took part in selective competition of XIII Asian games in 1998. Their means, standard deviations, and ranges for height, mass, and analyzed throws of the subjects are presented in Table 1. one throw was analyzed for each subject, and it was her best in the competition.

Table 1 Mean, Standard Deviation, min, max for height, Mass, and analyzed throws of the Eight Women Javelin Throwers.

Parameter	M	SD	Min	Max
height	1.71	2	1.70	1.74
Mass	69	3.4	60	74
Age	22	2	19	23
Analyzed throw	59	2.9	56	62

The subjects were videotaped from the right side and the rear right side of the throwing area by two Panasonic 200 tape-recorders at 50 frames per second. All subjects were right-handed throwers. The angle between the optical axes of the videotape was 60 degrees approximately. The height of the optical axis of the lens was 1.1 meters for each videotape, and the optical axis of the lens of the two tape recorders crossed in middle line of the runway, which 3.5 meters inside the throwing arc. The side view videotape was positioned approximately 15m from runway, and the rear side videotape was located approximately 16m from the crossed spot of the two optical axes. Using the ultra-red light spot did the synchronous setting of the tape record. The cube PEAK radial frame made in U.S was used to calibrate the photographic field of the throwing area, which error margin is not exceeding 0.007 m. In dealing with the tape recorder, domestic EIMG70 analyzing system was used to obtain needed data.

RESULTS:

Posture of left-foot planting: The posture of left foot planting has certain impact on left side supporting. According to anatomy, the knee joint unable flex under the condition of the foot twist inside during planting, and this kind of movement may hurt the side ligament of the knee. Because of self-protecting system of human body, most throwers tend to diminish landing angle during planting. By watching tape recorder, we found that the left foot of the javelin throwers planted ground with a heel side, (see Table 2) and the angles between major axis of left foot with throwing direction were different, the average is 21 degree at the moment of heel landing. But when landing with full foot, the posture changed, most throwers is 0, and the biggest angle is 12 degrees.

Table2 Mean, Standard Deviation, min, max for Angle between Left-foot Major Axis with Throwing Direction.

parameter	M	SD	Min	Max
Heel landing	21	3	16	24
Full landing	3	4	0	12

Supporting phase: In order to analyze left side supporting technique clearly, we divided it into 2 parts: the former half and latter half. In former half supporting phase, the javelin throwers' average hip angle (between torso and thigh) is 132 degrees at the moment of left foot planting the ground, and average knee angle (between thigh and shin) is 165 degrees. At the time of biggest buffering, average hip angle is 106 degrees, and average knee angle is 146 degrees. (See Table 3)

Table 3 Mean, Standard Deviation, min, max for Changes of the Left Hip and Knee Angle at the Throwing Stride.

parameter	M	SD	Min	Max
Landing knee angle	165	4	157	166
Buffering angle	146	9	133	157
Landing hip angle	132	9	126	143
Buffering hip angle	106	18	89	125

For javelin throwing, the most important factor is javelin's releasing speed. During planting, there is much loss of mass speed, and how much momentum transmits from lower leg to upper limb determines performance largely. In this study, the subjects' knee speed is 4.83 m/s at moment landing, and 0.5 m/s in biggest buffering. Meanwhile, landing hip speed is 4.74 m/s, and 1.1 m/s in biggest buffering. Mass speed decreased from 5.5 m/s in landing to 2.17 m/s at release. But javelin speed increased 9.24 m/s during transition. (see Table 4)

Table 4 Changes of speed at the Supporting.

parameter	M	SD	Min	Max
Landing knee speed	4.83	0.95	3.55	5.98
Knee Speed in Buffer	0.5	0.89	-0.42	1.88
Landing hip speed	4.74	1.13	3.12	6.23
Hip Speed in Buffer	1.1	1	0.14	2.58
Mass speed at landing	5.5	0.37	4.70	5.80
mass speed at release	2.17	0.32	1.57	2.49
javelin speed transmit	9.24	2.33	7.20	12.37

Stretching phase: After the biggest buffering of the left leg, it began to stretch; the average knee angle increase 10 degrees and average hip angle increase only 4 degrees. Affected by left leg, the left side of the body didn't play its positive role at landing; the heights of left shoulder have a trend to decrease.

The world elite javelin throwers outstand for rigid planting of the left leg during release, which attested by a lot of study. In this period, the left leg braced, and its speed transmit to hip, shoulder, elbow, wrist, hand at last, their speed gradually increased in sequence.

In brief, the posture of the left foot falling to the ground has influence on left leg supporting technique to certain degree. China's outstanding women javelin throwers should make a little enlargement inside of angle that button up at left foot planting. They have more buffer hence make the left shoulder, left hip supported not enough, they should enhance the cowgirl muscle the cluster carrying the constringency of left shoulder crest of left shoulder, they should enhance the cowgirl muscle anti-carrying contracting training.

DISCUSSION: The 3-D form of analysis used in the present study enable a more complex analysis of the javelin throw than the 2-D form used in the earlier studies. Although the results regarding the throwers were very detailed, none of the results alone explain the changes of the left leg that correlated significantly with the distance throw. But the bracing of the left leg technique play a more important role to the throw.

According to Track and Field text book, when the left foot fall to the ground, the foot major axis is 20 degrees with throwing direction, and this action can prevent the left leg, the hip and knee buffer too much along the throwing direction. But in my study, there is a little difference. The form and the rhythm that putting forward of the left leg contains bigger influence on left foot landing. During the left leg putting forward and landing, the knee joint stretches to its most degree, the thigh doesn't swing too high, this can prevent body center of gravity from rising and falling too much, and this also can quicken the rhythm of throwing step. According to the position that normal regulations listed in Track and Field text book, the left foot landed roughly 20-30 cm left side from the right foot in the last throwing step with toe inside, and the angle between major axis of the left foot with throwing direction was roughly 20 degree. When the left foot falls to the ground with the heel first, the left leg curve small. By watching the tape recorder of china top outstanding woman javelin throwers, we found that the left thigh have already overstepped the right thigh while crossing the right foot fall to the ground and quickly stretches to its full, and the left foot come close to the ground landed quickly. When the left foot falls to the ground, the body is side to the throwing direction, and the left foot contains a certain degree to button up. But along with the left foot all fall to the ground, it's inside button been consumedly let up. the leg's three main joints are buffers more along the throwing direction, and the efficiency that the momentum to deliver will decrease on a large scales.

The former supporting technique refers to the action from the left foot fall to the ground to the biggest curving of the left leg joint, that is to say to arrive the biggest buffering. When talking to this technique, most people refer to the technique of left leg supporting. I think that the left side supporting technique should include the action of left leg, left side of torso, left shoulder and the left arm. During whipping, the parts mentioned above act one by one in order. The bracing of the left side led to decreasing of their speed, the momentum transfer from lower body to upper body and to throwing arm. The amount of transferring is depended on the former half supporting techniques.

When landing, the left leg's curve can be acceptable on account of big reaction on the ground. But javelin-throwing technique demands a rigid supporting of the left leg. In practice, athlete of equal level under the equal term, the smaller degree of left leg buffer, the longer distance will be achieved. According to the anatomy's knowledge, quadriceps femoris muscles contain big influence to stretching of knee joint. Through analysis, we found the left leg of china top women athletes' quadriceps femoris muscles is inactive, and its anti-carry ability was bad, so they have a big margin with the world-class javelin throwers.

Seeing from the variety of the hip angle, the left hip have a lead to pull the right hip forward at left foot landing, but with the left foot landing, the hip should gradually bracing along with the lower part braking. Along with the previous constringency, the ex-muscle cluster of left leg contracts some earlier and this have a direct influence on supporting result, resulting in a un-efficiency momentum transfer. Seeing from the right side there have a full bow form, but if consider the left hip, and there have no substantial of full bow. If forward sending of the right chest timely, but the left side of the torso is not nervous, the left shoulder did not lock to its full, and it also consume part of momentum. Although the left side of the torso muscle has certain strain, the left shoulder cannot hold against, there will have a small pulling scale.

Left side supporting and stretching technique play an important role in javelin throwing. Among them, we should pay more attention to stretching technique. The little aware of stretching phase resulted in unfully delivery of javelin. If left leg curves too much, the hip and the left side of torso not stretch too more, so they will not take an active part. The transmission of momentum of left side was relatively small, and china women throwers showed a hasty throwing as a result.

REFERENCES:

- Bruce Elliott, J.Robert Grove, and Barry Gibson (1988). Timing of The Lower Limb Drive And Throwing Limb Movement In Baseball Pitching. *International Journal of Sports Biomechanics*, 1, 1-19.
- William C. Whiting, Robert J. Gregor, and Marie Halushaka (1991). Body Segment and Release Parameter Contributions to New-Rules Javelin Throwing. *International Journal of Sports Biomechanics*, 2, 111-123.
- Antti Mero, and Paave V, Komi (1994). Body Segment Contributions to Javelin Throwing During Final Thrust Phases. *Journal of Applied Biomechanics*, 2, 166-176.
- Roger Bartlet, Erich Muller, Stefan Lindinger, Fritz Brunner, and Calvin Morriss (1996). Three-Dimensional Evaluaton of the Kinematic Release Parameters for Javelin Throwers of Different Skill Levels. *Journal of Applied Biomechanics*, 1, 58-70.
- Norihisa Fujii, Mont Hubbard (2002). Validation of a three-Dimensional Baseball Pitching Model. *Journal of Applied Biomechanics*, 2, 135-149.
- Guang Sun (1998). Research on left supporting technique during last exerting in javelin throwing. *Chinese sports science and technology*, 9, 46.