Biomechanical Evaluation of Indian Javelin Throwers

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ABSTRACT

The purpose of the study was to analyze those biomechanical factors considered critical to the Javelin throw. The subjects of the study were under training Indian javelin throwers at Sports Authority of India, Netaji Subhas National Institute of Sports, Patiala. Angle of release, height of release, velocity of release, stride lengths and velocity of last stride lengths were analysed using Silicon Coach-Pro 7 software. Analysis revealed high angle of release, velocity at foot contact and lower velocity of release in case of Indian javelin throwers as compared to their international counterparts.

KEYWORDS

Angle of release, velocity of release, velocity at foot contact.

INTRODUCTION

Javelin throwing is an aerodynamic event. How far the javelin will go depends on the velocity, angle and height of release. Air resistance also has an effect on the javelin as it travels through the air. The athlete begins by imparting horizontal force to the implement towards the direction of the throw. Just before release, a nearly-vertical force is added. The summed effect of all the horizontal and vertical forces exerted determines its velocity and angle of release.

It is essential that various body forces contributing to the throw be exerted in proper order - timed to build on previous forces - in order to provide the greatest possible velocity at release. As the implement increases in velocity before its release, the parts of the body in a position to contribute must be able to **move faster** than the implement is already moving, if there is to be continued acceleration. This requires the larger, slower muscle groups of the athlete's body to be

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brought into play first, followed by the smaller, faster ones as the implement approaches maximum velocity prior to release.

The mass of the thrower and the length of his levers have a great effect on the forces that can be applied to the javelin prior to release. However, the thrower must also be able to run fast with the javelin in order to generate the horizontal velocity necessary for long throws. Since the big muscles move more slowly than the smaller ones (and since the implement is not heavy), it is far more important for javelin throwers to be **agile** than to be bulky.

RELEASE VELOCITY

Release velocity is the most important factor. In fact, a small percentage of increase in release velocity will always bring about a greater percentage of increase in distance, if all other factors remain constant. However, while the athlete must continually attempt to increase the implement's velocity, he **must avoid** increasing one velocity component (horizontal or vertical) without also increasing the other. Otherwise, the angle of release is likely to be too high or too low and the distance of the throw may be reduced, even though the release velocity has been increased.

During the release, the velocity of the entire body, not just the throwing arm, is an extremely important and often overlooked contributor to long javelin throws. Velocity of release is measured relative to the ground, not relative to the body. Studies reveal that the release velocity of hand or javelin varies from **26m/s to 28.5m/s**. There is some natural slow down of the body during the release, due to the throwing position that must be assumed. But because the thrower's foot is planted and the upper body continues to rotate forward, there is an increase in the forward velocity of the upper body, and of the javelin.

The best throwing position is one in which the thrower has taken a long final stride, increasing backward lean and, thus, the distance through which the javelin can be pulled. The rear leg is bent slightly and the front leg is straight at the beginning of the delivery, stopping the lower body's forward motion.

GROUND REACTION

The forces that can be applied to the implement, both horizontal and vertical, require resistance from firm ground; as the athlete thrusts against the implement, a counter-thrust is received from the ground. Two important points become apparent:

1. The forces that contribute to the acceleration of a throwing implement can be initiated much more effectively while the thrower is in contact with the ground;
2. The greater the forces applied against

the ground, the greater the forces against the implement.

Forces against the ground can be increased with **increase in strength**. The greater the strength with which the implement is lifted away from the ground, the greater the force against the ground. An increase in the distance over which the javelin can be pulled during delivery will increase the distance thrown. **Range of motion** is equally important. Exercises that stress pulling against resistance over great range of movement should be stressed. Also, javelin technique training should include pulling back the arm as far as possible prior to release.

ANGLE OF RELEASE

Regardless of the individual thrower's ability, there is a particular optimum throwing angle for every attempt. It is not necessarily the same angle for each thrower in an event, or even the same angle for an individual athlete's different attempts in the same competition. Since all the throwing implements are released above ground level, the optimum angle of release must necessarily be less than 45 degrees. How much less depends upon the height of release, the velocity of release and in discus and javelin throwing, the effects of air resistance. Although it appears that **34 to 36 degrees** is a reasonable average of opinions, studies indicate that there have been very successful throws with release angles ranging from less than 30 degrees to more than 40 degrees.

THE RUN UP

In theory, the faster the approach runs, the longer the throw. However, the thrower must sacrifice some velocity to get into an efficient throwing position. The withdrawal - drawing the javelin back in preparation for the throw - takes place with 4-6 strides to go. It is timed to coincide with the quick acceleration of the feet, which carries the feet well ahead of the centre of mass and puts the thrower's body in a position where it can exert maximum force on the javelin over the longest possible distance. Unfortunately, withdrawing the javelin also forces the thrower to use cross steps, which tend to slow the approach run.

As the right foot is grounded at the end of the next-to-last stride, the left foot is already moving ahead of it, with the thrower in a backward-leaning position of some 20 degrees from the vertical. The right knee bends as the left continues forward, lowering the body's center of mass in preparation for the throw. As per the literature, the approach run velocity of javelin throwers varies from **6.2m/s to 7.5m/s**. The velocity at final foot contact for men is **5.3m/s to 5.7m/s** and for **women is 4.4m/s to 5.6m/s**.

THE DELIVERY

When the heel of the left foot lands, the legs are well apart and the javelin is still held

as far back as possible. Some forward velocity is lost at this point; the thrower's goal is to lose as little velocity as possible. Rotation around two different axes aids in increasing the speed of the javelin during the delivery. The javelin thrower rotates forward over a horizontal axis through the point where the left foot is in contact with ground and the right shoulder rotates forward around the thrower's vertical axis. Holding the left arm close to the body just before and during the release aids in increasing the velocity of the rotation around the vertical axis.

The braced left leg flexes briefly as it lands, but straightening as the javelin is pulled forward powerfully. With chest forward and back arched, the thrower's shoulder begins leading the throw, with hand far behind. Then half way through the delivery, the elbow begins leading, with the hand remaining behind until just before the release. At release, the fingers give the javelin a stabilizing spin around its long axis, which continues until the javelin has landed. To maintain the javelin's velocity after it has been released, be sure it is thrown with the force applied along the javelin and through its centre of mass. This will eliminate wobbling (or the sometimes slightly sideways) deliveries.

FLIGHT CURVES

Discuses and javelins describe aerodynamic curves through the air because of the lift and drag effects of air resistance. Because of discus and javelin design, air resistance causes them to follow flight curves which are not parabolic. A discus or javelin sails through the air, the air flowing over the implement moves faster than the air flowing underneath, air pressure is diminished above the implement and a lifting force is created which helps the implement to sail a greater distance than would have been possible without fine aerodynamic design.

METHODOLOGY

The present data have been obtained on one female and three male javelin throwers. Each subject was given 7 to 8 attempts. The throws were video captured using Sony camera placed perpendicular to the plane of motion. The data were analysed using Silicon Coach - Pro 7 software. Because of the limitations of the system used regarding accurate spatial calibrations and camera speed, only the approximate and not exact values of the parameters were able to be analysed. Nevertheless, the study can be considered good enough to provide useful feedback to the National Javelin throwers.

RESULTS & DISCUSSION

The following table shows the approximate values of the kinematic parameters studied on the National Javelin throwers. The results indicate higher angles of release, velocity at foot contact and lower velocity of release as compared to the values cited in the literature.

Table 1 : Biomechanical Parameters of Indian National Javelin Throwers

S. No.	Name	No. of attempts	Approximate values of following kinematic parameters						
			Angle of Release (degrees)	Height of release (meters)	Velocity of release (m/s)	2nd last stride length (m)	Velocity of 2nd last stride (m/s)	Last stride length (m)	Velocity of last stride (m/s)
1.	Female	1	35	1.98	18.34	1.42	4.74	1.11	5.04
		2	41						
		3	41						
		4	45						
		5	41						
		6	41						
		7	40						
		8	39						
2.	Male - 1	1	37	1.78	22.92	1.53	6.94	1.39	6.60
		2	41						
		3	40						
		4	41						
		5	37						
		6	40						
		7	38						
3.	Male - 2	1	41	2.01	23.90	1.86	5.48	1.44	7.20
		2	40						
		3	38						
		4	40						
		5	39						
		6	39						
		7	36						
		8	41						
4.	Male - 3	1	42	2.37	24.43	1.49	7.45	1.58	7.66
		2	40						
		3	42						
		4	41						
		5	42						
		6	42						
		7	43						

RECOMMENDATIONS

1. In all throwing events, it is important that the athlete be as strong (and have as much body mass) as possible. In javelin throwing, strength training (concentrating particularly on leg strength and on the full range of motion of the throwing arm) is an important contributor to increasing the velocity of javelin at release.
2. To further increase release velocity, develop a technique that includes a fast approach run that continues throughout the delivery of the javelin, and a "pulling distance" that is as long as possible.
3. Experiment with different release angles under different conditions to determine the most efficient angle for each javelin and each delivery technique.
4. Have longer cross-over step.
5. Have bigger pull distance
6. Produce higher ground reaction force
7. Have stiffer support leg
8. Start hip rotation earlier and rotate their shoulder axis more at the end of Pull phase.
9. Release javelin further on the front (close to the toes of support leg)
10. Thrower to be agile than to be bulky.

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