ASSOCIATIONS BETWEEN JAVELIN THROWING TECHNIQUE AND RELEASE SPEED

Steve Leigh[1], Hui Liu[2], and Bing Yu[1]

Center for Human Movement Science, The University of North Carolina at Chapel Hill, Chapel Hill, NC, USA[1]
Sports Biomechanical Laboratory, Beijing Sports University, Beijing, China[2]

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INTRODUCTION: In javelin throwing, as with other throwing events, the release speed is the single most important factor contributing to long throws (Best et al., 1993; Hay & Yu, 1995; Hubbard et al., 2001). A greater release speed will increase the vacuum flight distance approximately in proportion to the square of the release speed (Hubbard, 1984). The vacuum flight distance is the major partial distance of official distance (Hay & Yu, 1995), and the official distance determines javelin throwing performance. Increasing release speed, therefore, will improve javelin throwing performance. The purpose of this study was to determine which technique variables are associated with greater release speeds.

METHODS: Sixty two competitive trials of 32 male and 30 female javelin throwers were recorded with two high-definition digital video camcorders placed parallel and perpendicular to the throwing direction. Twenty one body landmarks and the tip, tail, and centre of mass (COM) of the javelin were digitized for each trial. Three-dimensional (3-D) coordinates were calculated from the two camera views using the Direct Linear Transformation procedure.
The release speed of the javelin was calculated from the 3-D coordinate data of the COM of the javelin at the release. Trunk, hip, and shoulder Euler angles, the left leg-ground inclination angle, and elbow and knee angles were calculated from the 3-D coordinate data of the body landmarks. Speed and timing variables were calculated using critical instants of right foot down, left foot down, and release and the 3-D coordinate data of the body landmarks. The critical instants enabled meaningful inter-athlete comparisons to be made.
Males and females were analyzed separately to reduce confounding influences. Cross-sectional correlation and stepwise multiple regression analyses were performed to determine the relationships between the technique variables and release speed. Commonality analyses were performed to investigate interrelationships among the technique variables. A significance level of $\alpha = 0.1$ was chosen for this exploratory study.

RESULTS: For female javelin throwers greater release speeds were correlated with: shorter times in double support ($p < 0.05$); and greater runway speeds at left foot down, greater hip-shoulder separations at right foot down, and smaller left leg angles at left foot down ($p < 0.1$). A linear combination of runway speed at left foot down, right shoulder external rotation angle at right foot down, and time spent in single support accounted for 36% of release speed variability ($F = 4.79$, $p = 0.009$). Commonality analyses suggested some suppression effects and shared variance between variables (Table 1).
For male javelin throwers greater release speeds were associated with: shorter times spent in single support, greater trunk forward tilts at release, greater hip-shoulder separations at release, more right shoulder horizontal abduction at right foot down and left foot down ($p < 0.05$); and greater trunk forward tilts at left foot down, and more right shoulder external rotation at right foot down ($p < 0.1$). A linear combination of trunk forward tilt at release, left leg-ground angle at left foot down, and javelin yaw angle at release accounted for 45% of release speed variability ($F = 7.679$, $p = 0.001$). Commonality analyses suggested some suppression effects between variables (Table 2).

Table 1. Female Javelin Throwers' Release Speed Regression Equation

Variable	Mean	Coefficient	t (p)	Commonality%
Runway speed LFD	4.4 m/s	+1.602	+3.536 (0.002)	-27, -20, +13
Right shoulder ext. rotation RFD	34°	-0.018	-2.390 (0.024)	-27, -13, +13
Single support time	0.23 s	+13.113	+1.707 (0.100)	-20, -13, +13

Table 2. Male Javelin Throwers' Release Speed Regression Equation

Variable	Mean	Coefficient	t (p)	Commonality %
Trunk forward tilt REL	32°	+0.081	+3.958 (0.001)	-17, +1, 0
Left leg-ground angle LFD	46°	+0.150	+2.373 (0.025)	-17, 0, 0
Javelin yaw angle REL	-13°	-0.062	-2.347 (0.026)	1, 0, 0

DISCUSSION: Our data suggest that the technique variables associated with great release speeds are different for males and females. For female throwers the major factor for increasing release speed is to increase runway speed and maximise this speed up to the block at left foot down. Runway speed at left foot down has the strongest independent correlation with release speed and is the primary variable in the multiple regression equation. Reducing the double support phase time is a secondary factor. For a given overall throwing time any decrease in double support time will be associated with an increase in single support time. Females may also increase their release speed by applying force to the javelin for longer by increasing their throwing range of motion. This is accomplished by externally rotating their shoulder and twisting their trunk more before beginning the throwing motion, and by vaulting more during the block by planting their left foot further in front of them.

For male throwers a greater contribution from the throwing arm to generate release speed is shown. Males who are able to apply force to the javelin for longer by increasing their throwing range of motion tend to generate higher release speeds. This increased range of motion comes mainly from externally rotating and horizontally abducting their shoulder before beginning the throwing motion. Increasing trunk twist is also important. A negative correlation between release speed and yaw angle, i.e. a throw to the right side of the sector, may be reflecting this increased reliance on right arm motion to generate release speed.

Runway speed is an important factor for male throwers. In general, male throwers tend to have greater runway speeds than their female counterparts. This fact and the lack of statistically significant relationships between runway speed and release speed for males suggests there may be a threshold at which further increasing runway speed is of less importance than other factors. An increased forward trunk lean and a relatively upright left leg at the plant are not desirable, because this generates a forward pitching motion. The athlete is forced to counteract this motion driving them downwards by generating more vertical velocity, which is detrimental given the structure and line of action of human musculature. The great forward trunk leans may be indicative of an inability to control high runway speeds, which are causing forward pitching of the trunk instead of being converted to release speed.

CONCLUSION: To increase their release speeds javelin throwers should focus on increasing their runway speed, minimizing time for the throwing procedure, and effectively transferring runway momentum to release speed. Once runway speed is high, it may be more effective to increase release speed through arm motion rather than further increasing runway speed.

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