INTRODUCTION

The javelin throw is one of four Olympic throwing events, where a javelin is thrown for maximum distance. Flight distance is the major partial distance contributing to long throws, and is mainly dependent on a great release speed. The javelin is the most aerodynamic of all the Olympic throwing implements, so aerodynamic distance is a significant factor in throwing far. It is necessary to carefully control the release to optimize aerodynamic factors. Simultaneously maximizing release speed and controlling the release is technically demanding.

The purpose of this study is to explore the relationships between throwing technique and throwing performance.

METHODS

Two high-definition digital camcorders were used to record the javelin throw competitions at the 2007 USA Track and Field National Outdoor Championships, 2008 US Olympic Team Trials, and 2008 UNC/Nike Elite Meet. The camcorders were aligned so their optical axes were perpendicular and operated at 60 frames/second. The longest throws by the 30 female and 32 male competing athletes were subsequently analyzed. Twenty-one body landmarks, and the tip, tail, and center of mass of the javelin were manually digitized in both camcorder views for each throw [1]. Three-dimensional coordinate data were obtained using the Direct Linear Transformation procedure [2].

For each trial, the release parameters of release speed, height, and angles, and the partial distances were reduced. These variables represent throwing performance. Kinematic variables of joint and segment angles and positions were reduced at the final stride critical instants of right foot touchdown, left foot touchdown, and release. The whole body speeds and times between the critical instants were also reduced. These variables represent throwing technique, and are known as technical parameters.

Statistical analyses were performed to explore the relationships between throwing performance and throwing technique. Female and male javelin throwers were assessed separately. Statistical significance was set a priori at $\alpha = 0.1$. Bivariate Pearson correlation coefficients were calculated between the technical parameters and the official distance, release speed, and aerodynamic distance. Multiple regression equations were calculated to determine the effect of select technical parameters on release speed and aerodynamic distance. The technical parameters were the independent variables and release speed and the official distance were the dependent variables. The three technical parameters with the strongest bivariate correlation with the independent variable were chosen for entry into the multiple regression.

RESULTS AND DISCUSSION

For female javelin throwers greater official distances were associated with: greater hip-shoulder separations at right foot touchdown, smaller right elbow flexion angles at right foot touchdown, greater whole body speeds at left foot touchdown, smaller left leg angles at left foot touchdown, and shorter times spent in double support.

A linear combination of whole body speed at left foot touchdown (mean $= 4.4$ m/s; $b = 0.97$ ; $p = 0.07$) and time spent in double support (mean $= 0.14$ sec; $b = -15.21$; $p = 0.03$) accounted for a significant amount of release speed variability ($R^2 = 0.23$; $F = 4.12$; $p = 0.03$). A linear combination of
right elbow flexion angle at right foot touchdown (mean = 23°; b = -0.08; p = 0.01), right shoulder adduction angle at right foot touchdown (mean = -8°; b = -0.10; p = 0.05), and javelin inclination angle at release (mean = 41°; b = -0.27; p = 0.04) accounted for a significant amount of aerodynamic distance variability ($R^2 = 0.32; F = 4.00; p = 0.02$).

Our data suggest that female javelin throwers utilize a high runway speed with minimal braking during ground contact in the final stride to achieve great release speeds. Release speed is the most important factor for throwing long official distances. Using runway speed to achieve great release speeds is a method commonly taught by coaches. Our data also suggest that female javelin throwers control their release of the javelin with their throwing arm to keep the inclination of the javelin low. By keeping the javelin low, drag forces are minimized and aerodynamic distance can be increased. These results show that female javelin throwers use different strategies to achieve great release speeds and long aerodynamic distances.

For male javelin throwers greater official distances were associated with: greater right shoulder external rotation angles at right foot touchdown, smaller right shoulder horizontal adduction angles at right foot touchdown, shorter times spent in single support, lower javelin inclinations at left foot touchdown, greater trunk forward tilts at left foot touchdown, greater right shoulder adduction angles at left foot touchdown, smaller right shoulder horizontal adduction angles at left foot touchdown, greater trunk forward tilts at release, greater hip-shoulder separations at release, smaller right elbow flexion angles at release, and javelin center of mass positions in front of the right shoulder at release.

A linear combination of right shoulder external rotation angle at left foot touchdown (mean = 52°; b = -0.05; p = 0.07), right shoulder adduction angle at release (mean = -7°; b = 0.08; p = 0.02), and right shoulder horizontal adduction angle at release (mean = 5°; b = -0.15; p < 0.01) accounted for a significant amount of release speed variability ($R^2 = 0.31; F = 4.28; p = 0.01$). A linear combination of right knee angle at left foot touchdown (mean = 140°; b = 0.74; p = 0.08), right shoulder adduction angle at release (mean = -7°; b = -0.38; p = 0.03), and right shoulder horizontal adduction angle at release (mean = 5°; b = 0.45; p = 0.03) accounted for a significant amount of aerodynamic distance variability ($R^2 = 0.31; F = 4.10; p = 0.02$).

Our data suggest that male javelin throwers mainly use arm motion to generate great release speed and to control their release for long aerodynamic distances. The regression equations contain the same technical parameters with opposite sign regression weights for release speed and aerodynamic distance. This suggests that an increase in release speed is associated with a decrease in aerodynamic distance, and these technical parameters must be optimized. Our data also suggest that male javelin throwers utilize high runway speeds with minimal braking and low javelin inclinations to throw long official distances. The influence of these strategies, however, is secondary to arm motion and of less importance compared with female javelin throwers.

**CONCLUSIONS**

Release speed and aerodynamic distance are important factors for throwing a javelin long distances. Technique affects both of these factors. It is important for a javelin thrower to use an optimal combination of technical parameters to achieve a high release speed and a long aerodynamic distance to throw long official distances.

**REFERENCES**


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