THE OPTIMAL RELEASE ANGLES OF ELITE DISCUS THROWERS

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INTRODUCTION

The official distance achieved by a discus thrower has three components: the vacuum flight distance, the aerodynamic distance, and the distance lost at release. The vacuum flight distance is dependent on discus release characteristics: the resultant release velocity, and the release angle and height. The release angle significantly affects the vacuum flight distance, the aerodynamic distance (however this relationship may be non-linear), and, therefore, the official distance (Bartlett, 1992; Hay & Yu, 1995).

Optimal release angles have been determined from elite athletes' data and wind tunnel testing (Bartlett, 1992). These optimal angles were based on two assumptions: (1) release angle and resultant release velocity are independent, and (2) the optimal release angle is the same for all throwers. These two assumptions have not been validated. The optimal angles currently recommended may contain significant errors.

The purposes of this study were to determine the relationships between the release angle and the resultant release velocity, and between the release angle and the aerodynamic distance, and to determine the optimal release angle for single athletes.

METHODS

Two video camcorders were used to record 3 female and 3 male elite discus throwers' performances in actual competitions with a setup for the DLT procedure. At least 10 trials by each athlete were analyzed. Twenty-one body landmarks and the discus center were digitized for each trial (Hay & Yu, 1995). 3-D coordinate data were obtained using the DLT procedure (Abdel-Aziz & Karara, 1971). Release parameters were reduced for each trial (Hay & Yu, 1995).

Multiple regression analyses were performed to express the resultant release velocity and the aerodynamic distance as functions of the release angle for each subject. A forward selection procedure was used to determine the power of the best regression equation for each subject. The vacuum flight distance was estimated from the resultant release velocity and the release angle. The official distance was calculated as a sum of the estimated vacuum flight distance, the aerodynamic distance, and the distance lost at the release (Hay and Yu, 1995). The regression equations were applied to express the official distance as a function of the angle of release for each subject. A computer simulation was performed to determine the official distances within a range of release angles (30°-50°). The release angle corresponding to the longest official distance was considered the optimal release angle for a given subject.

RESULTS AND DISCUSSION

All subjects had linear relationships between the resultant release velocity and the angle of release. The regression coefficients for the release angle and resultant release velocity relationship varied among subjects.

The regression coefficients tended to show that the resultant release velocity decreased as the angle of release increased. The regression determinant for the resultant release velocity as a function of the release angle varied from 0.28 to 0.51 ($p < 0.01$). These results demonstrate that the resultant release velocity was affected by the angle of release for individual throwers. Increasing the angle of release resulted in a decrease in the release velocity. This indicates that increasing the vertical release velocity of the discus may result in a disproportionate decrease the horizontal release velocity because of the limited strength and power of the thrower. The dependency of the resultant release velocity on the release angle does not support the first assumption in the determination of optimal release angles from aerodynamic data alone. The relationship between the resultant release velocity and the release angle may depend on the physical and technical characteristics of an athlete. Further research is necessary to determine these physical and technical characteristics and how they relate to the optimal release angle.

Five of the throwers had linear relationships between the aerodynamic distance and the angle of release. The regression coefficients for the release angle and aerodynamic distance relationship varied among subjects. For four of the six throwers, the regression coefficients suggest that the aerodynamic distance increased as the angle of release increased. The regression coefficient for one subject suggests that the aerodynamic distance decreased as the angle of release increased. The regression determinants of the aerodynamic distance as a function of the release angle varied from 0.18 to 0.65 ($p < 0.01$) for five throwers. These results suggest that the aerodynamic distance is correlated with the release angle for most of the subjects. Our results, which show that increasing the release angle would increase the aerodynamic distance, are consistent with wind tunnel data. Aerodynamic data is important when calculating optimal release angles. Our results show that the relationship between the release angle and the resultant release velocity affects the optimal angle calculations.

The simulated official distance had a single maximum, which occurred with a release angle between 30° and 50° for all subjects. The optimum release angle varied among subjects, which does not support the second assumption in the determination of optimal release angles from aerodynamic data alone. The simulated optimal release angles for four subjects were similar to the mean release angles of elite discus throwers in the current literature. The simulated optimal release angles for two subjects were significantly greater than range of optimal release angles reported in the current literature. These results indicate that the release angles used by elite discus throwers are not necessarily optimal for a given individual elite discus thrower.

CONCLUSIONS

The optimal release angle for a given thrower is affected by both aerodynamic factors and their physical and technical characteristics. All these factors and characteristics should be carefully considered when determining the optimal release angle for a given athlete.

REFERENCES

Abdel-Aziz YI and Karara HM (1971). *ASP Symposium on Close Range Photogrammetry,* ASP, Falls Church, VA.

Bartlett, R.M. (1992). *Journal of Sports Sciences,* **10**, 467-510.

Hay, J.G. and Yu, B. (1995). *Journal of Sports Sciences,* **13**, 125-140.