

DO DARTS PLAYERS USE COMPENSATION FOR RELEASE TIMING OR MAXIMUM HAND SPEED?

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INTRODUCTION

When throwing darts at a target board variation in hand speed and release timing lead to variation in the landing height at the target. Such variations in technique execution cannot be compensated using feedback control since the delivery time is too short (Muller and Loosch, 1999). Instead throwing technique can be optimised using feedforward control to minimise the effect of execution variation. Questions to be answered are:

- How do release timing and hand speed variation contribute to variation in landing height?
- To what extent does throwing technique compensate for variations in release timing and hand speed?

METHODS

Three-dimensional position data was collected on one participant who threw a small ball at the centre of a dart board 18 times using 12 Vicon MX13 cameras operating at 800 Hz. The landmarks of the subject's throwing arm and hand were identified by three pairs of reflective markers placed to track the positions of shoulder, elbow and wrist joint centres and three markers attached to the first three digits (Figure 1).

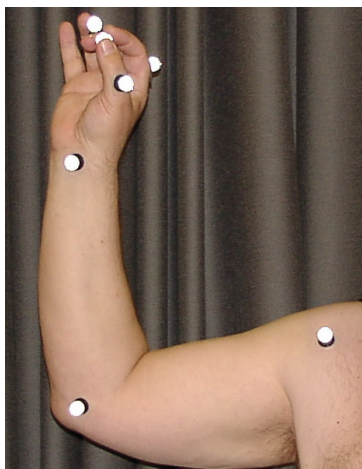


Figure 1: Reflective marker set used to track the motion of the arm and hand (posterior shoulder, lateral elbow and posterior wrist markers not shown).

When the ball was in the hand its position relative to the hand was determined and this was used to reconstruct the position of a hypothetical ball in the hand after the time of release. Quintic splines were fitted to the horizontal and vertical position of the actual ball and hypothetical ball. Release time was estimated as the average of latest time that ball was in the hand and earliest time ball was in flight as determined by comparison of spline value actual vertical ball height with heights from spline to hypothetical ball and parabolic fit to flight phase.

To determine the vertical variation at the target arising from the same percentage variation in release velocity as for maximum hand speed, horizontal and vertical release position and velocity were regressed against maximum hand speed. Release conditions were calculated from these and the landing height determined. The variance arising from hand speed variation was subtracted from the total variance in landing height and the corresponding release timing window calculated for each trial.

The expected landing height variation arising from variation in release velocity when release position and release angle were unchanged was calculated for each trial. The percentage reduction in variance from this value to that of the actual technique was calculated to give the level of velocity compensation. The landing height variation corresponding to release timing variation was calculated for a hypothetical circular hand trajectory at constant angular velocity. The percentage reduction in variance from this value to that of the actual technique was calculated to give the level of release timing compensation.

RESULTS AND DISCUSSION

The vertical accuracy of 18 throws at the target centre was -29.8 ± 37.1 mm. The vertical variation at the target arising from the 1.6% maximum hand speed variation (6.18 ± 0.10 ms^{-1}) was 8.5 mm corresponding to 5% of the total variance. The remaining variation (36.1 mm) corresponded to a release timing window of 3.6 ± 0.5 ms. This result is in conflict with that of Smeets et al. (2002) who found that hand speed variation was the major contributor.

Variation in landing height corresponding to release velocity variation of 1.6% without compensation was 22.8 mm so that the technique used reduced the variance due to velocity variation by 86%. Variation in landing height when timing variation is without compensation was 95.6 mm so that the technique used reduced the variance due to release timing variation by 86%.

CONCLUSIONS

The variation in landing height was due to variation in release timing (95%) rather than variation in maximum hand speed (5%). The technique used compensated for both release timing variation (86%) and maximum hand speed variation (86%). For players with greater accuracy in landing height it is speculated that this is a result of better compensation rather than less variation in release timing and maximum hand speed.

REFERENCES

1. Muller H and Loosch E, *J Hum Mvmt Stud.* **36**:103-126, 1999.
2. Smeets JBJ, et al., Throwing darts: timing is not the limiting factor. *Exp Brain Res.* **144**: 268-274, 2002.