

FACTORS AFFECTING THE JAVELIN'S ATTITUDE ANGLE IN AMERICAN JAVELIN THROWERS

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INTRODUCTION

The distance a javelin travels is affected not only by its release velocity and angle, but the javelin's orientation with the horizontal plane (its attitude angle). Several authors have reported optimal values for these release angles [1,2]. Recent work has found that during the final release phase, American female javelin throwers exhibit much larger attitude angles while having similar release angles to their male counterparts [3]. These large attitude angles are detrimental for the javelin's flight and can lead to shorter throw distances [1,2]. The American females' trunk forward/backward lean angles also differed from the males' during the early part of the release phase. However, a significant relationship between the trunk's lean angle and the javelin's attitude angle did not exist and so other differences should be investigated.

The purpose of this study was to further examine the differences in the javelin's attitude angle between American female and male elite-level javelin throwers. In particular, to determine how the throwing arm's wrist position relative to the shoulder position may contribute to the attitude angle differences observed.

METHODS

The nine finalists for the men's and for the women's javelin throw competition at the 2003 US National Championships were filmed at 60 Hz with two cameras. Standard DLT methods were used to obtain 3D coordinates for 21 body landmarks and 3 javelin landmarks. The 3D coordinates were expressed in an orthogonal reference frame in which the X axis pointed toward the right, the Y axis pointed forward, and the Z axis pointed upward (see Fig. 1).

For each athlete, the two best analyzable throws were used. At the end of the run-up, the right-handed javelin thrower performed a crossover step onto their right foot (RTD), planted their left foot (LTD), and released the javelin (REL). Each throw was digitized from before RTD past REL. The relatively low frame rate was adequate for this study as the parameters investigated exhibited small changes during the time frame studied.

The javelin's attitude angle (ATT) was defined as the angle between the projection of the javelin's long axis on the YZ plane and the +Y axis. The arm angle (ARM) was defined as the angle between the projection of the vector pointing from the right wrist to the right shoulder onto the YZ plane and the +Y axis. These angles were computed at RTD and at LTD.

The difference between these two angles created with the horizontal (DIFF) was also computed.

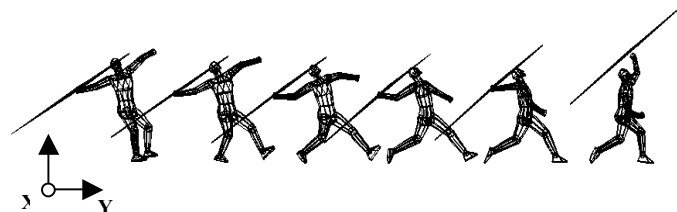


Figure 1: Sequence of the release phase of the javelin throw.

Mean and standard deviation values were computed for the male and female groups. Student's t-tests were used to determine if differences existed between the male and female values. An experiment-wise $\alpha = 0.05$ was used with a correction made for multiple comparisons. Correlation coefficients were computed between ATT and ARM values at RTD and LTD for each gender and for the pooled data.

RESULTS AND DISCUSSION

Table 1 gives the mean and standard deviation values for the male and female groups. There was a statistically significant positive correlation between ATT and ARM at RTD for the pooled data as well as each gender separately. At LTD, none of these correlation coefficients were statistically significant. DIFF values were significantly different at both RTD and LTD indicating that there are differences in the angle between the thrower's arm and the javelin's long axis which are presumably due to differences in wrist angles.

Results suggest that by raising their throwing wrist, females may be able to decrease their attitude angle at RTD. There is a strong relationship between the javelin's attitude angle at RTD with its value at LTD and REL. Thus, having a smaller value at RTD may be enough to create a more favorable attitude angle at REL. Wrist flexion/extension angles should also be considered.

REFERENCES

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Table 1: Mean (standard deviation) values (given in degrees) for the javelin's attitude angle, arm angle and their difference at RTD and LTD for males and females. * denotes statistical significance.

	ATT-RTD*	ARM-RTD*	DIFF-RTD*	ATT-LTD*	ARM-LTD	DIFF-LTD*
Males	26.3 ± 5.3	8.8 ± 6.6	17.1 ± 6.0	31.3 ± 5.2	8.4 ± 4.4	22.8 ± 8.0
Females	35.7 ± 9.0	13.4 ± 5.2	22.3 ± 6.5	40.3 ± 5.3	6.7 ± 3.4	33.6 ± 6.6