KINEMATIC ANALYSIS OF U.S. DECATHLETE SHOT PUT PERFORMANCE

SMITH, S.
Sport Science Division
U.S. Olympic Committee
USA

This project represents part of the continuing involvement of the Division of Sports Science of the U.S. Olympic Committee with the Decathlete Development Project within TAC, the governing body for track and field in the U.S. For the past three years, staff members of the Sports Biomechanics Department have obtained both qualitative and quantitative video images of decathlete performances during the national championships. In this presentation, the results of the analysis of the shot put performances of U.S. elite decathletes will be reported.

The purpose was to analyze selected kinematic parameters describing shot put performances of elite U.S. decathletes. The obtained information provides baseline data of competitive performances upon which subsequence performances of these or other Decathletes can be evaluated.

A secondary purpose was to correlate the selected kinematic parameters with put distance.

METHODS

The analysis was two-dimensional in nature with the kinematic data being obtained from video images. During the 1989 USA/Mobile Track and Field Championships in Houston, Texas, the shot put performances of 13 elite scores between approximately 7800 and 8300 points were recorded. The trials were videotaped by a Panasonic D5000 camera and stored by an AG - 2400 recorder. The camera was positioned perpendicular to the movement path of the athlete across the ring. The best of three put attempts was selected for analysis, and the Peak Video/Computer Motion Measurement System was used to collect the data from the video images.

The images were digitized at 60 Hz on the Peak system and the data were smoothed using a 5 Hz Butterworth filter. A 15-segment model was selected, and center-of-mass determinations were calculated using the body segmental data by Dempster.

Of the 13 Decathletes in the shot put event, 10 exhibited the glide technique; the remaining three decathletes used the spin technique. Only the results of the analysis on the throws obtained by the decathletes using the glide technique are being reported.

The mean height and weight for this group was 1.87 m and 83.86 kg, respectively. Corresponding standard deviations were .04 and 3.63. Average distance for the 10 best puts was 13.59 m ± 1.27 m with a standard deviation of 1.27. None of these figures was noticeably changed by eliminating the three decathletes who preferred the spin technique. Including: displacement, velocity, angular measures and temporal values.

Specific kinematic parameters were selected to describe put performance. The displacement measures included the horizontal and vertical movements of both the shot and center-of-mass of the Decathlete during the propulsive or power phase of the movement sequence. Shot velocity at release was the only speed variable included in the analysis. Angular measures were restricted to those quantifying the angle of projection of the shot at release and the angle of inclination of the trunk. Temporal measures were selected to designate specific movement phases that were identified.

Four timing intervals were designated as indicated bellow:

1. Initial phase
2. Glide phase
3. Stabilizing phase, and
4. Power or propulsion phase

The initial phase was defined as the time interval between an observable, balanced position assumed by the Decathlete prior to beginning the movement sequence and the lifting of the ipsilateral foot.

The glide phase was designated as the time duration between the take-off and touchdown of the ipsilateral foot.

The stabilizing phase described the time period between touchdown of the ipsilateral foot and touchdown of the contralateral foot.

Power or propulsion phase was deliminated by the time period beginning with touchdown of the contralateral foot and ending with release of the shot.

Total movement time was the sum of the time durations for all four of the previously defined sequences.

RESULTS

Analysis of the temporal patterns exhibited in the performances of the 10 Decathletes using the glide technique is presented in this slide. Because of the variation in total movement time, the temporal measures are expressed as a percentage of total time. The initial phase comprised approximately two-thirds of the total time and 20 percent of the time period was spent in the power phase. Percent values of 6.3 were found for both the glide and stabilizing phases. If, however, the timing sequence is referenced to the lifting of the ipsilateral foot then approximately 18% in the glide phase, 18% in stabilizing , and 62% in power propulsive.

Findings from the analysis of the velocity and angular measures are shown in this slide. At release, the average resultant shot velocity was 9.18 m/s, and the mean value for the angle of projection of the shot at release was 44.38 degrees. The angle of inclination of the trunk, on the ipsilateral averaged 81.7 degrees, i.e. the putting shoulder was 8.3% anterior to the hip.

Displacement variables for shot and center-of-mass during the power phase are depicted in the next slide. Additionally the third variable describing projectile motion; height of the shot at release is 1.98m.

Correlational analysis of the selected kinematic variables measured with shot put distance was one of the purposes of this study. Three separate groups of variables were formed in which the relationship of each variable with put distance was determined. The correlation coefficients of variables describing projectile motion are shown in the present slide. None of the three variables was significantly related to put distance.

Each of the temporal measures was also correlated with put distance. The relationship between each time interval and throw distance is depicted in this slide. All of the relationships were negative and non significant.

For the shot and center-of-mass movements in both the horizontal and vertical directions, moderate-to-low correlation coefficients were observed. Negative relationships were seen except for the vertical movement of the center-of-mass in the power phase. None of the relationships was statistically significant.

Based upon the results of both the descriptive and correlational statistical analyses, the following conclusions are warranted:

1. No significant statistical relationship was found between put distance and the parameters describing projectile motion.
2. No significant statistical relationship was found between put distance and shot or center-of-mass movement during the power or propulsion phase.
3. The negative but nonsignificant statistical relationship found between put distance and temporal variables reflect the importance of the force component in the impulse-momentum relationship.

Recommendations for future projects include:

1. Analysis of U.S. elite decathlete shot put performances using a three-dimensional format; this will permit the analysis of the spin technique as well as a more accurate determination of angular variables.
2. Expand the shot put data base to include U.S. elite shot putters.
3. Future analyses should include a comparison of U.S. Decathlete shot put performance with world elite Decathletes.