TECHNICAL CHARACTERISTICS OF ELITE MALE AND FEMALE DISCUS THROWERS

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This study identified technical characteristics of discus throwing techniques used by elite male and female discus throwers. Fifty-seven male and fifty-two female elite discus throwers were divided into four groups based on their longest official distances. Flight distance was the major determinant of the official distance for male athletes. Flight distance and aerodynamic distance contribution to the official distance for females. Horizontal and vertical velocities of the discus at release were major determinants of the official distance for both all athletes. Increases in the horizontal and vertical velocities of the discus during different phases had different effects on the official distance for all athletes. Results provide information for technical training of discus techniques and basis for future discus throwing studies.

KEY WORDS: biomechanics, discus throw, trend analysis

INTRODUCTION: Discus throwing is one of the four throwing events in track and field. Complicated movements performed at high speed in a limited space make the discus throw technically and physically very demanding. The technically and physically demanding nature of the discus throw requires thorough biomechanical studies to have a good understanding of the techniques and training of elite discus throwers. However, a recent extensive review of literature revealed that, although there are many debates on different aspects of the techniques of throwing the discus, the biomechanical studies on this topic are very limited (Bartlett, et al, 1991; Gregor et al., 1985; Hay and Yu, 1995a, 1995b, 1996). The primary reason for the lack of biomechanical studies appears to be the complexity of the technique of throwing the discus. The lack of biomechanical studies on discus throwing techniques limited coaches' and athletes' understanding of the techniques and appropriate physical and technique training for performance improvement. The purpose of this study was to identify critical characteristics of discus throwing techniques used by elite male and female discus throwers.

METHODS: Two S-VHS video camcorders were used to videotape the performances of fifty-seven male and fifty-two female finalists in men's and women's discus throw competitions of 1990 Goodwill Games, 1990 US Olympic Festivals, and 1997, 1998, and 1999 USA Track and Field National Championships, and 2000 USA Track and Field Olympic Team Trials. Three dimension coordinates of 21 body landmarks and the center of the discus in the best trial of each athlete were obtained at a frame rate of 60 frames/second. Raw three-dimensional coordinates were smoothed using a low pass digital filter at an estimated optimum cutoff frequency of 7.14 Hz (Yu and Andrews, 1999). Six critical instants in a discus throw were identified: maximum backward swing of the discus, right foot takeoff off, left foot takeoff, right foot touchdown, left foot touchdown, and release. These six critical instants divide a discus throw into five critical phases: initial double-support phase, first single-support phase, flight phase, second single-support phase, and delivery phase. A deterministic model of discus throw described by Hay and Yu (1995a) were used to determine the biomechanical parameters for analyses. The official distance was decomposed to flight distance (the distance between landing and release points), aerodynamic distance (the difference between the flight distance and the estimated flight distance in vacuum), and distance lost at the release (the difference between the flight distance and official distance) (Hay and Yu, 1995a). The release velocity was decomposed to horizontal and vertical components. Each of the horizontal and vertical components of the release velocity was considered as the sum of the increases in the corresponding velocity component during the five critical phases. Athletes in each gender group

were divided into four groups based on the official distance: below 55 m group, 55 to 60 m group, 60 to 65 m group, and above 65 m group. Trend analyses were conducted to determine if a biomechanical parameter had an increasing or decreasing trend as a function of official distance group. A 0.05 type I error rate was used to determine statistical significance in trend analyses.

RESULTS: Both male and female athletes had increasing trends in flight distance (Figure 1). Female athletes also had an increasing trend in aerodynamic distance. Both male and female athletes had increasing trends in the horizontal and vertical velocities of the discus at the release (Figures 3 and 4). No significant trends were observed for the angle of release and height of release. Male athletes had increasing trend in the decrease of the vertical velocity of the discus during the second single-support phase (Figure 5). Both male and female athletes had increasing trends in the increase of the vertical velocity of the discus during the delivery phase (Figure 6). Female athletes also had an increasing trend in the increase of the horizontal velocity of the discus and a decreasing trend in the decrease of the vertical velocity of the discus during the flight phase (Figures 7 and 8).

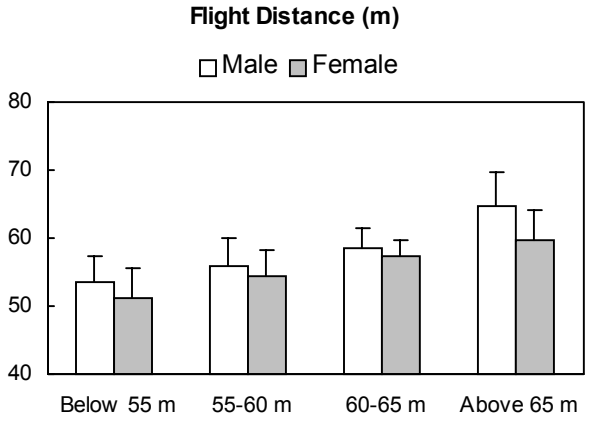


Figure 1 - Comparison of flight.

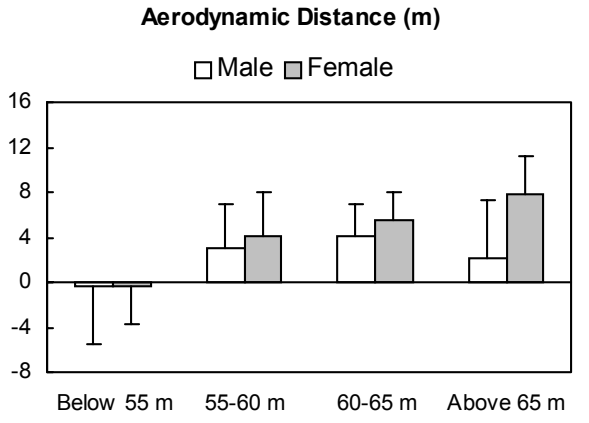


Figure 2 - Comparison of aerodynamic distance.

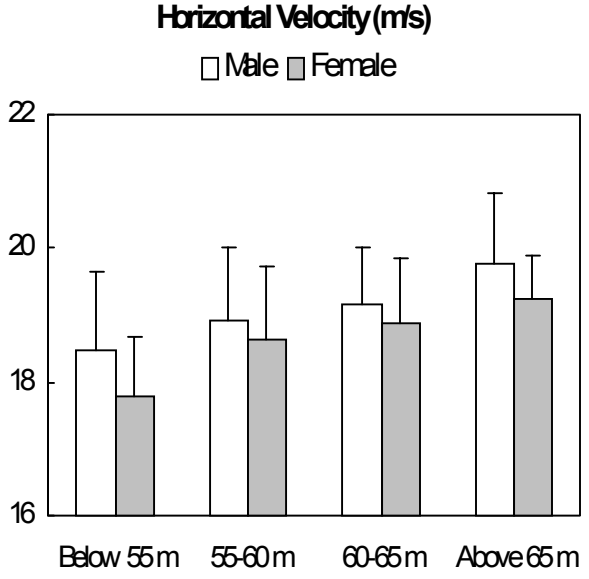


Figure 3 - Comparison of horizontal velocity.

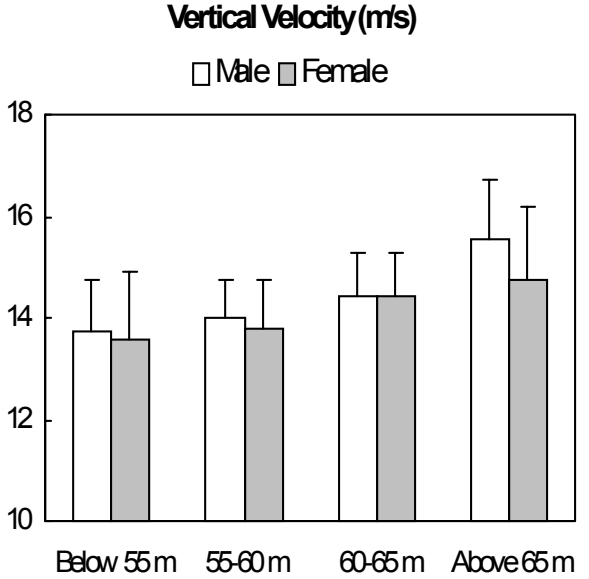
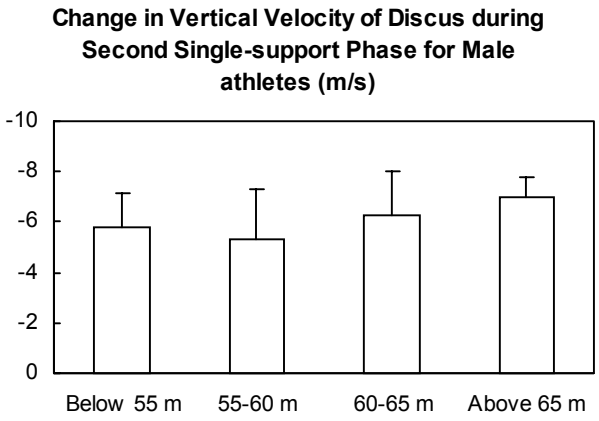
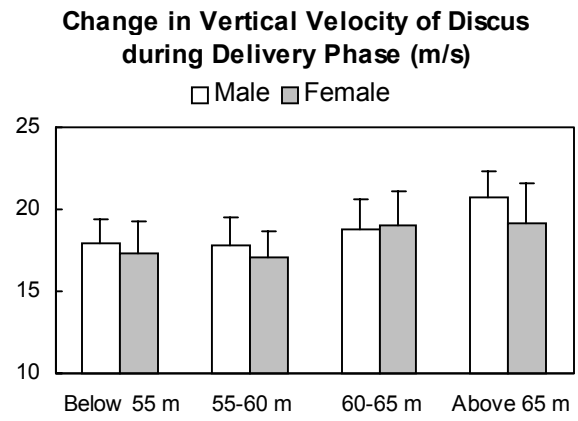


Figure 4 - Comparison of vertical velocity.





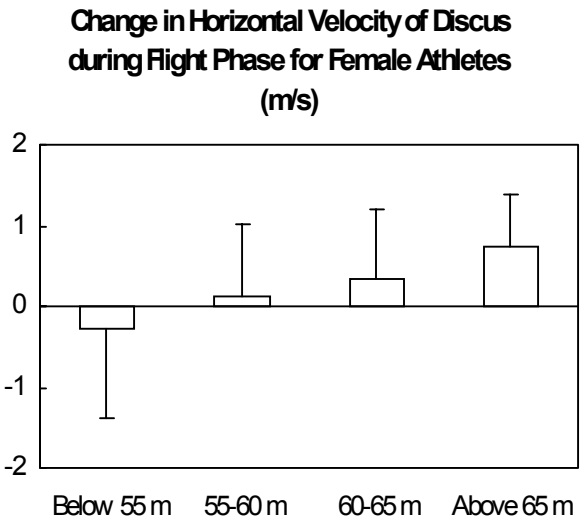


Figure 7 - Comparison of change in horizontal velocity of discus during flight phase for female athletes.

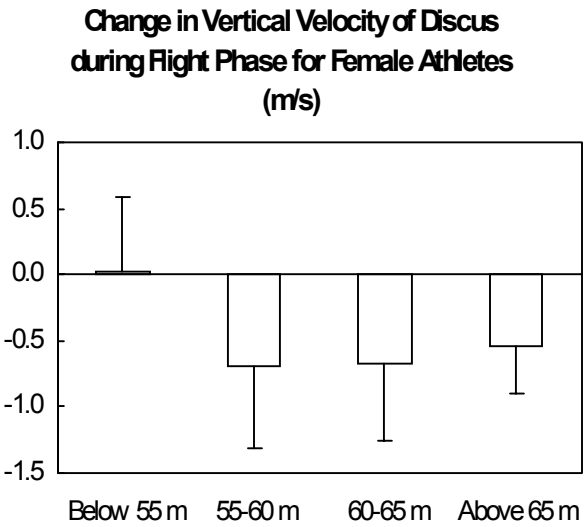


Figure 8 - Comparison of change in vertical velocity of discus during flight phase for female athletes.

DISCUSSION: The results of this study provide important information regarding the technical characteristics of elite male and female discus throwers. Male athletes had only an increasing trend in the flight distance while female athletes had increasing trend in both flight and aerodynamic distances. These results suggest that male athletes' official distance mainly depends on the increase in the flight distance while female athletes' official distance depends on flight distance as well as aerodynamic distance.

Our results also show that both male and female athletes had increasing trend in horizontal and vertical velocities of the discus at the release, but no significant trend in angle and height of release. These results suggest that release velocity is the most important contributor to the increase in the official distance for both male and female athletes.

Our results further show that both male and female athletes had an increasing trend in the increase of the vertical velocity of the discus during the delivery phase. These results suggest a

critical effect of the increase in the vertical velocity of the discus on the official distance during the delivery phase for both male and female athletes.

In addition, male athletes had a decreasing trend in the increase of the vertical velocity of the discus during the second single-support phase while female athletes had an increasing trend in the increase of the horizontal velocity of the discus and a decreasing trend in the decrease of the vertical velocity of the discus during the flight phase. These results suggest that the direction of the athlete-plus-discus system's rotation during the second single-support phase for male athletes and during the flight phase for female athletes may be crucial for the vertical velocity of the discus at the release and thus the official distance. For female athletes the athlete-plus-discus system's rotation speed about the vertical axis and the translation speed may also be critical for the official distance.

Considerable efforts have been made to determine the factors affecting the aerodynamic distance for female athletes. The velocity of the discus at the release and the angle and height of release did not show any significant effect on the aerodynamic distance. The exclusion of these factors leaves the discus tilting angle, attack angle, and spinning speed at the release as possible factors affecting the aerodynamic distance. It is still not clear why the aerodynamic distance significantly decreased for the athletes in the above 65 m group.

Future studies are needed to investigate the athlete-plus-discus system movements during the second single-support phase and delivery phase for male athletes, and during the flight phase and delivery phase for female athletes. The biomechanical variables that need to be considered may include system angular momentum vectors at the associated critical instant, the changes of the system angular momentum vectors during critical phases, the rotations of the lower extremities, trunk, and upper extremity during these phases. Kinetic studies may also be needed to investigate the physical demands in discus throw especially during the delivery phase.

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