KINEMATIC COMPARISON OF THE BEST AND WORST THROWS OF THE TOP MEN'S DISCUS PERFORMERS AT 1996 ATLANTA OLYMPIC GAMES

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INTRODUCTION: The objective of this research project was to perform kinematic comparisons between the best and worst discus throws of the top four men's performers at the 1996 Atlanta Olympic Games. This comparison examined the critical technical factors that resulted in the athletes' best or poorest performance.

METHODS AND PROCEDURES: The discus throws of the qualifying and final rounds were filmed by three video cameras at distances from 50 to 80 m. One camera was situated at the back of the circle, camera 2 was to the side and camera 3 was positioned at 45 degrees to the left-front of the circle in order to provide the thrower's attempt information. Figures 1 and 2 illustrate the

Fig. 1 Discus

Fig. 2 Discus side

perspectives of camera 1 and 2. Field dimensions and anatomical locations were used to create a calibration cube used in the 3-D DLT conversion. The control cube consisted of 9 points representing a composite of circle dimensions and anatomical landmarks and 21 data points were digitized and entered into the 3-D DLT module and converted to real displacements. The 21 data points digitized were left foot (fifth metatarsal), ankle, knee, hip, right, hip, knee, ankle, left wrist, elbow, shoulder, right shoulder, elbow, wrist, hand, discus, base of the neck, mastoid process, top of the head, left and right circle diameters at the hash marks. The real coordinate endpoints were smoothed using a 10 Hz cutoff frequency in a low-pass digital filter. The 3-D displacements of the circle diameter were compared to the actual 250 cm displacement. The top four performers' trials yielded an average error of 2.8 cm (1.1%) using the DLT transformation algorithm (Finch, A., Ariel, G. & Penny, A., 1997).
For the purposes of kinematic comparison, the following throwing performance parameters were selected: disc release velocity, disc projection angle, release eight, time of movement, horizontal velocity of body CM, right hip and right shoulder horizontal velocities.

RESULTS AND DISCUSSION: The top four Olympic discus throwers' height and weights were: Riedel (199 cm, 110 kg), Dubrovshchik (193 cm, 115 kg), Kaptyukh (197 cm, 117 kg), and Washington (188 cm, 109 kg).

The best and worst throws recorded by the top four performers in the Discus event: 1) Riedel (Germany), 2) Dubrovschchik (Belarus), 3) Kaptyukh (Belarus), and 4) Washington (United States of America) were selected for kinematic analysis. The medalist throws were 69.4 m (OR) by Riedel, 66.6, 65.8, and 65.4 m for Dubrovshchik, Kaptyukh, and Washington. The performers' poor throws were 6.3, 6.9, 2.0, and 4.1 m shorter, respectively (See Table 1 and Figure 3).
The resultant release velocities calculated for the best (worst) throws were 3118 (3008), 2725 (3343), 2567 (2269), and 2500 (2440) cm/s for Riedel, Dubrovshchik, Kaptyukh, and Washington, respectively (See Figure 4).
The projection angles for best (worst) throws were 32.4 (30.2), 30.0 (36.4), 35.4 (30.8) and 29.9 (59.9) degrees for Riedel, Dubrovshchik, Kaptyukh, and Washington (See Figures 5 and 6).

Table 1: Throwing Kinematics for Top Four Discus Performers at 1996 Atlanta Olympics

	Dist m	Rel Vel cm/sec	Proj Ang deg	Rel Ht m	Move Time sec
1a. Riedel (GER)	69.4m (OR)	3080.1	21.9	1.5	3.0
1b. Riedel poor	63.1	3008.2	30.2	1.4	1.4
% Change	-9.1%	-2.3%	+38%	-7%	-53%
2a. Dubrovschchik (BLR)	66.6m	2718.5	29.1	1.8	2.3
2b. Dubrovschchik poor	59.7	3343.1	36.4	1.9	1.6
% Change	-10.4%	+23.0	+25%	+6%	-30%
3a. Kaptyukh (BLR)	65.8m	2599.0	37.3	1.6	1.9
3b. Kaptyukh poor	63.8	2269.6	30.8	1.4	1.1
% Change	-3.0%	-11.6%	-17%	-12%	-42%
4a. Washington (USA)	65.4m	2498.0	29.9	1.2	1.6
4b. Washington poor	61.3	2440.7	59.9	1.4	1.3
% Change	-6.3%	-2.3%	+100%	+17%	+12%

Note: Trial a is best throw, Trial b is poor throw

To examine the contribution of the spinal rotation to the horizontal disc velocity, the differences between the right hip and shoulder horizontal velocities were calculated. The arm action contribution to the disc horizontal velocity was determined by the difference between the disc horizontal velocity and the right shoulder velocity. The effectiveness of the blocking action was determined by the differences between the right hip and CM horizontal velocities. The horizontal velocities for the trunk rotation, arm action and blocking action are presented in Table 2.

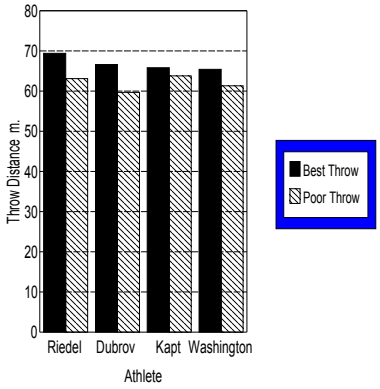

FIGURE 3. DISCUS THROW

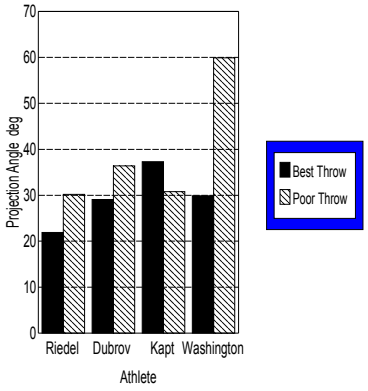

FIGURE 4. DISCUS PROJECTION

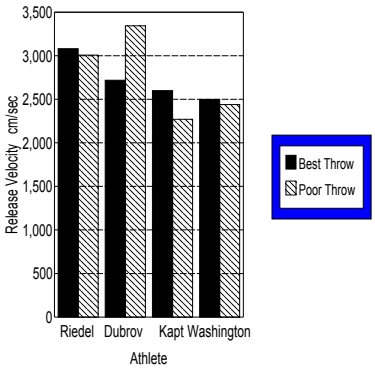

FIGURE 5. DISCUS

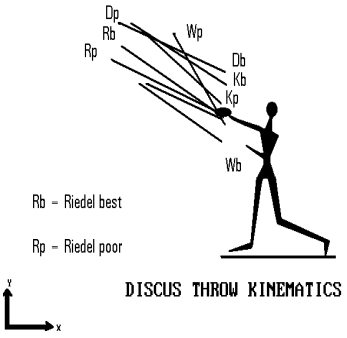

FIGURE 6. THROWING

CONCLUSIONS: An examination of the projection velocity, angle, and release height information found that Riedel, Dubrovschchik, and Washington increased their projection angles, resulting in poor throws (Pfaff, 1994). Additionally, Riedel and Kaptyukh lowered their release height in their poor attempts. The influence of these throwing adjustments can not be fully determined because the aerodynamic effects of the disc attitude, angle of attack, and wind conditions were not analyzed (Atlmeyer, L., Bartonietz, K., & Krieger, D., 1994). The throwing velocities were similar to those reported by Ariel in 1976 on Silvester and Oerter (Ariel, G., Finch, A., & Penny, A., 1997) and the projection velocities decreased in 3 of the 4 performers' poor attempt. Also, the time of movement decreased during the poor throws, and the gold medal throw took the longest movement time (Ariel, G., Finch, A., & Penny, A., 1997). The more successful throws typically had longer time

Table 2: Throwing kinematics for the block, trunk, and arm action

Competitor	Variable cm/s	Best Throw	Worst Throw	Difference
Riedel	CM Hor. Vel.	29.8	173.0	143.2
	Block Vel.	99.9	242.4	-142.5
	R. Hip Vel.	129.7	415.4	285.7
	Trunk Vel.	233.9	-87.4	-321.3
	R. Shoulder Vel.	363.6	328.0	-35.6
	Arm Vel.	2192.5	2093.0	-99.5
	Disc Vel.	2556.1	2421.6	-134.5
Dubrovschchik	CM Hor. Vel.	166.6	-5.5	-172.1
	Block Vel.	230.7	146.7	84.0
	R. Hip Vel.	397.3	141.2	-256.1
	Trunk Vel.	120.8	354.5	233.7
	R. Shoulder Vel.	518.1	495.7	-22.4
	Arm Vel.	1803.5	1819.9	16.4
	Disc Vel.	2321.6	2315.6	-6.0
Kaptyukh	CM Hor. Vel.	118.6	87.2	31.4
	Block Vel.	160.1	241.0	-80.9
	R. Hip Vel.	278.7	328.2	49.5
	Trunk vel.	116.3	100.6	-15.7
	R. Shoulder Vel.	395.0	428.8	33.8
	Arm Vel.	1686.0	1516.0	-170.0
	Disc Vel.	2081.0	1945.5	-135.5
Washington	CM Hor. Vel.	72.6	48.8	-23.8
	Block Vel.	-36.7	-134.4	-171.1
	R. Hip Vel.	35.9	-85.6	-121.5
	Trunk Vel.	334.6	303.7	-30.9
	R. Shoulder Vel.	370.5	218.1	-152.4
	Arm Vel.	1772.7	1003.6	-769.0
	Disc Vel.	2143.2	1221.7	-921.5

The horizontal velocity due to the body torsion, found that Riedel and Washington used less twisting action in their poor throws and Dubrovshchik used substantially more torsion. The changes between trials in the horizontal velocities due to the arm action were –4.5%, +.9%, -10%, and –43.3% for Riedel, Dubrovshchik, Kaptyukh, and Washington, respectively.

durations which would provide more time for the storage of elastic energy in the arm during the turns and better energy return (Dapena, 1994). Throwing technique information found that Riedel and Washington increased their arm action during their poor attempts rather than using a body torsion/flinging motion. The blocking action data showed that Riedel and Kaptyukh did not block their forward momentum and Washington was actually moving back during the blocking phase. An examination of selected kinematic variables of discus throwing techniques found that poor throwing trials by the top performers at the 1996 Olympic Games were caused by improper projection angles, faulty plant foot blocking action, and poor transfer of velocities from the torso to the arm and then the discus.