BIOMECHANICAL ANALYSIS OF DISCUS THROWING AT THE 1996 ATLANTA OLYMPIC GAMES

Gideon Ariel[1], Alfred Finch[2], and Ann Penny[1]
[1]Ariel Dynamics, San Diego, California, USA
[2]Indiana State University, Terre Haute, Indiana, USA

INTRODUCTION

History was made at the Atlanta games by utilizing the Internet to provide biomechanical data immediately for use at remote sites. Video cameras were utilized to record the events and the data was transmitted to computers on-site for conversion to digital format. Video clips of individual performances in various events were made available for downloading free of charge from the Ariel Dynamics website usually within hours of the actual performances. The posted events were filmed from various perspectives utilizing numerous cameras providing data capable of yielding 3-D biomechanical results. This rapid availability of sporting activities for study by scientist, athletes, coaches, and the general public on the Internet is a history making event. It further illustrates the potential of Internet as a research tool.

The purpose of the present research project conducted at the XXVI Olympiad in Atlanta was to expand the biomechanical applications and the interactive capabilities of the Internet to make sport performances rapidly available to everyone. The Track and Field events, particularly the top four discus performances at the Atlanta Olympics in 1996, were selected for kinematic analysis to illustrate these procedures because they are unique in captivating an enthusiastic world-wide audience.

PROCEDURES

In the present study, a biomechanical analysis of the Discus throwing was performed. Video records were collected on the preliminary and final performances of the Men's Discus event. Video cameras were placed in key positions, approximately 45 degrees to the plane of the path of the thrown object or of the athletic performance itself, in order to record the particular event. Three video cameras positioned at distances from 50 to 80 m recorded all discus throws at 60 fields/sec. One camera was located at the back of the circle, camera 2 was to the side and camera 3 was situated, 45 deg. to the left-front of the circle. Figures 1 and 2 illustrate the camera positioning.

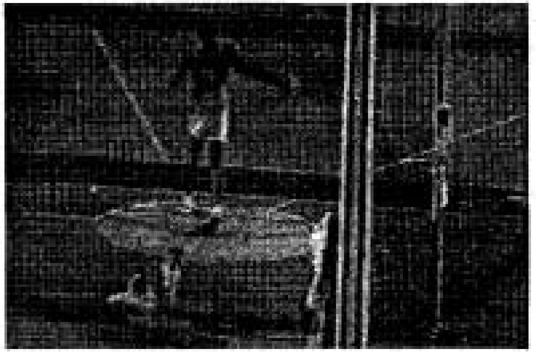

Figure 1. Discus rear camera view

These are dynamics video clips from which one can control and observe the movement. For non-compress full video one can log on to our web site at: http://www.arielnet.com and download the original video clips through FTP connection.

The video pictures were grabbed from each view with Intel Smart Video Recorder Plus frame grabber and the files were stored in Audio Video Interlace format (AVI). These data were then uploaded, via satellite, to the Ariel Dynamics website. The stored data were available to all free of charge. The AVI files can be downloaded frame by frame from the Ariel Dynamics FTP Site for digitizing. The files are in compressed video format in order to conserve bandwidth. The resolution of compressed files are lower than the regular files but the data was able to be rapidly available which was the purpose of the study.

To download these files, visit http://www.arielnet.com and click on the FTP Site Button. Then, select the Olympics directory and click on the desired AVI file(s). For a detailed list and explanation of what each file contains, click the 'ATLANTA' link from the middle frame of the main page. The list is also obtainable by clicking on any of the sport icons on various pages of the site.

RESULTS

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 throw 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.

A control cube consisting of 9 points representing a composite of circle dimensions and anatomical landmarks and 21 data points were digitized and entered into the three dimensional 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 2.9 cm (1.2%) using the DLT transformation algorithm.

From the present kinematic data, an enormous amount of results could be analyzed. However, the throwing performance parameters selected were: disc release velocity, disc projection velocity along the YZ plane, the height of release, and the time of movement.

Throwing Results

The resultant release velocities calculated the best four throws were 3080.1 cdsec for Riedel (GER), 2718.5 cdsec for Dubrovschchik (BLR), 2599.0 cdsec for Kaptyukh (BLR) and 2498.0 cdsec for Washington (USA) (see Table 1 and Figure 3).

The projection angles in the YZ plane representing the angle in respect to the horizontal were 21.9, 29.1, 37.3, and 29.9 degrees for Riedel, Dubrovschchik, Kaptyukh, and Washington, respectively (see Figure.4).

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

Place Performer	Distance m	Rel Velocity cm/sec (yz)	Proj Ang deg	Rel Ht m	Move Time, sec
1. Riedel (GER)	69.4m	3080.1	21.9	1.5	3.0
2. Dubrovschchik (BLR)	66.6m	2718.5	29.1	1.5	3.0
3. Kaptyukh (BLR)	65.8m	2599.0	37.3	1.6	1.9
4. Washington (USA)	65.4m	2498.0	29.9	1.2	1.6

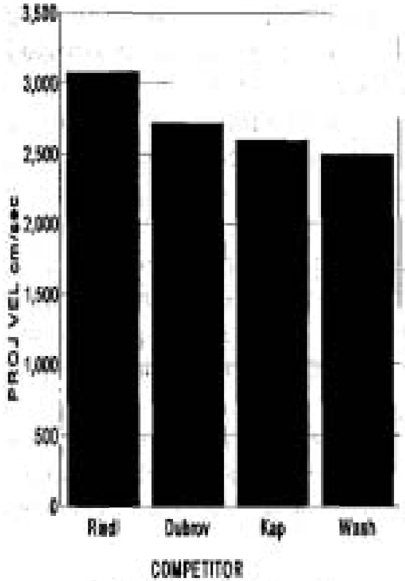

Figure 3. Discus projection velocity (cm/sec)

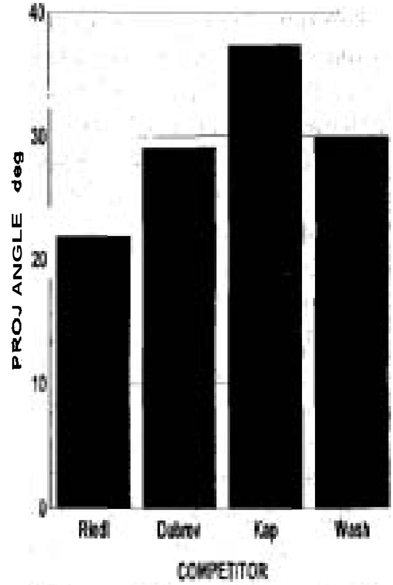

Figure 4 Discus release angle (deg)

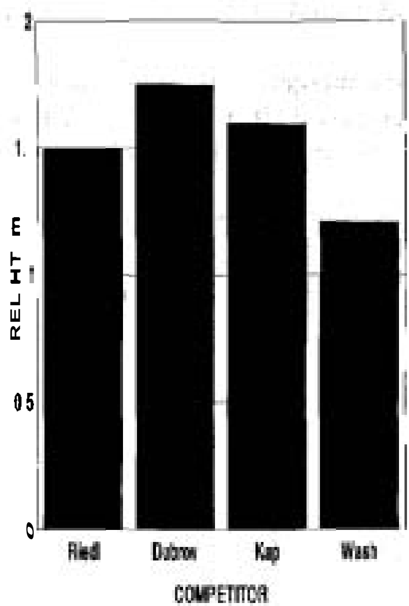

Figure 5. Discus release ht m

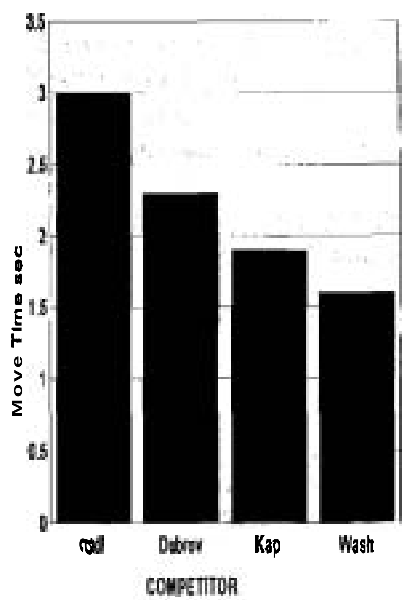

Figure 6. Discus throw movement time (sec)

The heights of release of the discus were 1.5 m, 1.75 m, 1.6 m, and 1.21 m for Riedel, Dubrovschchik, Kaptyukh, and Washington, respectively (see Figure 5).

The elapsed times to complete the turns of the throw were 3.0 seconds for Riedel, 2.3 sec for Dubrovschchik, 1.9 sec for Kaptyukh, and 1.6 seconds for Washington (see Figure 6).

The combined effect of the projection velocity, projection angle, and height of release resulted in medalist throws of 69.4 m (Olympic record) by Riedel (GER), 66.6 m by Dubrovschchik (BLR), 65.8 m for Kaptyukh (BLR), followed by 65.4 m for Washington (USA) (see Table 1, Figures 7 & 8). The aerodynamic variable of angle of attack was not determined for these throwing trials.

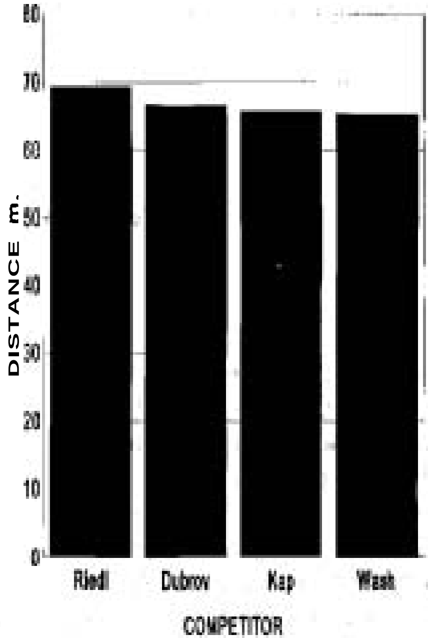

Figure 7. Discus throw distance (m)

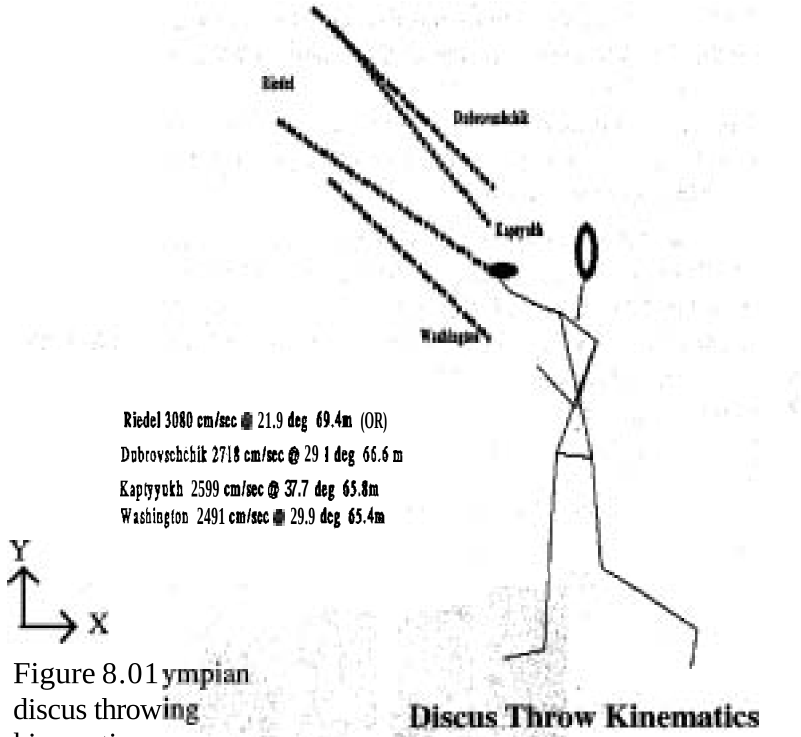

Figure 8.01ympian discus throwing kinematics

CONCLUSIONS

The throwing velocities determined were similar to the velocities calculated for analyses performed by Ariel in 1976 on Silvester and Oerter. There were negligible differences in the projection angles used by the four best discus throwers in the Atlanta Olympics but there were significant differences in the resultant projection velocities between the top four contestants analyzed. Riedel, the gold medalist generated the greatest projection velocity of 3170.1 cdsec and Washington had a projection velocity of 2484.9 cdsec, which represented an 28% increase in solely the speed of the discus over the fourth place finisher.

An examination of the projection velocity, angle, and release height information would indicate that Dubrovschchik and Kaptyukh probably could have thrown at lower projection angles as result of their greater release height, in order to improve performance (Pfaff, 1994). Also, these projection angles would have to be adjusted for the lift and drag provided by the disc velocity, angle of attack of the disc, and the wind conditions, which were not calculated in this analysis (Altmeyer, Bartonietz, & Krieger, 1994).

Interestingly enough, Washington performed the throwing movement in 46% less time, while Riedel took the longest amount of time to release the discus. This may indicate that Washington moved across the circle too quickly, thus not allowing enough time for the storage of elastic energy in the arm during the turns. Consequently, a lower energy return was observed at the release of the discus (Dapena, 1994).

The study successfully demonstrated that digitization is a biomechanical task which can be performed between different geographical locations using the Internet as the interfacing medium. The applications of this technique and intellectual resource appear unlimited. These video clips can be transmitted digitally in AVI format to a server in one part of the world and then interfaced to the biomechanical program for further analysis. Many Olympic events make fixed laboratory studies difficult, including equine events, sailing, and cross-country skiing. Coaches can film actual performances on site using cameras with direct AVI format input attached to Laptop computers. These files can then be digitized or transmitted through Internet protocols for subsequent analysis.

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