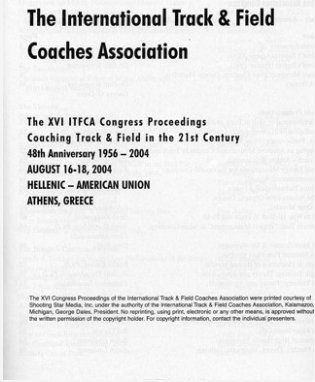




Biomechanical Analysis of the Shot-Put at the 2004 Olympics

The only biomechanical analysis performed in the Athens Olympic Games

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Below find a reprint of the 6 relevant pages of the article "Biomechanical Analysis of the Shot-Put at the 2004 Olympics" in "International Coaches Association":

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plete throws. The trimmed videos from each performer were transmitted through the Internet to a server in order to distribute the data to multiple locations for analysis. Shown in Figure 1 are 2 of the 5 camera views utilized in digitizing the data.

Dimensions of known factors and various other measured objects in the field of view were used for the calibration points. For security reasons, it was impossible to place a pre-measured calibration frame on the field. Known measurements on the field as well as the athletes' body dimensions were used. Additional measurements were made on the field the next day and can be viewed at:

<http://www.macrosport.com/activities/Olympic-Games-2004/default.htm>

The results were verified against known official measurements of the shot put circle area.

The Ariel Performance Analysis System (APAS) was used to conduct the biomechanical processes.

Synchronized data sequences from each of the camera views were utilized. For each camera view, 19 points were digitized. The body parts for the left and right sides of the body included the:

- Foot
- Knee
- Elbow
- Shoulder
- Ankle
- Hip
- Wrist

Additional measurements recorded the:

- right hand
- shot put
- base of the neck
- mastoid process
- top of the head

Data points were digitized and entered into the three dimensional linear transformation (DLT) module and converted to real displacements. The real coordinate endpoints were smoothed using cubic spline filter.

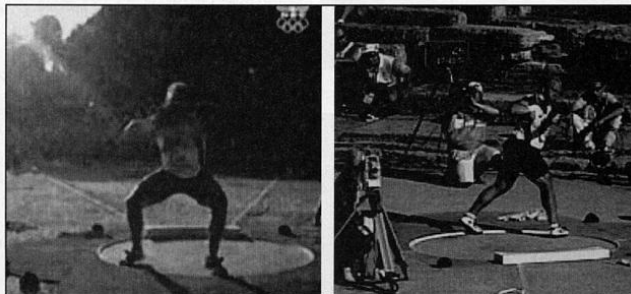


Figure 1: Two camera views of shot putting performance

Biomechanical Analysis of the Shot-Put Event at the 2004 Athens Olympic Games

Gideon Ariel, Ph.D., Ann Penny, John Probst, Rudolf Buijs, Erik Simonsen, Alfred Finch, and Larry Judge

Introduction

The Shot Put competition at the 2004 Athens Olympiad was held in the Ancient Olympia stadium. This was the site of the Ancient Games of the Olympiad, 2,800 years ago. Despite skepticism by the rest of the world, the organizers of the Athens games did so many things right, and nothing exemplified this more than holding the shot put competition at Ancient Olympia. In a games already steeped in history, the organizers thoughtfully connected the Ancient and Modern Olympics in a serene setting that was so unusual that it will be remembered as one of the highlights of these games.

The biomechanical analysis of the Shot Put event was sponsored by the International Track and Field Coaches Association. This was the only biomechanical analysis performed at the Athens Olympic Games where cameras were placed on the performance field.

The competition was exciting and the setting was as intimate as it was historical. The shot put normally takes place in the middle of the field with the track separating the crowd from the event that seems so distant as if it's happening in another place. At Olympia, the shot put took center stage as the only event being competed with 15,000+ fans watching from the grassy knoll right next to the pit. It was great to be a part of it.

The crowd was treated to a fascinating men's event, which ended in controversy when Ukraine's Yuriy Bilonog tied the United State's Adam Nelson, which meant Bilonog would really beat Nelson, unless Nelson could come back with one last amazing throw, which he did, except he fouled. Although he stated he did not foul, video images showed that a foul occurred during the crucial final attempt. As a result of the existing tie, the final result was decided

by the 2nd best distance thrown by Bilonog, Nelson's were fouls. So Nelson had to settle for the Silver, while two other Americans, John Godina and Reese Hoffa, finished out of contention, far short of the prediction that Americans would sweep the event.

The purpose of this project was to collect video records of competitors at the 2004 Olympic Games at Olympia Greece where the Shot Put event was conducted. Multiple cameras were placed on the field at key distances and in angular locations relative to the shotput. In addition to the stationary cameras on the field, camera outputs from the television broadcasting companies were used in assisting the stationary cameras.

All throws were recorded at 60 frames per second and performances were analyzed for the present study. All the Men's and Women's throws at the preliminary and finals were collected and analyzed. Due to publishing deadlines, only the best 3 male performers were analyzed for the present paper. The parameters measured were the body's:

- segmental velocities
- center of mass pathway, and
- release velocity

The kinematic patterns of the various athletes' segmental positioning were presented for visual interpretation.

Methods

Multiple high speed digital cameras (60 frames/second) were used to collect videos of the shot put performers in the 2004 Olympic Games. All throws in the preliminaries and final performances were recorded. Videos collected were transferred automatically to two notebook computers via IEEE1394 interface PCMCIA cards, and synchronized to produce trimmed files representing the com-

Institute for Biomechanical Research, Coto Research Center, Coto De Caza California, ¹Indiana State University, Terre Haute, Indiana, USA, ²Institute of Medical Anatomy University of Copenhagen, Denmark, ³University of Florida, Gainesville, Florida

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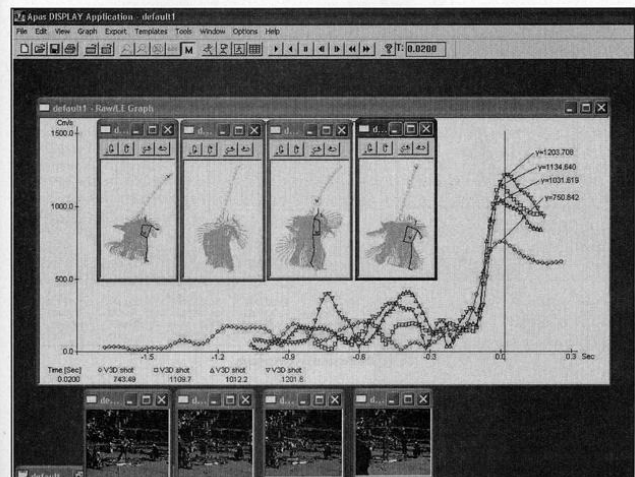


Figure 2: Shot put velocities curves

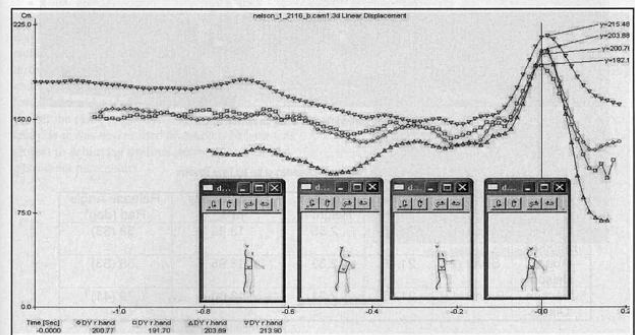


Figure 3: Vertical heights curves of the hand representing the release heights.

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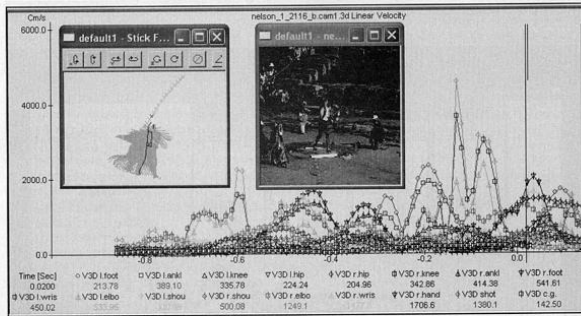


Figure 4: Velocities curves for body's segments.



Figure 5: Strobing photographs representing the different styles

Table 1 Selected Kinematic Performance Parameters of the Top Three Throwers

Performer	Place	Distance m	Release Height m	Shot Velocity m*s ⁻¹	Release Angle Rad (deg)
Yuriy Belonog	Gold (1)	21.16	2.55	13.85	.58 (33)
Adam Nelson	Silver (2)	21.16	2.33	13.95	.58 (33)
Joachim Olsen	Bronze (3)	21.07	2.31	13.60	.72 (41)

Results

The present kinematics analyses yielded an enormous volume of results. Due to time and space considerations, the most significant parameters for the shot put technique were selected for analysis and discussion.

The results of the top 3 male athletes were selected for this study. The remaining data is published on a Website and will be presented in the oral presentation at the 2005 China International Biomechanics Conference. The resultant velocities curves calculated for the best throws are presented in Figure 2 and the release heights for the athletes are shown in Figure 3.

Shown in Figure 4 are the three dimensional resultant velocities during the finals competition by Belonog, Nelson, and Olsen for the:

- feet
- hips
- knees
- shoulders
- elbows
- the shot put
- hands

Discussion

The shot put distance depends on a variety of factors. The angle in which the athletes can achieve the optimal acceleration of their arm segments would represent optimized performances. Factors that influence optimal performance would be:

- release height
- release velocity, and
- release angle.

Segmental acceleration depends on the technique that allow optimal combinations of the above parameters. Nelson and Yuriy both obtained the same throwing displacement, but Nelson was able to generate 7.2% faster shot projection velocity with 9.4% lower release height, and both competitors putt the shot at the same projection angle. From the present analysis it was determined that Adam Nelson was closest to achieving optimal performance for his movement parameters.

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Athens 2004 Olympic Stadium Entrance