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

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The stadium was Ancient Olympia. The site of the ancient Games of the Olympiad, 2,800 years ago. The site of the modern Games of the Olympiad; the shot put competition was held there.

The Purpose of this study was to analyze the best Shot-put performances in the Athens Olympic Games, 2004. The Shot-Put event at the 2004 Olympics was conducted at the sacred Olympia location. The Biomechanical Analysis of the Shot Put event was sponsored by the International Track and Field Coaches Association. Multiple high speed digital video cameras were placed in specific location on the field at proper angles in order to capture the performance of the athletes in the preliminaries and finals. This was the only biomechanical analysis performed at the Athens Olympic Games where cameras were placed on the performance field.

Two stationary cameras were placed at 45 degrees to each other. In addition 3 more cameras used by the NBC broadcasting were used to assist the other 2 cameras. Temporal and kinematics variables were calculated from the videos records and were analyzed yielding three-dimensional biomechanical results. Pattern of the segments movement were used rather then absolute values, to assist the athletes and the coaches.

Because of limited space, Kinematics parameters presented in this study are for the best 3 final performers. However, analysis was perform for all participants and will be presented in the oral presentation.

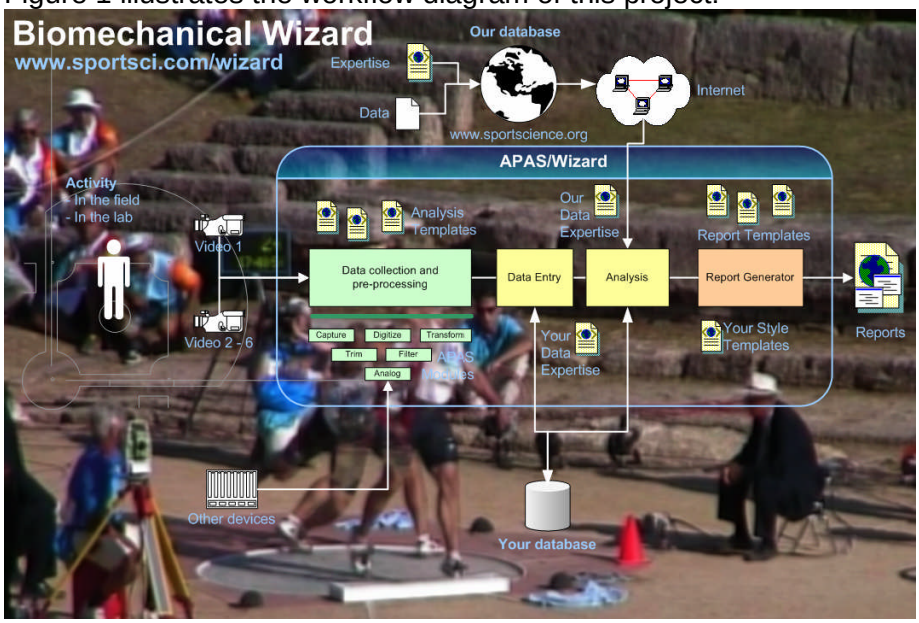
Key Words: Kinematic Analysis; Angular Velocities; Linear Velocities; Angle of Release; 2004 Olympic Games.

INTRODUCTION:

Despite skepticism from the rest of the world, the organizers of the Athens games have done so many things right and nothing exemplifies this more than holding the shot put at 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 probably be remembered as one of the highlights of these games whenever they are recalled. 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. In Olympia, the shot put took center stage as the only event being competed with 15,000+ fans watching right on top of it 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 the Ukraine's Yuriy Bilonog tied the United States' 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, except he said he didn't foul, but he really did. So Nelson settled for the silver, while two other Americans, John Godina and Reese Hoffa, finished out of contention, far short of his 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 in key angular locations to capture the activities during the Olympic Games. The cameras were place on the field at specific distance and angle relative to the shot-put Circle. In addition to the stationary cameras on the field, cameras 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 and Women throws at the preliminary and finals were collected and analyzed. Due to publishing restriction, only the best 3 performers will be analyzed for the present paper. The parameters measured were body's segments velocities, Center of Mass pattern, and release velocity. The kinematics patterns of the various bodies' segments presented.
Figure 1 illustrates the workflow diagram of this project:



Method: Multiple high speed digital cameras (60 fps) were used to collect videos of the shot-putters performers in the 2004 Olympic Games. All throws at 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 trimming files representing the complete 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.
All the video digital cameras recorded at 60 fields per second. Fig. 1 Illustrate 2 out of 5 cameras 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. Since it was impossible to place a pre-measured calibration frame in the field for security reasons, known measurements on the field as well as utilizing the athletes' body was used. More measurements were made on the filed the next day. One can see the measurement procedures in the next day 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 cameras views were utilized. For each camera view, 19 points were digitized. The body parts included the foot, Ankle, knee, hip, wrist, elbow and shoulder for the left and right sides of the body as well as the

right hand, Shot, and base of the neck, mastoid process the top of the head. Data points were digitized and entered into the 3 dimensional linear transformation (DLT) module and converted to real displacements. The real coordinate endpoints were smoothed using Cubic Spline filter.

Fig 2. Two cameras views of performance

Results: The present Kinematics analyses yielded an enormous volume of results. However, because of the time and space considerations, the most significantly parameters were selected for analysis and discussion.

The results of the top 3 top athletes were selected for this study. The remaining data is published on a Website and will be presented in the Oral presentation at the conference.

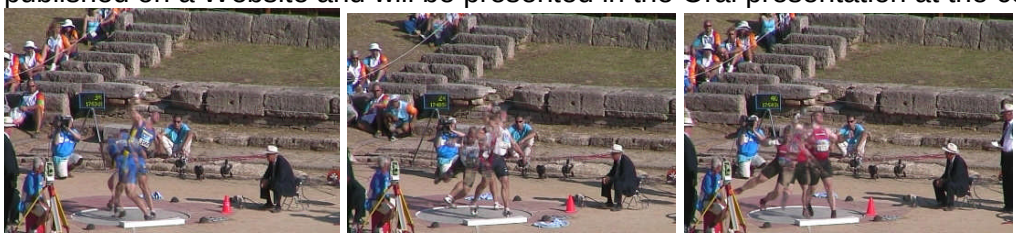


Figure 3 Strobe representation of the three Medalists

The resultant velocities curves calculated for the best throws reported at figure 3.

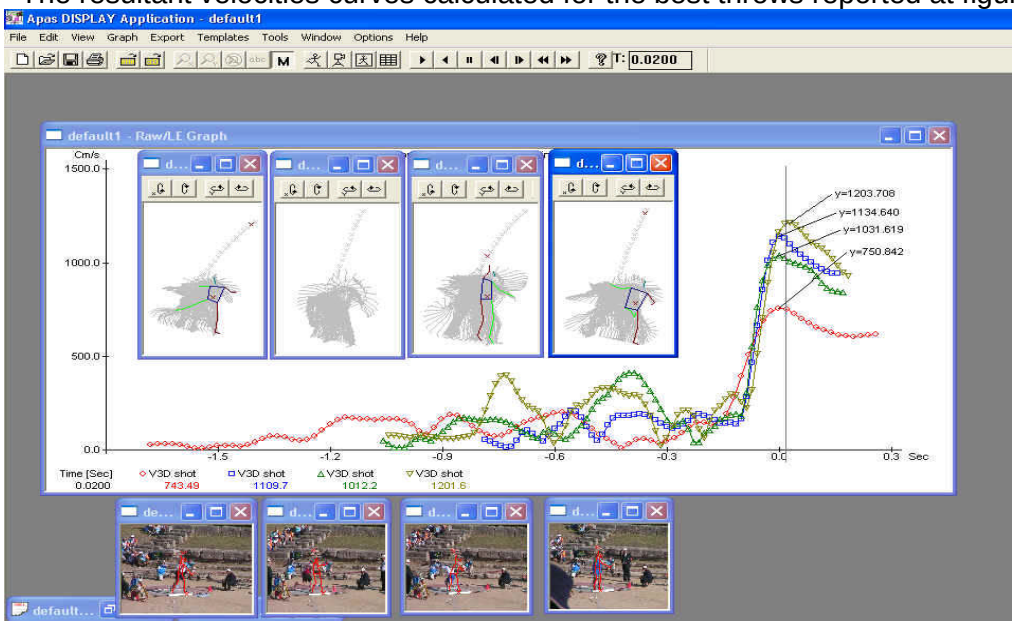


Figure 4 Shot-put velocities curves

Figure 5.Illustrates the hand heights curves:

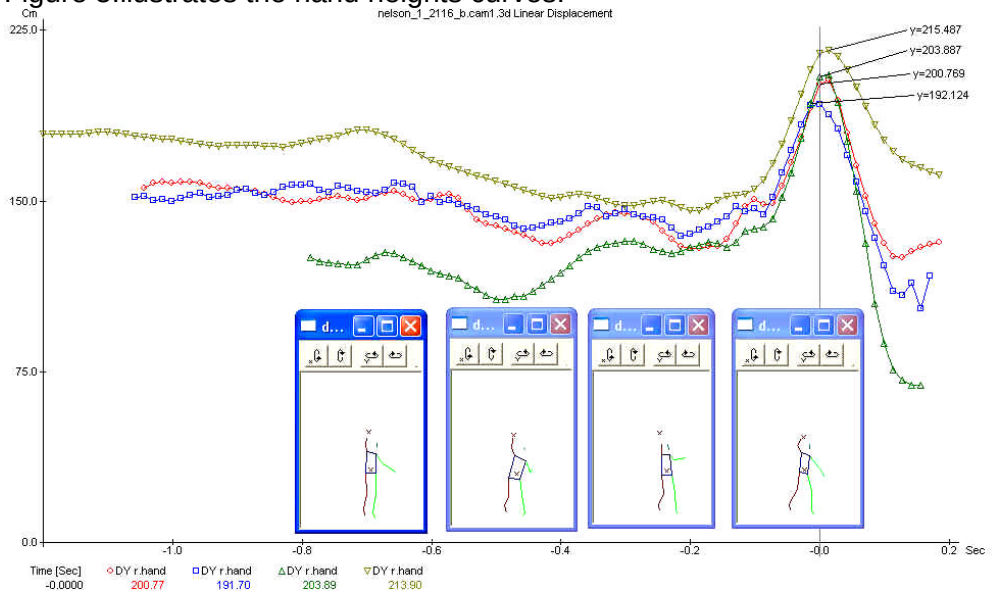


Figure 6.Vertical heights curves of the hand representing the release heights.

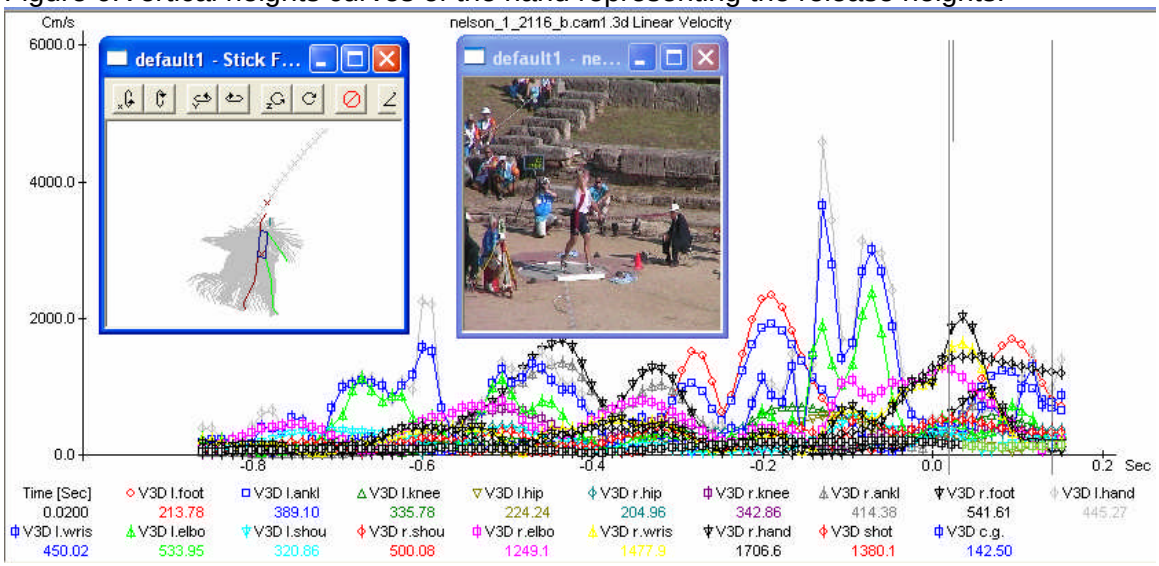


Figure 7. Velocities curves for body's segments

Table 1 represent the physical parameters of the three best Throwers

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

Table 1. Physical parameters results.

Discussion:

The Shot-put distance depends on variety of factors. The angle in which the athlete can achieve the optimal acceleration to his/her arm segments. The release height, release velocity and release angle. The segment acceleration depends on the technique to allow optimal combinations of the above parameters. From the present analysis it was determined that Adam Nelson exhibit close to optimal performance.

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