Optimizing Athletic Performance
Through High-Technology
Utilizing the APAS/Wizard System

By Gideon Ariel, Ph.D.
Athens Olympics, 2004
MOVEMENT ANALYSIS CAN BE APPLIED TO:

- Athletics
- Industry
- Medicine
- Space
ALL APPLICATIONS UTILIZED SIMILAR QUANTIFICATION TECHNIQUES
Capture videos using several cameras simultaneously and save the clips directly as AVI files to your hard disk. This allows you to connect multiple digital video cameras to your computer and to start capturing with one mouse click.
The Spectrum of Athletic Performances

- **Explosive events**
  - Throwing
  - Sprinting
  - Jumping

- **Endurance events**
  - Long distance run
  - Swimming
  - Cycling

- **Accuracy events**
  - Golf
  - Archery

- **Team sports**
  - Soccer
  - Basketball
  - Hockey

- **Esthetic events**
  - Figure skating
  - Gymnastics
  - Diving

- **Multi events**
  - Decathlon
  - Pentathlon
Hardware

- **Main Computer System**
- **Workstations**
- **High Speed Camera**
- **Capture Card**
- **Network**
  - Intranet
  - Internet
Analysis of Performance Requires:

Video Recording
Digitizing the Data
Manual
Automatic
Transformation of the Data
2D - Two Dimensional
3D - Three Dimensional
Camera Views
Technological advances have made it possible to integrate, synchronize, and simultaneously display video records, kinematic, kinetic, EMG, and force plate data of human movement.
The world record in triple jump of 18.29m by J. Edwards, UK
Digitizing

- Manually
- Automatically
Software Integration
Display and Analysis
Biomechanical Analysis of Discus Throwing at Olympic Games
Methods

The track & field project involved collecting video records of the preliminaries and final performances of various events for the immediate development of digital movies to be uploaded on the internet.
There Were 18 Throwers During the Qualifying Round and the Best 8 Athletes Competed for the Gold Medal in the Final Round.
Video Cameras Were Placed in Several Locations to Maximize the Data Obtained for the Event
Because the Discus Throw Involves Both Linear and Rotary Motion, the Optimal Data Collection Situation Utilizes at Least Three Cameras Placed Appropriately So That None of the Athlete's Motion Is Obscured
Dimensions of Known Factors and Various Other Measured Objects in the Field of View Were Used for the Calibration Points
3-D DLT Composite Control Cube
Results

Dubrowschik Release HT 175cm

Riedel GER 69.4m OR Velocity 3170cm/sec

Dubrowschik release ht 1.58m

DISCUS THROW KINEMATICS
The Order of Finish Was:
Riedel Representing Germany (GER) Winning the Gold,
Dubrovschchik From Belarus (BLR) Finishing Second,
the Bronze Medal Was Won by Kaptyukh From Bulgaria,
and the Fourth Place Finisher Was Washington Representing the United States.
## Washington Throwing Kinematics

<table>
<thead>
<tr>
<th>Attempt</th>
<th>Distance m.</th>
<th>Velocity cm•sec(^{-1})</th>
<th>Projection Angle rad (deg)</th>
<th>Release HT cm</th>
<th>Move Time sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best Throw</td>
<td>65.4</td>
<td>2541(V_r) 2134 (V_x)</td>
<td>.52 (29.9)</td>
<td>120</td>
<td>1.2</td>
</tr>
<tr>
<td>Worst Throw</td>
<td>61.3</td>
<td>2441 (V_r) 1222 (V_x)</td>
<td>1.05 (59.9)</td>
<td>140</td>
<td>1.4</td>
</tr>
<tr>
<td>% Change</td>
<td>-6.3%</td>
<td>-4.0% (V_r) -43.0% (V_x)</td>
<td>+100%</td>
<td>+17%</td>
<td>+12%</td>
</tr>
</tbody>
</table>
Riedel GER 69.4m OR Velocity 3170 cm/sec

\(^{\Delta} = \text{VEL_MAG_Discus}\)

Dubrovshchik BLR 66.6m Vel 2718 cm/sec

\(^{\Delta} = \text{VEL_MAG_R.EXTI}\)

Kaptuukh BLR Velocity 2598 cm/sec

\(^{\Delta} = \text{RAW_Y_Discus}\)

\(^{\triangledown} = \text{VEL_MAG_Discus}\)

Washington USA Velocity 2498 cm/sec

\(^{\Delta} = \text{VEL_MAG_Discus}\)
DISCUS PROJECTION VELOCITY  cm/sec

COMPETITOR

PROJ VEL  cm/sec

3,080.1
2,718
2,599
2,498
0

500
1,000
1,500
2,000
2,500
3,000
3,500

Riedel
Dubrov
Kap
Wash
Dubrovskochik Proj Angle 29.1 deg

\[ \Delta = \text{VEL}_Y \_R \_EXT1 \]
\[ \triangledown = \text{VEL}_Z \_R \_EXT1 \]

**Riedel Proj Angle**

\[ \circ = \text{VEL}_Y \_Discus \]
\[ \triangledown = \text{VEL}_Z \_Discus \]
DISCUS RELEASE ANGLE  deg

COMPETITOR

PROJ ANGLE  deg

21.9
29.1
37.3
29.9

Riedel
Dubrov
Kap
Wash
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.
Dubrovschchik Release HT 175cm

Kaptyukh REL HT 160cm

Riedel REL HT 150cm

Washington REL HT 121 cm
DISCUS RELEASE HEIGHT m.

<table>
<thead>
<tr>
<th>COMPETITOR</th>
<th>RELEASE HT m.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riedel</td>
<td>1.5</td>
</tr>
<tr>
<td>Dubrov</td>
<td>1.8</td>
</tr>
<tr>
<td>Kap</td>
<td>1.6</td>
</tr>
<tr>
<td>Wash</td>
<td>1.2</td>
</tr>
</tbody>
</table>
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.
<table>
<thead>
<tr>
<th>Competitor</th>
<th>Move Time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riedel</td>
<td>3.0</td>
</tr>
<tr>
<td>Dubrov</td>
<td>2.3</td>
</tr>
<tr>
<td>Kap</td>
<td>1.9</td>
</tr>
<tr>
<td>Wash</td>
<td>1.6</td>
</tr>
</tbody>
</table>

**DISCUS MOVEMENT TIME (sec)**
## Throwing Kinematics for Top Four Discus Performers at 1996 Atlanta Olympics

<table>
<thead>
<tr>
<th>Place</th>
<th>Performer</th>
<th>Dist</th>
<th>M Vel</th>
<th>Rel Cm/sec</th>
<th>Proj ang deg</th>
<th>Rel Ht</th>
<th>Mov T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Riedel (Ger)</td>
<td>69.4</td>
<td>3080.1</td>
<td>21.9</td>
<td>1.5</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Dubrovschchik (Blr)</td>
<td>66.6</td>
<td>2718.5</td>
<td>29.1</td>
<td>1.8</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Kaptyukh (Blr)</td>
<td>65.8</td>
<td>2599.0</td>
<td>37.3</td>
<td>1.6</td>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Washington (USA)</td>
<td>65.4</td>
<td>2498.0</td>
<td>29.9</td>
<td>1.2</td>
<td>1.6</td>
<td></td>
</tr>
</tbody>
</table>
Riedel 3080 cm/sec @ 21.9 deg. 69.4 m (OR)
Dubrovschchik 2718 cm/sec @ 29.1 deg. 66.6 m
Kaptyukh 2599 cm/sec @ 37.3 deg. 65.8 m
Washington 2498 cm/sec @ 29.9 deg. 65.4 m
Throwing Pattern Analysis

Filename: riedstk2

VIEWING Module C.B.A. Inc.
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). The Aerodynamic Variable of Angle of Attack Was Not Determined for These Throwing Trials
Washington Best Throw

WASHINGTON POOR THROW
<table>
<thead>
<tr>
<th>Attempt</th>
<th>Max Angular Horizontal Shoulder Velocity rad•s⁻¹</th>
<th>Shoulder Ang Velocity at Release rad•s⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best Throw</td>
<td>26.1</td>
<td>13.7</td>
</tr>
<tr>
<td>Worst Throw</td>
<td>20.1</td>
<td>11.2</td>
</tr>
<tr>
<td>% Change</td>
<td>-23%</td>
<td>-18%</td>
</tr>
</tbody>
</table>
THE CASE OF THE LONG JUMP:

CARL LEWIS

MIKE POWELL
Velocity of the Center of Mass

Mike Powell 8.95m - World Record
Change of the Height of CM
Height of the Center of Mass

Mike Powell 8.95m - World Record
## Parameters of the Long Jump

<table>
<thead>
<tr>
<th>General Information</th>
<th>M. Powell</th>
<th>C. Lewis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Official Distance [m]</td>
<td>8.95</td>
<td>8.91</td>
</tr>
<tr>
<td>Effective Distance [m]</td>
<td>8.98</td>
<td>8.91</td>
</tr>
<tr>
<td>Favorable Wind Velocity [m/s]</td>
<td>0.3</td>
<td>2.9</td>
</tr>
</tbody>
</table>

**The Approach**

| Average Speed: 11-6m to the Board [m/s] | 10.79 | 11.23 |
| Average Speed: 6-1m to the Board [m/s] | 10.94 | 11.26 |
| The Length of the Third-Last Stride [m] | 2.4   | 2.23  |
| The Length of the Second-Last Stride [m] | 2.47  | 2.7   |
| The Length of the Last Stride [m] | 2.28 | 1.88 |

**The Take-Off**

| CM Horizontal Velocity [m/s] | 9.27 | 9.11 |
| CM Vertical Velocity [m/s] | 4.21 | 3.37 |
| Angle of Projection [deg] | 24.1 | 20.3 |
| Angle of body Lean at Touch-Down [deg] | 71.8 | 77   |
| Angle of body Lean at Take-Off [deg] | 73.9 | 67.5 |
The Future – The Virtual Coach

• Virtual Biomechanic Desk
  • Locate and download your favorite Biomechanical Data from one convenient, easy-to-use interface.
  • Software that allows users to share Biomechanical libraries with each other no matter where they are located. Coach_virtual provides a search capability for videos, 3D/2D Files capability for users to communicate in forums of like interest.
  • Each Coach is a download/upload source
  • Each User Computer, when it is on, it becomes a shared directory

• For more information:  http://www.arielnet.com
What are the requirement and steps in Purchasing a new Biomechanical System

- Set your objectives for Analysis
- System Tryout
- Perform a full project with the tryout system
- All hardware must be off the shelves
- Software must be downloadable
- Upgrades must be free
- Workstations must be added to the system
- Price must be realistic
THANK YOU