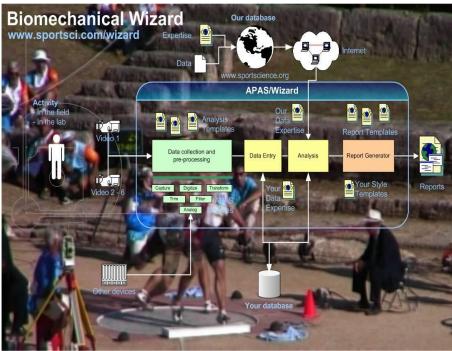# Biomechanics from the Big Bang to the Cloud
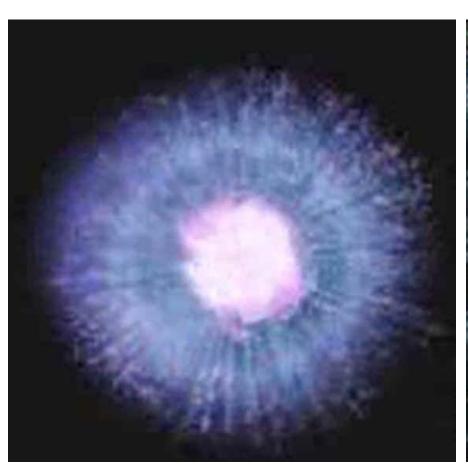
The Geoffrey Dyson Award and Keynote Presentation
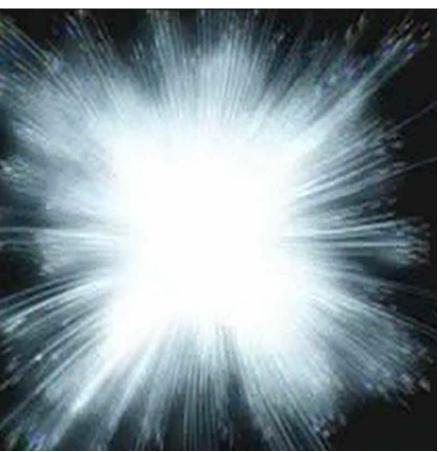
By

Gideon Ariel, Ph.D.

It all started with the Big Bang
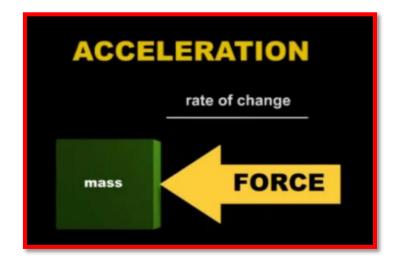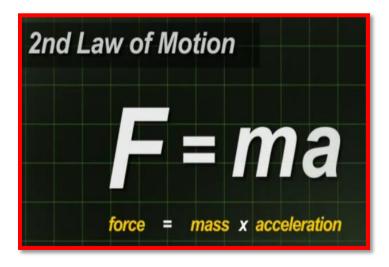
Newton, Sir Isaac (1642-1727), **Albert Einstein** 1879 – 1955)
Two scientists, separated by two hundred and fifty years of time and experiences, formulated and explained the laws of nature which relate to our modern field of Biomechanics. The pioneering work and creative concepts of seeing natural phenomena of Isaac Newton and Albert Einstein have provided us with tools to study and understand bodies in motion.

Newton's second law of motion, was F=ma and with it, he created our field of Biomechanics. The fact that Force depends on mass and acceleration established the principles that govern any field of Biomechanics

Leonardo Da Vinci inventions
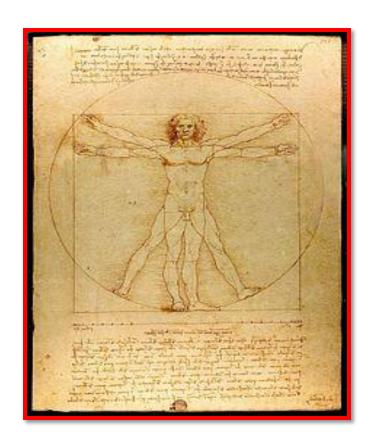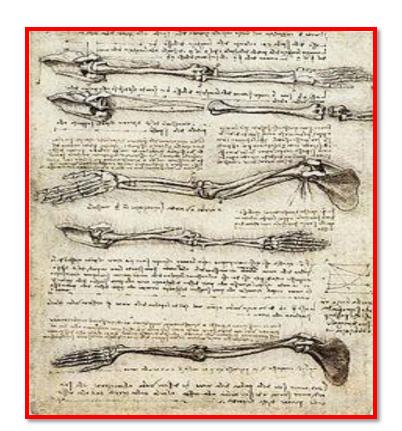
Although nature commences with reason and ends in experience it is necessary for us to do the opposite, that is to commence with experience and from this to proceed to investigate the reason

Billions of years after our Earth was formed, humans appeared and we began our own creative history. One of the greatest of all of our "modern" biomechanicst, was Leonard da Vinci. Leonardo lived from 1452 to 1519 and was one of the first people to study and integrate the "bio" with the "mechanical".

Just three years before beginning his painting of *Mona Lisa del Giocondo*, Leonardo Da Vinci gave us a full description in 1500 of the camera obscura.

Da Vinci
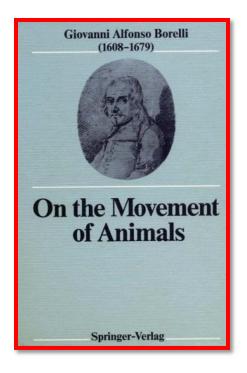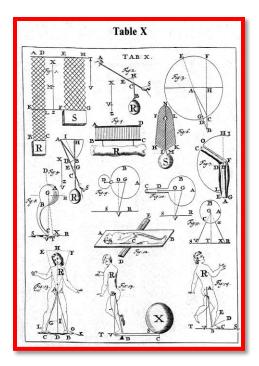
one of his drawings
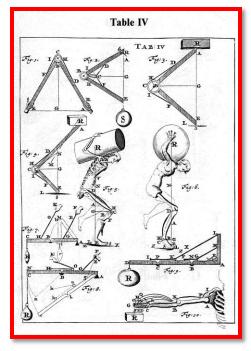
An unlikely player in this story, Da Vinci also presented a drawing of a magic lantern in 1515. If mentioned at all in Da Vinci biographies, optics including the camera and lantern, are usually listed last. However Leonardo was well ahead of his time even in this branch of physics.

Giovanni Alfonso Borelli (1608-1679)

More than 100 years after Leonardo, another scholar and scientist developed and studied human and machine interactions. Giovanni Alfonso Borelli actually calculated forces on the body at different gaits and positions of movement.
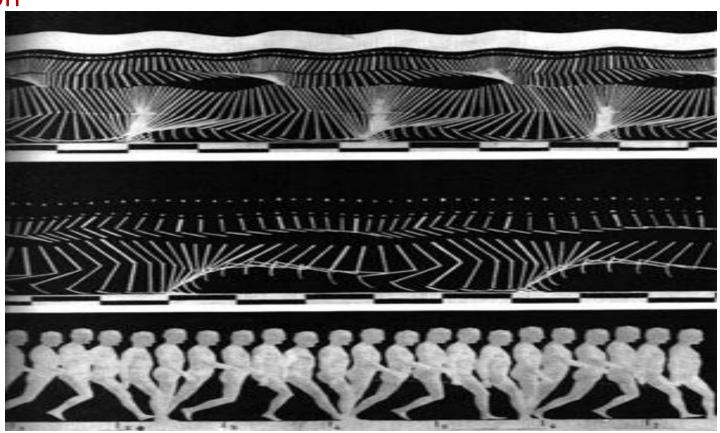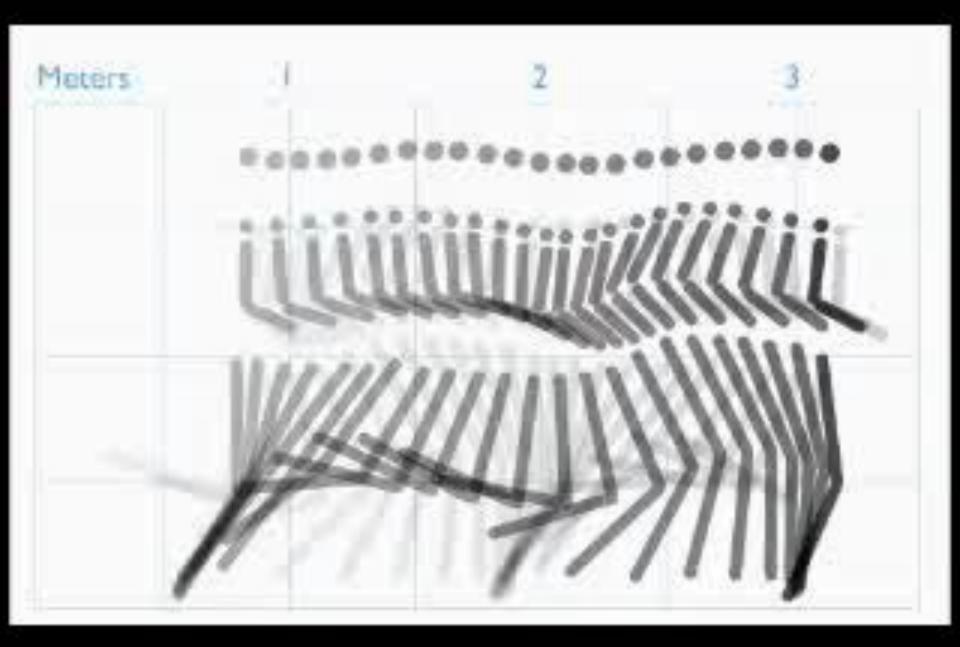
Giovanni Alfonso Borelli is often described as the father of biomechanics. He was born in Naples in 1608. His De Motu Animalium, published in 1680, extended to biology the rigorous analytical methods developed by Galileo in the field of mechanics. Borelli calculated the forces required for equilibrium in various joints of the human body well before Newton published The Laws of Motion. Borelli was the first to understand that the levers of the musculoskeletal system magnify motion rather than force, so that muscles must produce much larger forces than those resisting the motion.
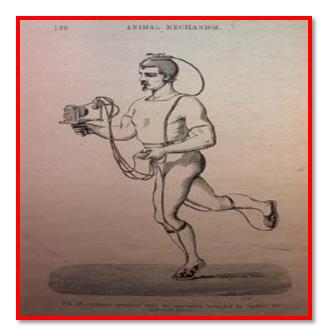
No race of any importance will be undertaken without the assistance of photography to determine the winner ... in an important race the decision of the camera would be preferred to that of the judges.- Eadweard Muybridge – (1830-1904)

The Lumiere's

Marey

Le Prince

Eastman

Daguerre

Muybridge

Niepce

Edison

Acres

Who invented motion pictures?
No one. No one person that is.
No individual can claim the title for his own. However, they are all co-inventors of a medium which has been waiting to be discovered for more than two thousand years.
The time has come. *(above) Some of the many names involved.*

Marey. In the late 1800s, Etienne-Jules Marey looked for ways to apply the new medium of photography to the new science of physiology. He built cameras that could capture a rapid sequence of images, then focused them on moving people. With his cameras, Marey neatly dissected time and space, revealing the dynamic rhythms of the human body in motion
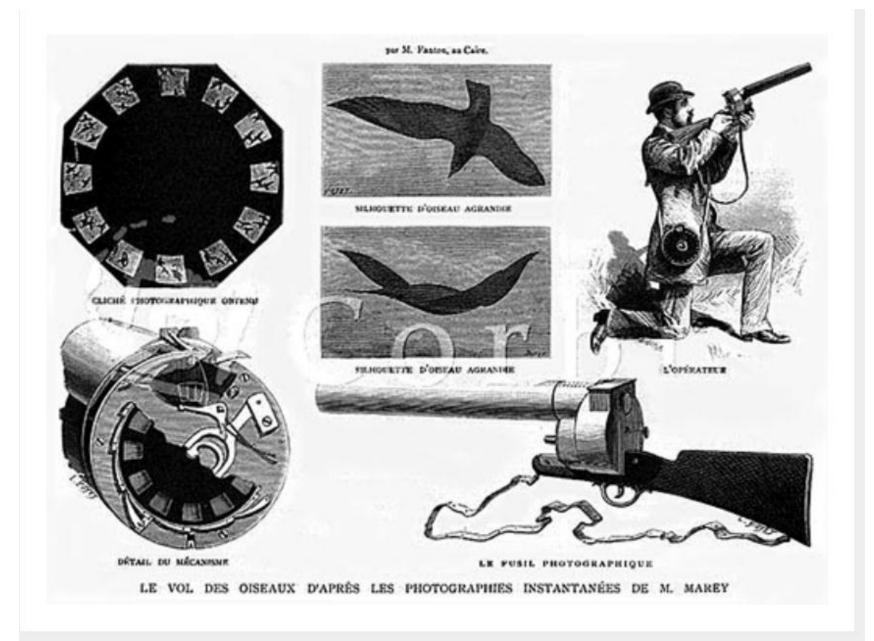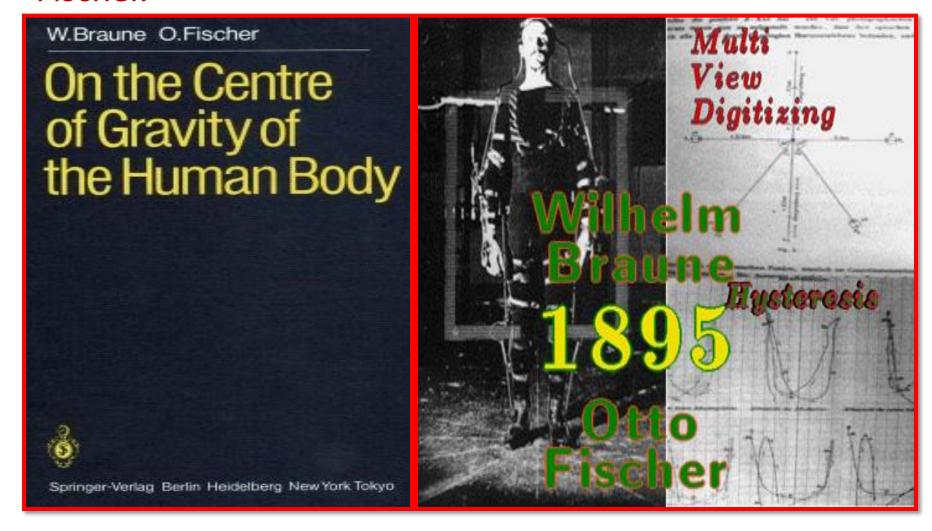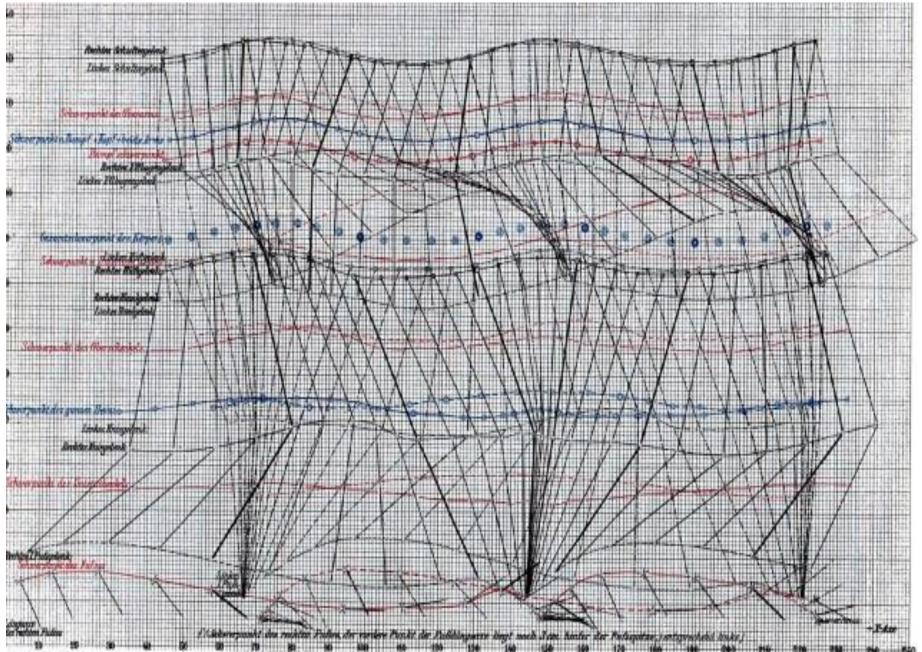
Marey's photographic skills contributed to the high speed photography we employ today. multiple cameras. In 1882, Étienne-Jules Marey became the first person to eliminate the need for The French inventor did this by capturing motion with a photographic gun that initially used a glass plate that rotated like a gun barrel to capture the pictures

CLICHÉ PHOTOGRAPHIQUE OBTENU

SILHOUETTE D'OISEAU AGRANDIE

par M. Vantos, au Caire.

SILHOUETTE D'OISEAU AGRANDIE

L'OPÉRATEUR

DÉTAIL DU MÉCANISME

LE FUSIL PHOTOGRAPHIQUE

LE VOL DES OISEAUX D'APRÈS LES PHOTOGRAPHIES INSTANTANÉES DE M. MAREY

Marey's Photographic Gun

Following the development of some of the photographic work, one of the first representation of human movement at Gait Analysis were Brune and Fischer.

Fig. 4. Projection of the 31 phases on the plane of gait with the partial centres of gravity (red), the centres of gravity of different systems (blue) and the total centre of gravity of the body (⊙)

Braune and Fischer were the first one to formulate how to extract three dimentional measurement from photographs. This method of calculating image coordinates was revolutionary at the time. However, their ideas are used today as the bases of the Direct Linear Transformation employed in 3D analysis.

Fig. 8. Cyclogram or *stick-diagram* superimposed over a subject equipped with flashing tubes. The rectangle in the centre of the picture was added to facilitate image coordinate measurements. From Braune & Fischer (1895).
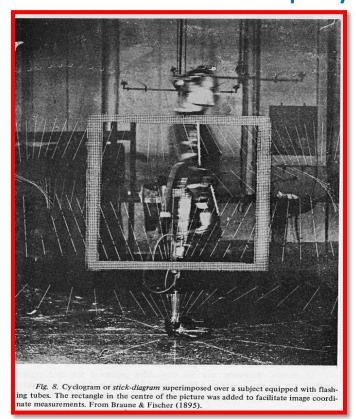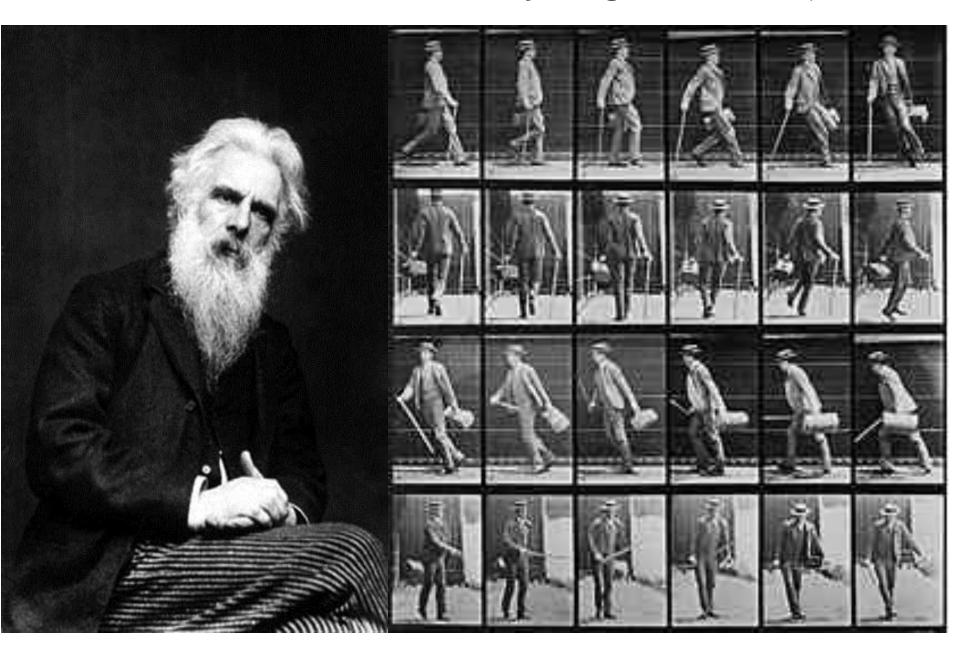
Fig. 9. Relation between object-space coordinates, camera lay-out and image coordinates. From Braune and Fischer (1895), p. 196.

Eadweard James Muybridge 1830 –1904)

Race Horse First Film Ever 1878 Eadweard

Muybridge was hired by railroad baron Leland Stanford, in 1872, to settle a bet that Stanford had made with a fellow horseman regarding a horse's gallop. The bet was whether the horse had all feet in the air at some point during the gallop or not.
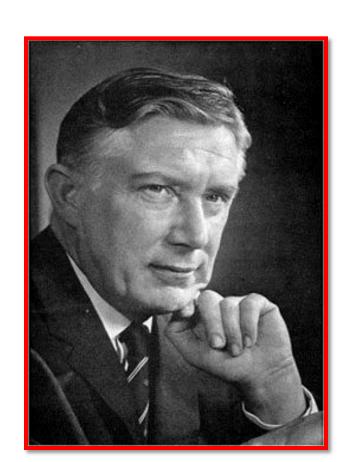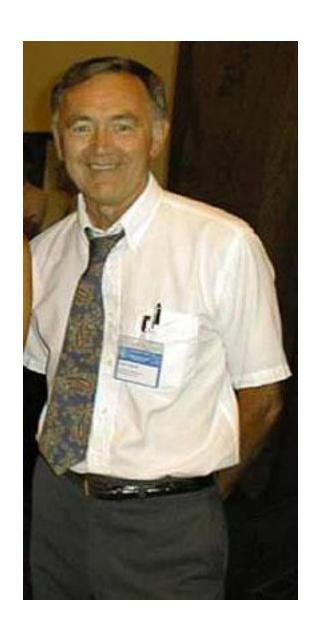
Leland Stanford

Leland Stanford Jr. on his pony
Palo. Alto. may 1879

Photographed may 1879
by
Eadweard Muybridge

24 — 1

a series of 8 phases of a stride by
a pony while cantering. Photographed
on wet collodion plates.
E. M.

All of these scientists, inventors, photographers, and the various technological developments bring us to the great sports scientist, Geoffrey Dyson
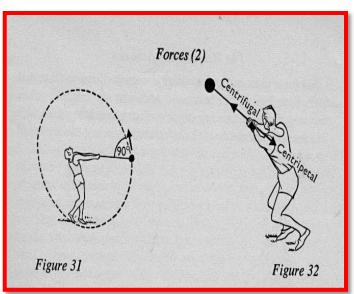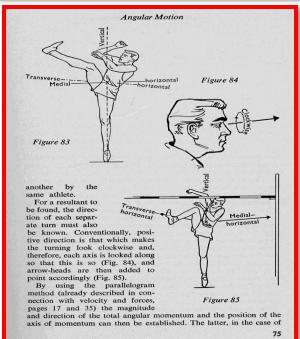
The International Society of Biomechanics for Sports was started based on Dyson's personality and knowledge. It was Dr. Juris Tserauds who was inspired by Dyson to start the ISBS organization in the early 80's

Perth1999
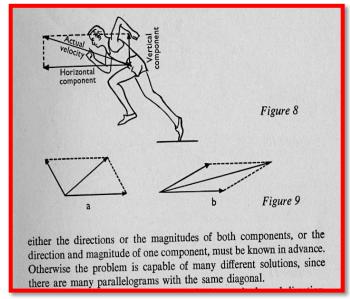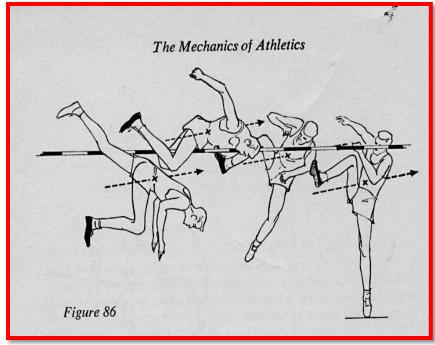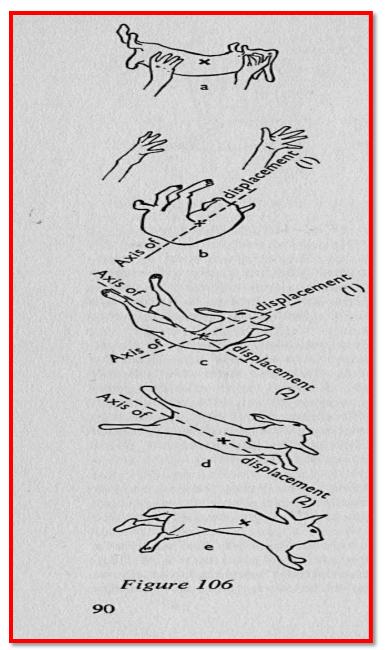
Figures from Dyson Book, The Mechanics of Athletics

Forces (2)

Centrifugal

Centripetal

90°

Figure 31

Figure 32

Actual velocity

Horizontal component

Vertical component

Figure 8

a

b

Figure 9

either the directions or the magnitudes of both components, or the direction and magnitude of one component, must be known in advance. Otherwise the problem is capable of many different solutions, since there are many parallelograms with the same diagonal.

Angular Motion

Vertical

Transverse Medial

horizontal horizontal

Figure 84

Clockwise

Figure 83

another by the same athlete.

For a resultant to be found, the direction of each separate turn must also be known. Conventionally, positive direction is that which makes the turning look clockwise and, therefore, each axis is looked along so that this is so (Fig. 84), and arrow-heads are then added to point accordingly (Fig. 85).

By using the parallelogram method (already described in connection with velocity and forces, pages 17 and 35) the magnitude and direction of the total angular momentum and the position of the axis of momentum can then be established. The latter, in the case of

Vertical

Transverse horizontal

Medial horizontal

Figure 85

75

The Mechanics of Athletics

Figure 86

Figure 106

90

Angular Motion

Figure 107

The Future Coach

The Kodak Cine Special running 64 frames per second film
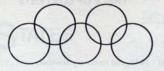
Taking film in Mexico City–1968 Bob Beamon's World Record

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Analysis of Long Jump
BOB BEAMON (8.90m) VS CARL LEWIS (8.71m)

Gideon Ariel   Coto Research Center

The purpose of this analysis is to compare the kinematic characteristics of Bob Beamon's jump (1968 Olympics in Mexico City) of 8.90 meters (29'2.5") to Carl Lewis' jumps (1982 T.A.C. meet). Lewis' first jump was officially approved and the distance was 8.71 meters (28'7"). Lewis fouled on the second jump (by as much as 1.5") the distance measured was 8.82 meters (28'11.3"). It is important to note that Beamon's jump took place at an altitude of approximately 6000 feet. Carl Lewis jumped at an altitude closer to sea level.

The film on the jumps was actually taken from a video recording taken during the competition. The camera speed was 30 frames per second; the camera was penned, but not zoomed. A special technique was used to digitize the performance. A fixed point on the field, in the same plane of the athlete's movement, was digitized. Later on all the displacement and velocity data were plotted relative to the "moving"

fixed point. In this manner the penning speed was partialed out in order to attain the true velocity of the various body segments and the center of gravity. The distance jumped was measured, using two known scale fact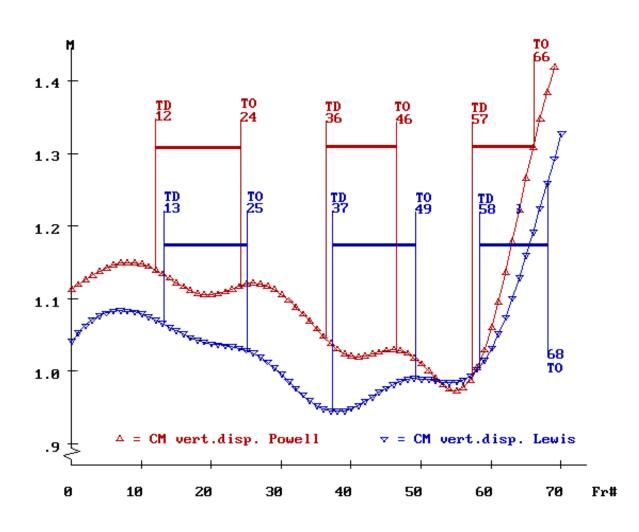ors in the plane of the motion. The first scale factor was a one meter horizontal distance between two marks along the pit (this scale measure was available only for Lewis' jumps). The second scale factor was the distance from the landing mark to the end of the pit (12 meters from the edge of the take-off board). In Lewis' legal jump the one meter scale was used to verify the distance between the landing mark and the end of the pit, and vice versa. After the calculations of the multiplier from the known scale factors, the length of the shank of the athletes was measured and calculated and then it was used as the scale factor for all the digitized frames in the sequence. All the information related to the scale measures and kinematic data are presented in Table 1.
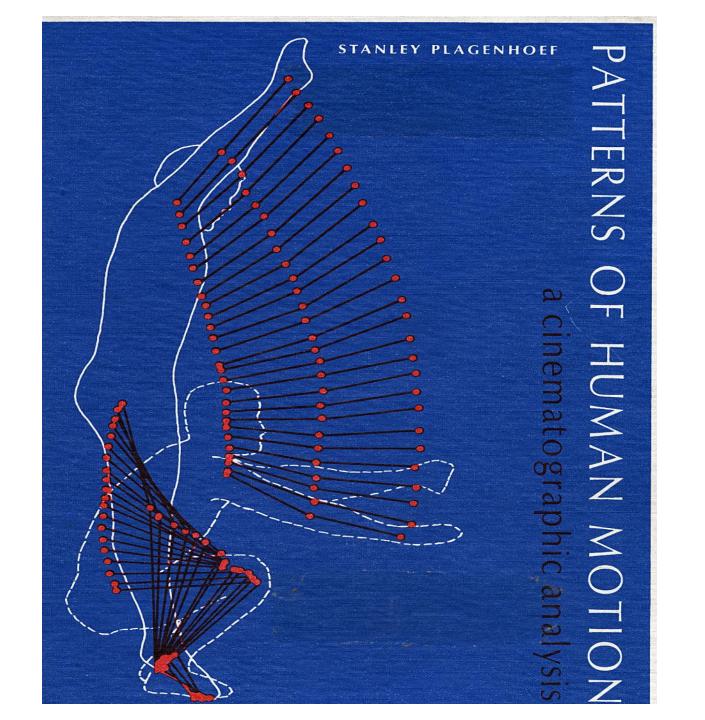
Table 1

	Bob Beamon	Carl Lewis	Carl Lewis
Distance (Meters) :	8.90	8.71	8.82
Distance (Feet) :	29'2.5"	28'7"	28'11.3"
Legal jump :	Good	Good	Foul
Year :	1968	1982	1982
Distance measured from the landing mark to the end of the pit	3.10m 10'2"	3.29m 10'9.5"	3.18m 10'7"
Distance digitized from the landing mark to the end of the pit	60.3cm 23.75"	28.6cm 11.25"	51.4cm 20.25"
Scale measure digitized on the screen	shank = 4.02"	shank = 2.17" 1 meter = 4.25"	shank = 4.08" 1 meter = 8"
True length of the scale measures	shank = 52.5cm	shank = 51.0cm 1 meter	shank = 51.0cm 1 meter
The digitized distance between the feet landing mark and the buttock landing mark	•••• ••••	•••• ••••	7.6cm 3"
The true distance between the feet landing marks	••••	••••	35.0cm 13.75"
Velocities of the Center of Gravity at breaking point....			
X—Horizontal	11.76m — 38.55'	12.97m — 42.52'	12.58m — 41.25'
Y—Vertical	2.68m — 8.8'	2.33m — 7.30'	2.49m — 8.17'
R—Resultant	11.45m — 37.54'	11.66m — 38.23'	11.09m — 36.36'
Angle to the horizontal	13.5 degrees	11.5 degrees	13 degrees
Velocities of the Center of Gravity at Take-off....			
X—Horizontal	11.79m — 38.66'	13.00m — 42.62'	11.73m — 38.50'
Y—Vertical	3.92m — 12.85'	4.00m — 13.11'	2.96m — 9.71'
R—Resultant	11.12m — 36.50'	10.20m — 33.44'	9.04m — 29.64'
Angle to the horizontal	20.5 degrees	23 degrees	19 degrees
The vertical height of the C.G. at take-off	1.085 meters 3.56'	0.982 meters 3.22'	1.004 meters 3.29'
The calculated (•) horizontal distance of the C.G.	12.00m 39.45'	13.18m 43.40'	9.93m 30.40'

* $X = (V_x (V_y + (SQRT(V_y**2 + 2gY))))/g$

Change of the Height of CM

STANLEY PLAGENHOEF

PATTERNS OF HUMAN MOTION

a cinematographic analysis

efficiency. The contribution of each body segment to the whole motion may also be found. This is obtained in the computer program, Appendix B, when the relative velocity and acceleration for a given segment is zeroed, and the whole motion recalculated to find out how much change occurs without the movement of that particular segment. The velocities and accelerations are reinserted and the entire analysis is repeated with the next segment velocities and accelerations zeroed. In this manner the relative contribution of each segment's movement can be determined. This could not be done using the absolute motion method. (The absolute motion method is presented in Appendix C.)

A three-segment motion analysis and the use of the computer programs should be reserved for graduate students. The undergraduate should be aware of the numerous forces due to motion and the complexity of the calculations without being responsible for determining force magnitudes and directions. When the study of three-segment motion is completed, students realize fully that muscle action is totally unpredictable from observation of movements alone.

THREE-SEGMENT MOTION

Figure 5-5 shows a three-segment motion with segment 1 rotating about a fixed point, and segments 2 and 3 rotating about a moving axis. (Note segments 2 and 3 have a minus angular acceleration.) The free body diagram for each segment, showing inertial forces and weight, is presented in Fig. 5-6, and Fig. 5-7 gives a breakdown of the forces to aid in writing the force formulas. The force and moment formulas are as follows:
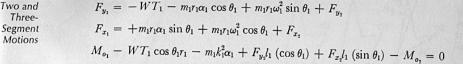
Segment 3

$$F_{y_3} = -WT_3 + m_3 r_3 \alpha_3 \cos \theta_3 + m_3 r_3 \omega_3^2 \sin \theta_3 - m_3 R_1 \alpha_1 \cos \phi_1 + m_3 R_1 \omega_1^2 \sin \phi_1$$
$$+ m_3 R_2 \alpha_2 \cos (180° - \phi_2) + m_3 R_2 \omega_2^2 \sin (180° - \phi_2)$$
$$+ m_3 (2\omega_1 V_2 + 2\omega_1 V_3 + 2\omega_1 \omega_2 r_3) \sin \theta_3 - m_3 2\omega_2 V_3 \sin \theta_3$$

$$F_{x_3} = -m_3 r_3 \alpha_3 \sin \theta_3 + m_3 r_3 \omega_3^2 \cos \theta_3 + m_3 R_1 \alpha_1 \sin \phi_1 + m_3 R_1 \omega_1^2 \cos \phi_1$$
$$+ m_3 R_2 \alpha_2 \sin (180° - \phi_2) - m_3 R_2 \omega_2^2 \cos (180° - \phi_2)$$
$$+ m_3 (2\omega_1 V_2 + 2\omega_1 V_3 + 2\omega_1 \omega_2 r_3) \cos \theta_3 - m_3 2\omega_2 V_3 \cos \theta_3$$

$$M_{o_3} - WT_3 \cos \theta_3 r_3 + m_3 k_3^2 \alpha_3 + m_3 R_1 \omega_1^2 \sin (\phi_1 - \theta_3) r_3 - m_3 R_1 \alpha_1 \cos (\phi_1 - \theta_3) r_3$$
$$+ m_3 R_2 \omega_2^2 \sin (\phi_2 - \theta_3) r_3 - m_3 R_2 \alpha_2 \cos (\phi_2 - \theta_3) r_3 = 0$$

Segment 2

$$F_{y_2} = -WT_2 + m_2 r_2 \alpha_2 \cos (180° - \theta_2) + m_2 r_2 \omega_2^2 \sin (180° - \theta_2)$$
$$- m_2 R_1^1 \alpha_1 \cos \phi_1^1 + m_2 R_1 \omega_1^2 \sin \phi_1^1 - m2 V_2 \omega_1 \sin (180° - \theta_2) + F_{y_3}$$

$$F_{x_2} = +m_2 r_2 \alpha_2 \sin (180° - \theta_2) - m_2 r_2 \omega_2^2 \cos (180° - \theta_2) + m_2 R_1^1 \alpha_1 \sin \phi_1^1$$
$$+ m_2 R_1 \omega_1^2 \cos \phi_1^1 + m2 V_2 \omega_1 \cos (180° - \theta_2) + F_{x_3}$$

$$M_{o_2} + WT_2 \cos (180° - \theta_2) r_2 - m_2 k_2^2 \alpha_2 - m_2 R_1^1 \omega_1^2 \sin (\theta_2 - \phi_1^1) r_2$$
$$- m_2 R_1^1 \alpha_1 \cos (\theta_2 - \phi_1^1) r_2 + F_{y_3} l_2 (\cos 180° - \theta_2)$$
$$+ F_{x_3} l_2 (\sin 180° - \theta_2) - M_{o_3} = 0$$

Two and Three-Segment Motions

$$F_{y_1} = -WT_1 - m_1 r_1 \alpha_1 \cos \theta_1 + m_1 r_1 \omega_1^2 \sin \theta_1 + F_{y_2}$$
$$F_{x_1} = +m_1 r_1 \alpha_1 \sin \theta_1 + m_1 r_1 \omega_1^2 \cos \theta_1 + F_{x_2}$$
$$M_{o_1} - WT_1 \cos \theta_1 r_1 - m_1 k_1^2 \alpha_1 + F_{y_2} l_1 (\cos \theta_1) + F_{x_1} l_1 (\sin \theta_1) - M_{o_2} = 0$$

Fig. 5-5
Three-segment motion.

Fig. 5-6
Free body diagrams for three-segment motion.

```
C       (1) COMPUTE THE M + 1 VALUES OF XBAR (I), WHERE M IS THE DEGREE
C       OF THE POLYNOMIAL Y(M).
C       (2) NORMALIZE THE INITIAL VALUES OF X(I) TO THE INTERVAL (-1,1).
C       (3) PERFORM THE LAGRANGIAN INTERPOLATION TO OBTAIN M+ 1 VALUES OF
C       YBAR(I) WHICH CORRESPOND TO THE M + 1 VALUES OF THE XBAR(I).
C       (4) COMPUTE THE COEFFICIENTS C(I).
C       (5) CONVERT THE CHEBYSHEV SERIES FOR Y(M) TO ITS EQUIVALENT POWER
C       SERIES.
C       (6) CONVERT THE POWER SERIES FROM THE INTERVAL (-1,1) TO THE
C       INTERVAL (A,B).
C       (7) PUNCH THE COEFFICIENTS OF THE FINAL SERIES EXPANSION.
C       M = DEGREE OF THE POLYNOMIAL Y(M) DESIRED.
C       XMIN = FIRST VALUE OF X (SMALLEST VALUE OF ORIGINAL X-COORDINATES)
C       DELTX = INCREMENT BETWEEN VALUES OF X, THAT IS, (X(I) - X(I) - 1).
C       Y(J) = VALUE OF THE ORIGINAL Y CORRESPONDING THE JTH VALUE OF X.
C       R(I) = THE ITH ROOT, OR XBAR(I).
C       V(I) = THE ITH VALUE OF XP(I), OR NORMALIZED X(I).
C       C(I) = THE ITH COEFFICIENT OF THE CHEBYSHEV SERIES IN (-1,1).
C       F(I) = THE INTERMEDIATE STORAGE USED IN COMPUTING INTERPOLATED
C       YBAR(I), IN COMPUTING C(I)@S, AND IN CONVERTING C(I)@S TO FINAL
C       POWER-SERIES COEFFICIENTS IN (A,B).   THE FINAL COEFFICIENTS ARE
C       STORED IN Y(J).
C       CHEBYSHEV POLYNOMIAL APPROXIMATION - EQUIDISTANT DATA
        DIMENSION Y1(90),DATTH(8,50),DATV(8,50),DATA(8,50),NFBD(8,50)
        DIMENSION S(20),V(90),Y(90),C(20),F(20),DATY(8,50),DATL(8,50)
        DIMENSION YGRAPH(4),IC(4),DATW(8,50),DATR(8,50),DATK(8,50)
        DIMENSION W(8),XL(8),R(8),A(8),B(8),XMASS(8),CG(8,2),Z(8,2)
        DIMENSION PCTR(8),PCTK(8), EN(8),NFU(8),CIS(8),CXL(8),DATM(8,50)
        DIMENSION DUMW(8),DUMR(8),DUMK(8),WHOA(10),WHOB(10),MP(8),YMAXX(8)
       1,OMEGA(8),ALPHA(8),OMEG(8),ALPH(8),FX(8),FY(8),XMOMT(8)
       2,FXA(8),FYA(8),AMOMT(8),XK(8),IZ(8),DFX(8,50)
       3,FXE(8,50),FYE(8,50),  XFI(8),XFA(8),YFI(8),YFA(8),MI(8),MA(8)
       4,DFY(8,50),RE(8,50),RR(8,8),AA(8,8),THETA(8),STORE(5,50,8)
        COMMON PI,CONST,W,XL,XK,R,A,B,XMASS,CG,Z,OMEGA,ALPHA,OMEG,ALPH
       1,NSEG,IT,FXE,FYE,NPOS,RE,RR,AA,THETA
        EQUIVALENCE(YGRAPH(1),X1),(YGRAPH(2),X2),(YGRAPH(3),X3)
      1 READ 300,WHOA
        IF(EOF,60)9999,9998
   9998 READ 300,WHOB
    300 FORMAT(10A8)
        PRINT 301,WHOA,WHOB
    301 FORMAT (///1X,10A8/1X,10A8)
        PRINT 302
    302 FORMAT(* ANG.= DEG.. VEL.= DEG. PER SEC.. ACC.= DEG. PER SEC. SQ.*
       1)
        READ 5,NSEG,  NPOS,XMIN,DELTX
      5 FORMAT(I1/I4/2F10.5)
        READ 104,NTRK,TRNKNL,KIP,NSPEC,NSPEC1
    104 FORMAT (I1,F10.3,3I1)
        READ 101,(PCTR(I),PCTK(I),I=1,NSEG)
        READ 101,( EN(I),I=1,NSEG)
    101 FORMAT(7F10.3)
        READ 136,COR
    136 FORMAT(I3)
        READ 101,(W(I),I=1,NSEG)
        READ 303,(MP(ID),ID=1,NSEG)
    303 FORMAT(7I1)
        READ 101,(YMAXX(ID),ID=1,NSEG)
        DO 3000 I=1,NSEG
   3000 READ 3010,XFI(I),XFA(I),YFI(I),YFA(I),MI(I),MA(I),IZ(I)
   3010 FORMAT(6E8.1,A2)
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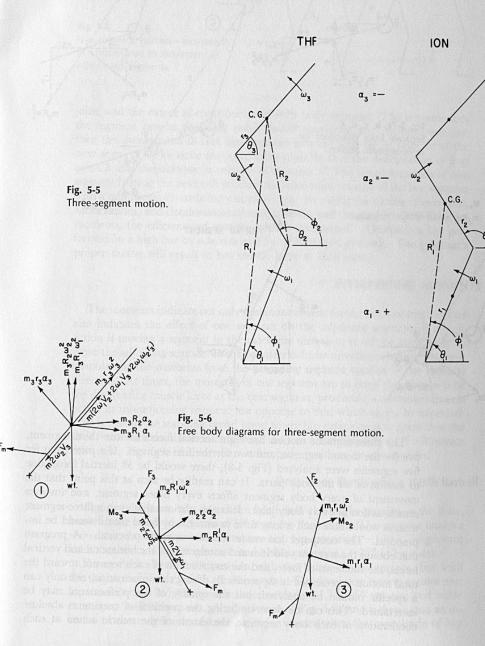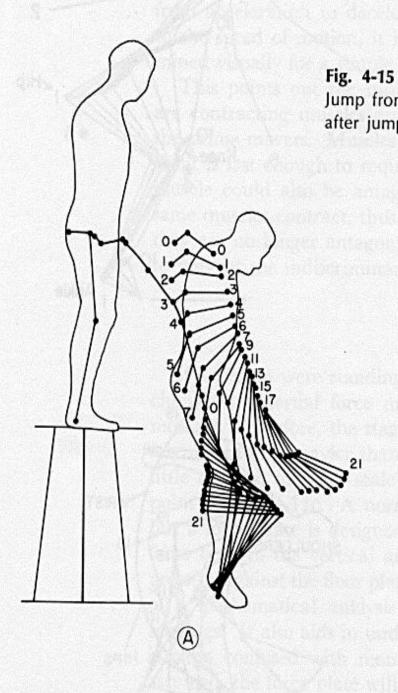
Fig. 2-17

Glass top tracing table. This equipment is used when the paper must be moved for each frame because of camera movement or in recording a body motion relative to a moving object (i.e., rowing, bicycling).

Fig. 4-15
Jump from stool (a) and jump up
after jump from stool (b).

Ⓐ

Ⓑ
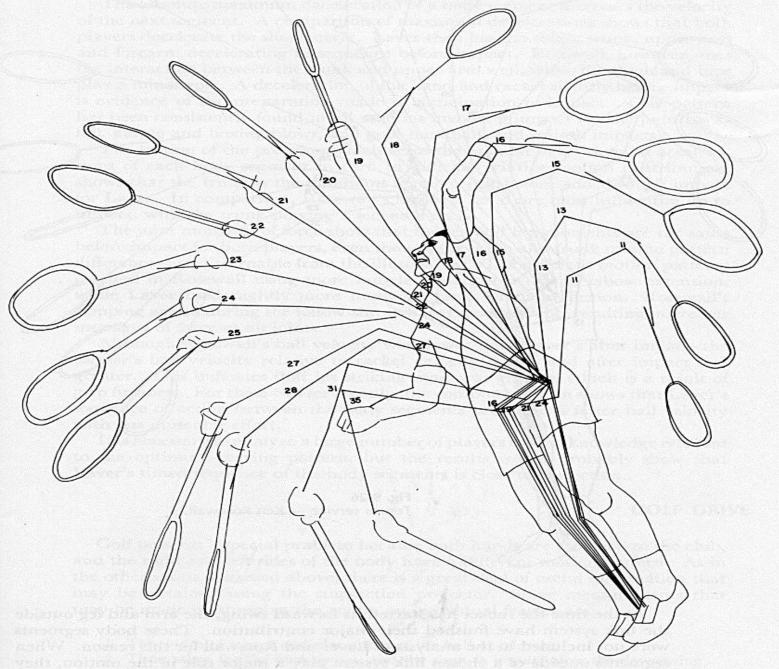
Fig. 9-25
Tennis service — Rod Laver.
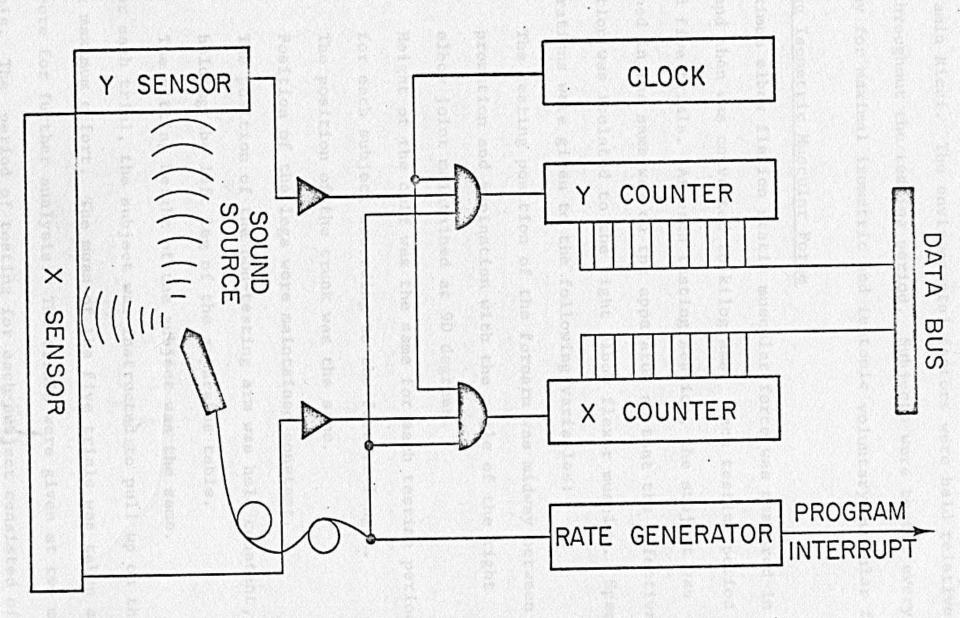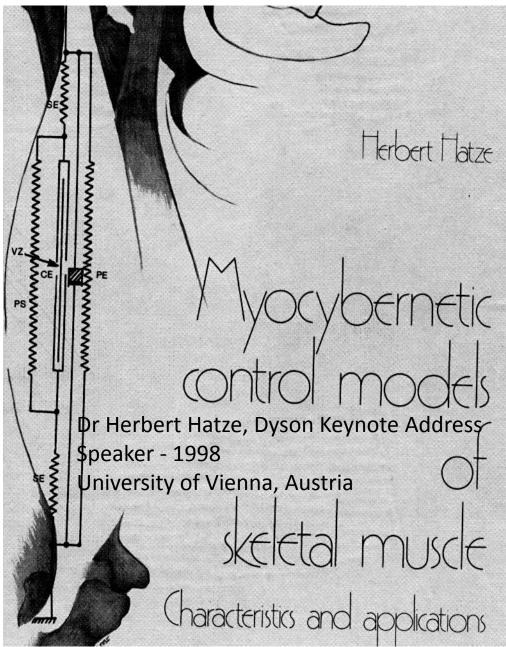
FIGURE 4. Schematic representation of Graf-Pen operation.

First Digitizer in the World interface to the first Time Sharing in the World for Biomechanical Analysis

Dr. Ann Penny 1971

Herbert Hatze

Myocybernetic
control models
of
skeletal muscle
Characteristics and applications

Dr Herbert Hatze, Dyson Keynote Address
Speaker - 1998
University of Vienna, Austria
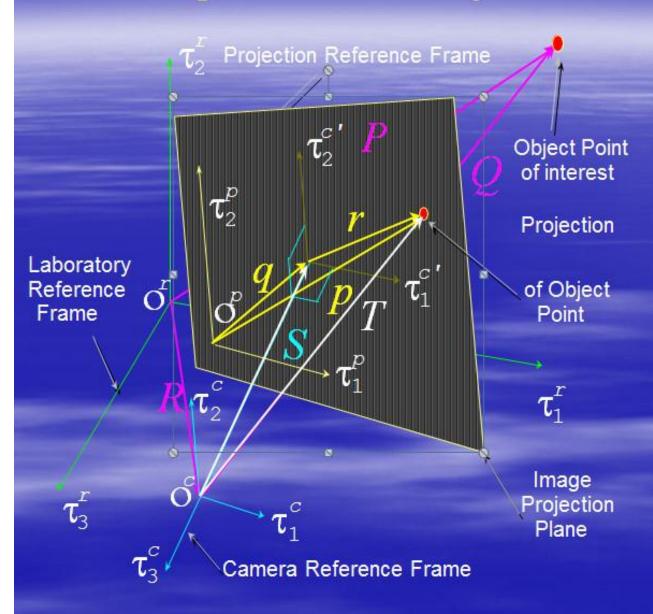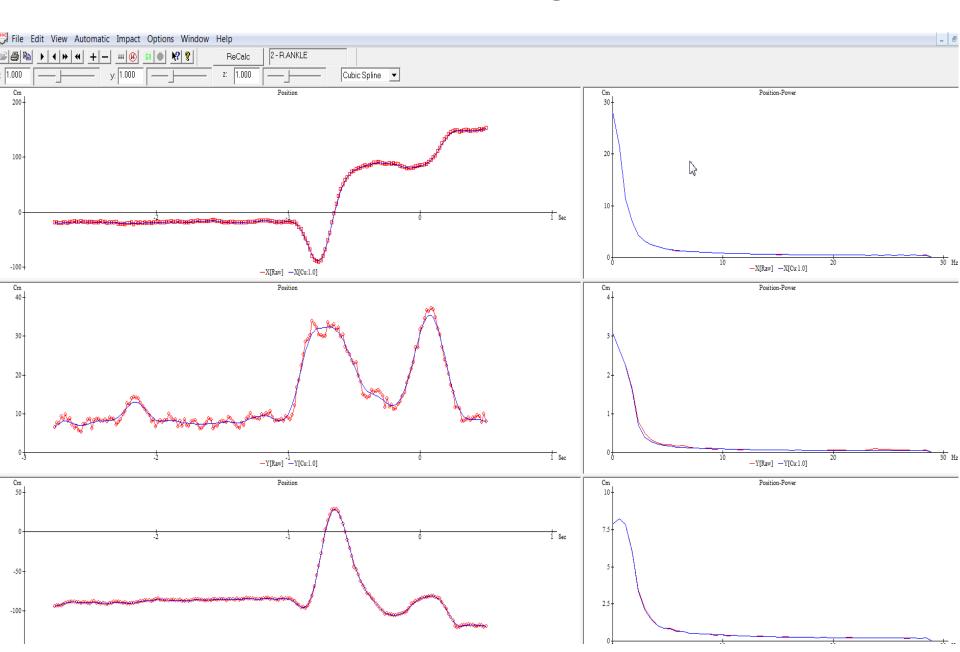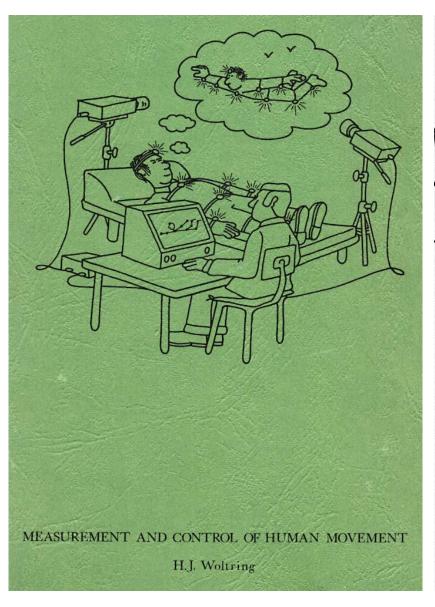
Photogrammetric Physical Parameters

Filtering

MEASUREMENT AND CONTROL OF HUMAN MOVEMENT

H.J. Woltring

y-axis

image point

p

y_p

x_o

x-axis

x_p

y_o

XC_2

z-axis

optical axis

optical system

observed direction

camera station
(Perspective Centre)

XC_1

Fiducial Marks

P Target

Fig. 1. Relation between external and internal quantities in space intersection.

COMPUTERIZED BIOMECHANICAL ANALYSIS OF HUMAN PERFORMANCE

Gideon Ariel

University of Massachusetts

ABSTRACT

A kinetic analysis of human motion, one of the greatest advances in the field of biomechanics, has been expanded by the computer-digitizer complex which allows analysis of total body motion through utilization of slow motion cinematography, special tracing equipment to convert the data, and the high-speed computer. Appropriate programming results in a segmental breakdown of information of the whole motion including the total body center of gravity, segment velocities and accelerations, horizontal, vertical, and resultant forces, moments of force, and the timing between the body segments. This analysis provides a quantitative measure of the motion and allows for perfection and optimization of human performance applications of biome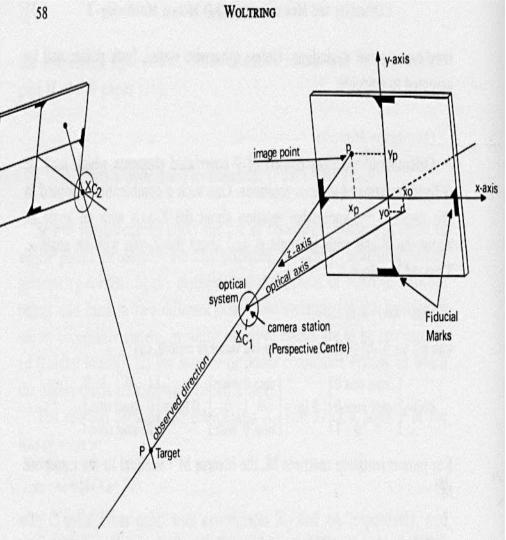chanical analyses permit an objective, quantitative assessment of performance replacing the uncertainty of trial and error, eliminating the element of doubt, and provides a realistic opportunity for improved performance.

INTRODUCTION

As early as the fifteenth century Leonardo Da Vinci wrote:

> Mechanical science is the noblest and above all others the
> most useful, seeing that by means of it, all animated bodies
> which have movement perform all their actions.
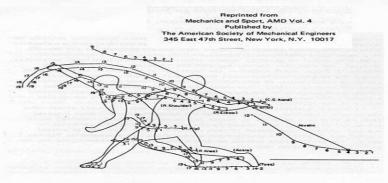
Since that time, biomechanics of human motion developed; however, the kinematic and kinetic analyses of the human body lacked specific force analysis. It was only after the combining of high speed photography, anatomical data, and the utilization of man as an integral part of a system, that total motion analysis of human performance was realized. The computer-digitizer complex has reduced the long tedious hours of tracing and hand calculations to a matter of minutes and, thus, complex whole body motion analysis can be practically obtained. This analysis provides a quantitative measure of the motion and allows for perfection and optimization of human performance in industry, sport, and human factors in man-product interactions, as well as,

COMPUTERIZED BIOMECHANICAL ANALYSIS OF HUMAN PERFORMANCE

Gideon Ariel
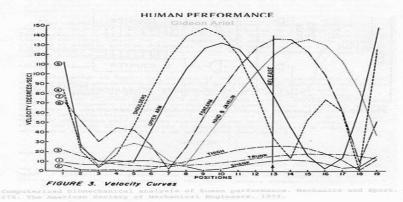
University of Massachusetts

1971
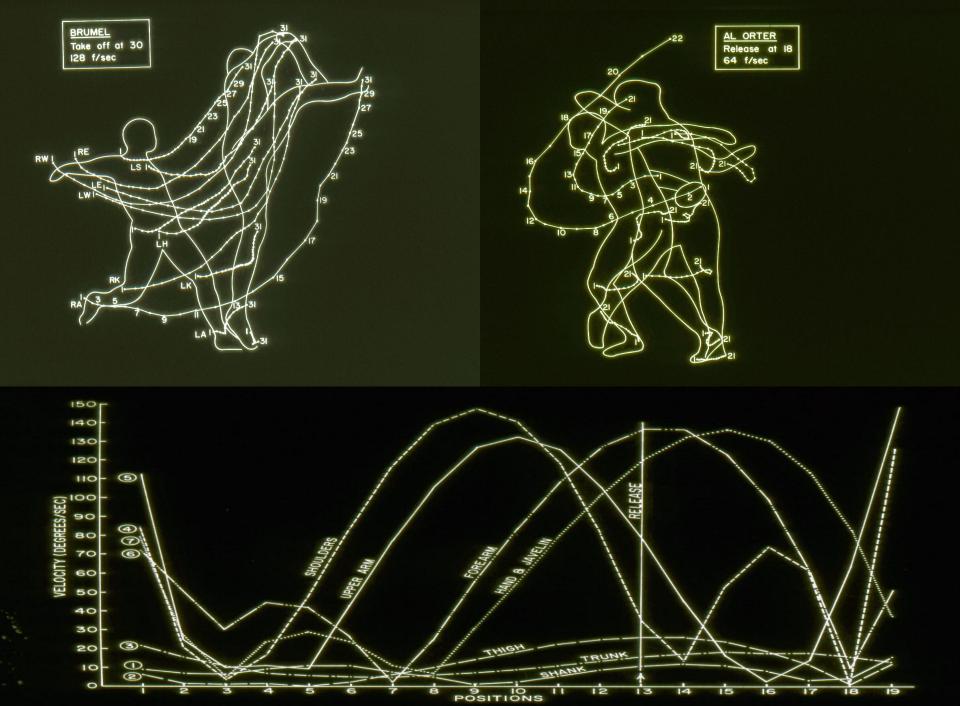
COMPUTERIZED BIOMECHANICAL ANALYSIS
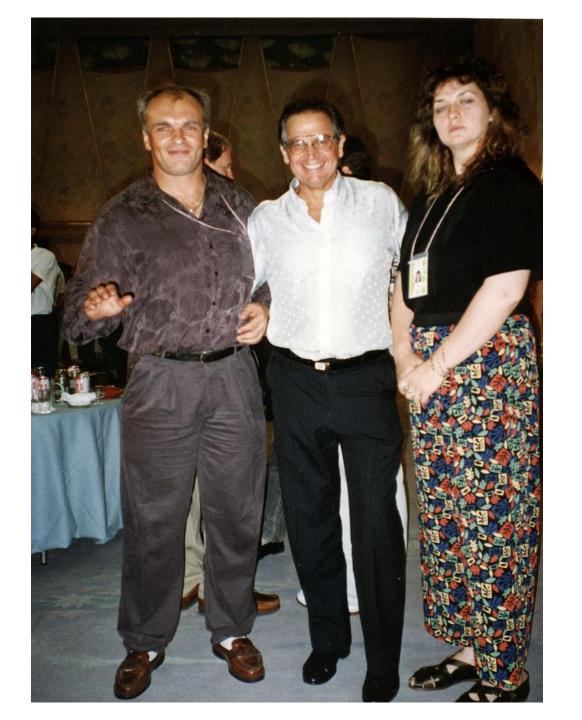
OF

HUMAN PERFORMANCE

Gideon Ariel

FIGURE 3. Velocity Curves

LUSIS

Abb. 2   Lusis   freies Körperdiagramm

Abb. 3   Geschwindigkeitskurven

BRUMEL
Take off at 30
128 f/sec

AL ORTER
Release at 18
64 f/sec

VELOCITY (DEGREES/SEC)

SHOULDERS
UPPER ARM
FOREARM
HAND & JAVELIN
RELEASE
THIGH
TRUNK
SHANK

POSITIONS

CBS MORNING NEWS

Computer helps design shoe that walks on air

By MILTON COLE

AMHERST — Walking on air.

The very thought is so pleasurable that the expression is used constantly to describe emotionally inspiring success.

But now a computer and a former Olympic athlete have merged knowledge and technology so they could make "walking on air" totally commonplace.

Dr. Gideon Ariel of Belchertown and his Computerized Biomechanical Analysis company in Amherst have designed shoes in which one does walk on air.

How efficient the shoe

They are the result of a survey on how efficient is the design of shoes in general, and how can they be made more efficient.

The result of that survey and study could be shoes that have one walking on air.

And if the air-shoes are the most unusual of the products of CBA, they are not the only ones.

For example, there is a new exercise machine that makes it unnecessary to have a large room to house it, and makes it possible to do all your exercises in half the average-size bathroom.

There is a tennis racket with a pivoting handle that enables a player to absorb the shock of a ball hit at him and return it with maximum force and accuracy.

And there is a study being made for the Department of Defense on how to make the foot soldier more efficient as far as equipment and uniform are concerned, and what is the most efficient way to hold and shoot a submachine gun.

These are some of the more unusual studies that have been or are being made. But there are others, enough others that the business started by Ariel six years ago has now grown into a multi-million-dollar firm that is expanding.

Take the air shoe.

Originally the U.S. Bureau of Standards contracted with CBA several years ago to do a survey on the efficiency of design of the common shoe.

The study, including filming of people walking and then slowing the film down to analyze frame-by-frame what happens when a person takes a step, showed that the common shoe is not an efficient design.

The protruding heel causes a person to step onto the heel of the foot first, putting the strain of each step on it, and then expanding that strain up through the leg into the lower back.

"It showed that the way we walk and the kind of shoes we walk with can be a cause of lower back trouble as well as the cause of foot and leg problems.

"The computer showed that the most efficient way to walk is the way we walk barefoot, with a rolling motion so that the force we generate as our foot hits the ground will cause a rolling motion, pushing the body forward on the foot, instead of jarring the force up the leg."

How to utilize knowledge

How to utilize that knowledge?

After the report was sent to the federal agency, Gideon and his compatriots at CBA worked on putting theory into reality.

One shoe was designed, aimed at providing the rolling motion, but still sending some of the jarring motion up the legs. Then came the idea of using that jarring action to provide forward motion.

The air shoe was born. The prototype is designed for athletes, and has been used successfully in practice by the members of the U.S. women's volleyball team.

They have found that they jump higher, and they end up with fewer leg problems, muscle pulls, etc. as a result of landing on their feet after a jump.

Basketball players are experimenting with them, along with runners.

The design is of a regular nylon-bodied running shoe, with the rubberized rippled or cleated sole.

But the inside has another rippled rubberized insert running the entire length of the shoe. On the outside of the heel of the shoe is a small air intake valve.

A rubber-bulb pump is inserted into the valve and the insert is filled with air, like filling an auto or bicycle tire or a football or basketball.

Then the shoe is put on, laced and tied. And when one walks on it, he or she is literally and actually walking on air.

Air forced out

Each step forces the air from one spot in the insert into another by use of computer-designed valves, and the result is a cushioned step whether walking or running or jumping, and a rolling effect when one walks or runs.

"They should end problems with leg muscles, shin splints, bone spurs, etc. And they should cut foot fatigue for runners," Ariel said.

Right now the design has been acquired by the Pony Shoe

PUMPING UP the sole prepares the new "air shoe" for use. It was designed by Computerized Biomechanical Analysis in Amherst, and CBA president Dr. Gideon Ariel is getting the shoes ready. (Richard Carpenter Photo).

Company, which makes footwear for all kinds of sporting activities.

Ariel figures that the shoe will be used in Olympic and other national and international competition. He believes it will find a place in sports, particularly basketball, and perhaps football as well.

But it also should result in use in regular shoes worn by the general public, and could have the nation, if not the world, walking on air, and being healthier for it, if Ariel and his computers are correct.

"Imagine how great this would be for paratroopers or others jumping from considerable heights," enthused Ariel.

The graying but husky University of Massachusetts doctoral graduate also is enthusiastic about the exercise machine he has designed.

Originally used weights

Originally he designed one for the Universal firm, one of the top such companies in the U.S., using the established method of actual weights attached to pullies and handles.

It was different and easier to operate than others on the market at the time, but still quite bulky and space-consuming.

The latest design, made possible by the omniscient and omnipresent computer, is a simple large cylinder connected to a variety of bars or pedals or overhead handles.

The computer is hooked up on a shelf as part of the system. You press a button, and the computer asks if you want to exercise.

You press buttons that indicate that you want to do weight lifting, and how much force or poundage you want to lift.

The computer then sets the valve that controls the hydraulic fluid in the cylinder and thus the amount of force necessary to lift the piston in the cylinder.

It eliminates the need for the actual weights to be there.

One of the people involved with Ariel in his enterprises is former U.S. Treasury secretary William Simon. He is interested in forming their own manufacturing firm to turn out the new tennis rackets that CBA has designed.

Doing research on tennis racket efficiency and how the ailment, "tennis elbow," occurs, CBA and Dr. Ariel found that the impact of a ball on the racket, sends a jarring force through the racket handle up the arm and against the elbow joint.
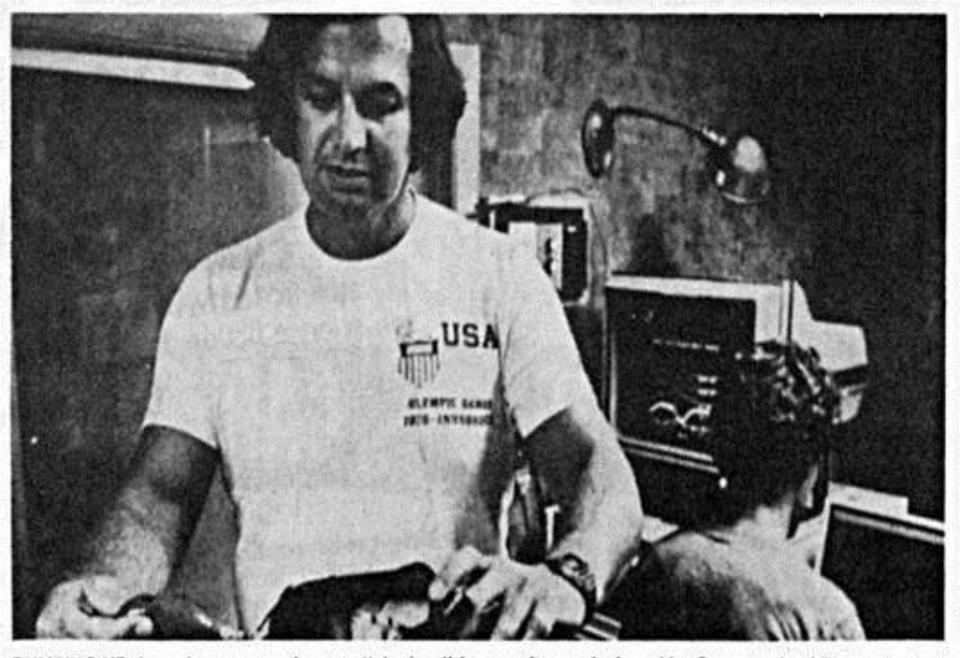
The computer suggested a rotating handle that would use that force to twist the handle, making it so the face of the racket is directly against the ball each time it hits the racket.

This not only eliminated the jarring force going into the elbow, it also made possible the opportunity for a perfect return shot.
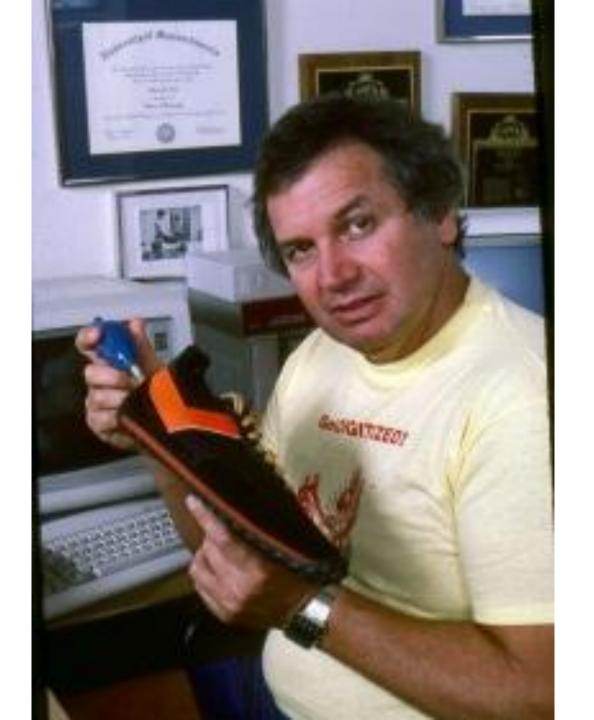
Using that racket, which Ariel says will be produced by someone within a year, either their own firm or one of the regular sporting goods manufacturers, with the tennis ball CBA designed for Spalding, could make for much improved tennis.

DR. GIDEON ARIEL demonstrates how the computerized exercise machine his Computerized Biomechanical Analysis firm of Amherst designed, with computer operating hydraulic piston to provide the same resistance as weights used on traditional exercise machines. (Richard Carpenter Photo).

PUMPING UP the sole prepares the new "air shoe" for use. It was designed by Computerized Biomechanical Analysis in Amherst, and CBA president Dr. Gideon Ariel is getting the shoes ready. (Richard Carpenter Photo).

Munich Olympics 1972

München 1972

Scientific Congress

Congress Guide

Wissenschaftlicher Kongreß

Tagungsführer

THE CONTRIBUTION OF THE POLE TO THE VAULT ★

75%

Gideon Ariel
Department of Exercise Science
University of Massachusetts

In the past, the kinematic and kinetic analysis of the human body has been lacking in analysis of forces and moment of forces. Today, with the use of high speed photography, anatomical data, and knowledge of mechanics, forces and moments of force about each body joint may be calculated for any instantaneous position. With the advent of computerization, the analysis of human motion becomes much less laborious, and the results more readily interpretable.

The purpose of this study was to find the contribution of the fiberglass pole to the vault by analyzing the world record performance in the pole-vault using engineering dynamics while utilizing a special computer program to obtain the results. A complete analysis was performed; however, the scope of this paper permits only a discussion of the contribution of the pole to the vault.

The Contribution of the Fiberglass Pole to the Vault: Figure 1 presents 105 frames 1/64 seconds intervals of Seagren's 18 - feet, 5¾ inches world record performance.

Figures 2 and 3 summarize the computer output for the moments of force and percent contribution of the fiberglass pole to the total moment and the vertical and horizontal forces created by the pole. The units for the moments are in Kg.M. and the units for the forces are in Kg.

In Figure 2, it can be observed that five phases occur as revealed by the changes in the direction of the moment of force. In the take-off, the moment of force was in the clockwise direction (same direction as the run). The positive percent contribution reveals that the pole, in this phase, hindered the motion. At the instance when the pole vaulter left the ground with his take-off leg, the moment changed direction to a counterclockwise direction (direction of the bend in the pole). In this phase, the pole also had a hindering effect. Just prior to the end of the swing phase, the moment changed direction again indicating a clockwise moment. From positions 21 to 40 (19/64 of a second), the contribution of the pole to the total moment ranged from a value of 166 percent in position 22 to 15 percent in position 40. **This phase, the moment contributing phase, is the critical phase for** successful pole-vaulting. Seagren in his attempt at 16'9" demonstrated a shorter contributing phase as indicated by (b) in Figure 2. Other pole vaulters at 16' demonstrated smaller contributing phase as indicated at (a) in Figure 2. The contributing phase appears to begin in the rock-back phase and continues until the beginning of the turn-phase. This "loading" effect of the pole (sum of run, plant, take-off, swing) contributes to the vertical force which is the main goal in the pole-vault.

Figure 3 indicates that the pole contributes to the vertical force between positions 32 to 49 (17-64) sec.). This vertical force is the result of the sum of the moment of force which was created by the good run, plant and take-off, as well as the flexible pole in the rock-back phase.
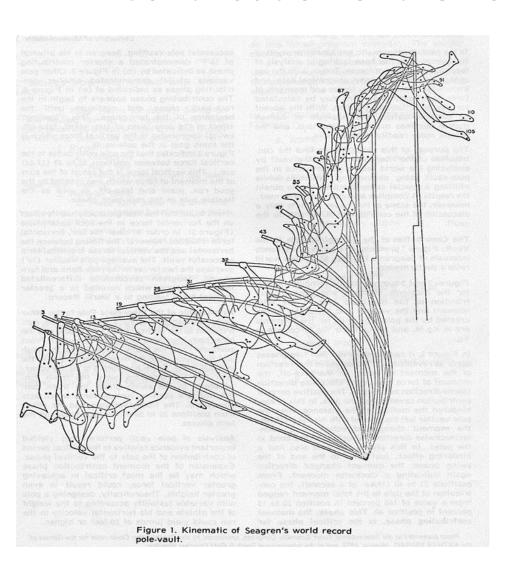
It was found that the fiberglass pole had its effect on the horizontal force in the rock-back phase (Figure 3). In order to clear the bar, horizontal force is needed; however, **the timing between the horizontal and the vertical forces is critical for a successful vault.** The average pole vaulter (16') overlaps the two forces in the rock-bank and turn phases. **Seagreen successfully differentiated these two forces which resulted in a greater vertical force leading to a World Record.**

Relationship of the Fiberglass Pole to the Other Body Segments: Figure 4 illustrates the contribution to the vertical force by the pole and the other body segments throughout the vault. From positions 1 to 6 the shank and foot, and the thigh and the trunk were the main contributors to the vertical force. From positions 6 to 10 the upper-arm and the forearms were the main contributors. In the swing phase the trunk contributed to a positive vertical force which acts downward. The fiberglass pole had its effect from positions 32 to 50 in the rock-back and the turn phases.

Analysis of pole vault performances yielded important evidence relative to the critical period of contribution of the pole to the vertical phase. Expansion of the moment contribution phase which may be the most critical in achieving greater vertical force, could result in even greater heights. Theoretically, designing a pole with variable fexibility according to the weight of the athlete and his horizontal velocity in the run could yield jumps of 20-feet or higher.

Contribution of the Pole to the Vault

Figure 1. Kinematic of Seagren's world record pole-vault.

Relationship of the Fiberglass Pole to the Other Body Segments: Figure 4 illustrates the contribution to the vertical force by the pole and the other body segments throughout the vault. From positions 1 to 6 the shank and foot, the thigh and the trunk were the main contributors to the vertical force. From positions 6 to 10 the upper-arm and the forearms were the main contributors. In the swing phase the trunk contributed to a positive vertical force which acts downward. The fiberglass pole had its effect from positions 32 to 50 in the rock-back and the turn phases.

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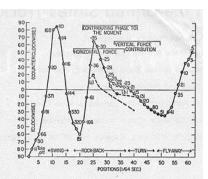

FIGURE 2. MOMENTS OF FORCE AND PERCENT CONTRIBUTION OF THE FIBERGLASS POLE TO THE MOMENT.
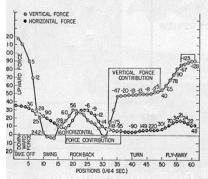

FIGURE 3. VERTICAL AND HORIZONTAL FORCES AND THE CONTRIBUTION OF THE POLE TO THESE FORCES.
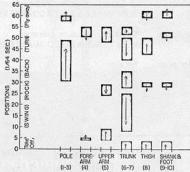

FIGURE 4. CONTRIBUTION TO THE VERTICAL FORCE BY THE DIFFERENT SEGMENTS THROUGHOUT THE VAULT.

Gideon Ariel

Die biomechanische Bewegungsanalyse mit Hilfe des Computers

Dr. Gideon Ariel ist Dozent am Institut für Leibesübungen der University of Massachusetts in Amherst. Er vertrat Israel in den Olympischen Spielen 1960 und 1964 in Kugelstoßen und Diskuswerfen und hält noch immer die Landesrekorde in diesen Disziplinen. Er arbeitete als israelischer Nationaltrainer und als Assistent Leichtathletik Coach der Universität von Massachusetts.
Dr. William Saville ist Dozent am Department of Exercise Science der Universität von Massachusetts in Amherst. Eine kritische Stellungnahme zu diesem Beitrag wird in einer der nächsten Nummern erscheinen.

In der Leichtathletik wurde im Olympia-Trainingslager des Dartmouth College eine biomechanische Bewegungsanalyse mit Hilfe eines Computers an der Leistung einer Reihe von dort trainierten Technikern vorgenommen. Die Ergebnisse wurden von Trainern wie Sportlern einhellig begrüßt. Einige der Sportler konnten aufgrund der Computer-Analyse sofort ihre Leistung verbessern. Andere kehrten nach Hause zu ihren Universitäten zurück und hatten die notwendigen wissenschaftlichen Daten erhalten, um mit einem intelligenten Arbeitsansatz ihr persönliches Programm zur Leistungsoptimierung auszuarbeiten. Von den vielen anwesenden Sportlern, besonders Diskuswerfern, Hammerwerfern, Kugelstoßern und Speerwerfern fand z. B. Michael Hoffmann die Computer-Analyse so nützlich, daß er, weil er einen groben technischen Fehler sofort beheben konnte, über drei Meter weiter im Diskuswerfen kam.

Diese biomechanische Bewegungsanalyse bietet einen neuen Ansatz in der Trainingslehre der Leichtathletik, der durch die gemeinsame Bemühung vieler Wissenschaftler und Techniker sowie den technologischen Fortschritt der letzten zehn Jahre möglich gemacht wurde. Mit einer Zeitlupenkamera kann jede beliebige sportmotorische Leistung aufgenommen werden und mit Hilfe von speziellen Netzgeräten übertragen werden. Das Programm des Computers löst die Information der Gesamtbewegung in die Bewegung der einzelnen Segmente auf. Als Daten werden der Körperschwerpunkt, die Geschwindigkeiten der Körpersegmente und ihre Beschleunigung, die Kraft an den Gelenken sowie die Kraftmomente bestimmt. Mit einem entsprechenden Computerprogramm können die Daten sofort interpretiert werden, und es ist möglich, die Bedeutung einer Einzelbewegung für die Gesamtbewegung abzuschätzen. Andere Information wird über Maximalgeschwindigkeiten bei einzelnen Positionen, über Beschleunigungen, über die Größe der Muskelkraft an jedem Gelenk, die vertikalen und horizontalen Kräfte an allen Gelenken und an den Bodenkontaktpunkten, Bewegungskoordination zwischen den einzelnen Körperteilen, interindividuelle Unterschiede aufgrund anatomischer Gegebenheiten bestimmt. Die Kombination der Kraftmomente, das miteinander verbundene Bewegungsmuster, Information dieser Art sind für alle leichtathletischen Übungen von großem Interesse und können zur Leistungsoptimierung beitragen.

Die wissenschaftlichen Prinzipien der analytischen Technik

Die einzelnen Teile des menschlichen Körpers bilden ein gegliedertes System. Die Gesetze der Physik gelten für ein System mit Gliedern in Bewegung, egal ob es sich dabei um ein menschliches oder um ein maschinelles System handelt. Die einzelnen Teile des Gliedersystems des menschlichen Körpers sind der Fuß, der Unterschenkel, der Oberschenkel, der Rumpf, die Schultern, der Oberarm, der Unterarm und die Hand.
Wenn ein solches Gliedersystem in Bewegung ist, wie das in jeder leichtathletischen Übung der Fall ist, wirken spezielle Kräfte auf jedes einzelne dieser Körperteile im Gliedersystem ein. Wenn wir z. B. die Kräfte analysieren, die auf einem schwingenden Unterarm einwirken, so ergeben sich die folgenden: (Abb. 1)
1. die Schwerkraft,
2. die Zentrifugalkraft aufgrund der Drehbewegung im Gelenk,
3. die Tangentialkraft senkrecht zur Körperteilbewegung.
Diese drei Kräfte würden immer auf Glieder in Bewegung einwirken, egal ob es sich um den

Biomechanical Analysis of Shotputting*

Gideon B. Ariel, Ph.D.

Computerized Biomechanical Analysis

INTRODUCTION

In recent years American shotputters have failed to duplicate the advances demonstrated by their Eastern European counterparts. In fact, at the 1976 Olympic games, it was perhaps the first time that no American was present on the winners' stand. The purpose of the analysis presented in this paper was to conduct a biomechanical analysis of selected American shotputters and compare their technique to that of the best six competitors in the Montreal Olympic Games.

METHOD

In August of 1978 a group of national class throwers were invited to Houston, Texas by the U.S. Olympic Committee for a shotputting clinic. Attending the clinic were some of the best American throwers in this event: England, Bob Feuerbach, Klein, Kruegger, Laut, Marks, Pyka, Schmock, Stones, Summers, Vincent, Walker, and Weeks. Comparison of the throws of these athletes was made with those of the top six finishers in the 1976 Montreal Olympics. The Olympic athletes who were analyzed were: Beyer, Mironov, Barisnikov, Alan Feuerbach, Gies, and Capes.

A high speed motion picture camera with 50 mm lens recorded the performances of each thrower at an angle of 90 degrees to the athlete's sagittal plane. Films were taken of three throws for each of the clinic athletes and of the single best performance of each Olympic competitor. Each throw was filmed from the beginning of the glide through the release of the shot. These films were interpreted through several analytic techniques: visual observation, frame counting, and computerized biomechanical analysis. Following the computations, tables and graphs were generated to determine patterns of motion which characterize championship performances.

For the computer analysis, the films were projected upon a translucent 36 x 36 inch glass screen. The film was digitized with a sonic stylus and the X-Y coordinates were stored in the computer's memory bank. As each frame was digitized, joint centers were projected onto a graphic display screen and connected by lines to form stick figures. The complete movement was recreated in stick figure form on the screen where examination and corrections, if needed, were made. Figure 1 illustrates a computer graphic output of one digitized sequence. After the digitizing was completed, special kinematic programs were executed to calculate parameters such as segment velocities, accelerations, and body center of gravity displacements.

In November, 1978, Alan Feuerbach, who finished fourth in the 1976 Games, were invited to the laboratory of Computerized Biomechanical Analysis, Inc. to examine his style cinematographically and to obtain direct kinetic measurement of the forces produced during foot impact. The latter information was obtained when Feuerbach put the shot from a modified throwing circle with two force platforms embedded within it. The force platforms were arranged in various configurations within the throwing circle so that these direct measurements could be obtained as the athlete was throwing. The force platform permits measurements of the forces on the ground at various phases of the throw and yields invaluable data relating to the contribution of each leg to the throw.

RESULTS

Cinematography

The present biomechanical analysis revealed that the most important factor in shotputting is the velocity of the shot at release. This factor is more important than either the height or the angle of release. Although some attention must also be given to the release angle, the primary goal of the competitor should be to generate the greatest ball velocity at the point of release. Other factors being approximately equal, the faster the ball at the release, the further the distance. The movement patterns associated with shotputting are directed towards generating the maximum velocity of the shot under given conditions. In order to achieve maximum velocity at the release, there must be a summation of forces from the various phases of the throw and the various body segments.

The movement pattern of the shot put can be partitioned into 5 phases which are illustrated in Figure 2 (from Marhold). The first is the starting phase when the athlete accelerates his body and the shot. The rear foot leaves the ground at the end of this phase. The second phase is the glide when the athlete is in the air for a brief amount of time, after which the rear foot again contacts the ground. It is important during this airborne phase for the rear leg to actively and rapidly bring the foot under the body. The third phase is a transitional phase when the rear foot touches the ground at the beginning and the front foot contacts the ground at the end of the phase. In this phase the athlete should minimize the deceleration of the center of gravity and allow transfer of energy to the push-off phase. The fourth phase, the pushoff, is the most important one. In this phase the front foot touches the ground initially and the shot leaves the hand at the end of the phase. During the push-off phase, the body exerts maximal acceleration of the shot toward the release.

It is this relationship between the transitional phase and the push-off phase which differentiates between the 50- and 70-foot shotputters. In order to optimize this interrelationship, the athlete should acquire certian style characteristics since any deficiency in the amount of power or technique will result in a shorter throw. In throws longer than 69 feet, the velocity calculated for the shot put was found to exceed 45 feet/second. As was previously mentioned, this velocity is the most critical factor in achieving maximum distance. It is important to note that, in order to produce this velocity, it is necessary to achieve specific coordination during all the previous phases of the throw. Too rapid a start can be as detrimental to producing an optimum final velocity as a low initial beginning can.

Figure 3 illustrates the resultant shot velocities of the Olympic competitors and revealed remarkable similarities among the athletes. Beyer, the gold medalist, demonstrated the highest shot velocity; however, Feuerbach, the fourth place finisher, produced a significantly lower shot velocity. In order to throw more than 69 feet, the athlete must release the shot at a speed exceeding 45 feet/second.

Figures 4 to 6 illustrate the resultant ball velocities of the athletes who attended the Houston clinic. It can be seen that the velocities and the distances are significantly lower than those observed for the Olympic competitors. Among the clinic throws, Bob Feuerbach demonstrated the highest velocity.

The effect of anabolic steroid upon skeletal muscle contractile force

GIDEON ARIEL, *Ph.D.*

(from the Department of Exercise Science, University of Massachusetts,
Amherst, Massachusetts, U.S.A.)

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Amherst, Massachusetts, U.S.A.)

The effect of anabolic steroid upon skeletal muscle contractile force

The work of Kochakian and Murlin [5] provides the basis for the use of anabolic steroids. The pharmacological properties of these steroids has proved of clinical value in the treatment of conditions where protein synthesis and reduced nitrogen loss is desired. Their use has been extended by "power event" athletes who have attempted to develop increased muscular contractile force. The use of anabolic steroids for this purpose is reported to be wide spread.

Johnson and O'Shea [4] found that strength, body weight, oxygen uptake and blood nitrogen retention were significantly increased when healthy subjects were administered an anabolic steroid. Fowler [3] reported no effects of steroids on strength. Casner, Early and Carlson [2] reported no significant strength increase due to steroid treatment. Ariel [1] found psychological enhancement of human performance by administration of placebos as anabolic steroids.

This supported study investigates the effect of the anabolic steroid (17-beta-hydroxy-17alfa-methyl-androsta-1,4-diene-3-one) upon the skeletal muscle contractile force.

METHOD AND MATERIALS

Six male varsity athletes were used. All six volunteers had experienced two years of weight training, five days a week. For a period of four months prior to the beginning of the test procedures all the subjects lifted for five days and were tested on the seventh day in the bench, military and seated presses and a squat. A standard warm up procedure was performed and each test was a maximal lift. The experiment was conducted during a subsequent eight week period. On the second, third, and fourth weeks of the study all the subjects were given placebo pills daily and informed they contained 10 mg. of 17beta-hydroxy-17alfa-methyl-androsta-1,4-diene-3-one, an oral anabolic steroid. From the fourth to the eighth week a double blind technique was used. Three of the subjects received 10 mg. of the oral anabolic steroid (17beta-hydroxy-17alfa-methyl-androsta-1,4-diene-3-one) and the remaining three subjects continued to receive the placebo. The oral anaoblic steroid and the placebo were assigned to the subjects by code, by the University Health Service and the investigator was not informed which subject received the steroid until after the eight weeks testing period.

Regression analysis was utilized to investigate the effect of the anabolic steroid

Effect of anabolic steroids on reflex components

GIDEON ARIEL AND WILLIAM SAVILLE

Department of Exercise Science, University of Massachusetts, Amherst, Massachusetts 01002

ARIEL, GIDEON, AND WILLIAM SAVILLE. *Effect of anabolic steroids on reflex components.* J. Appl. Physiol. 32(6): 795–797. 1972.—The purpose of this study was to investigate the effect of anabolic steroid on the nervous system by measuring the various reflex components of the knee jerk reflex. A double-blind technique was used to examine the effect of methandrostenolone (Dianabol) on the knee reflex of six male subjects. The anabolic steroid had a significant effect upon these reflex components. Significantly faster motor times and significantly slower latencies were obtained. From these results it can be concluded that the anabolic steroid acted upon the central nervous system and the biochemical processes involved in the reflex.

methandrostenolone; latencies; motor times; total reflex times

THE WORK OF KOCHAKIAN AND MURLIN (3) provides the basis for the use of anabolic steroids. The pharmacological properties of these steroids has proved of clinical value in the treatment of conditions where protein synthesis and reduced nitrogen loss is desired. Their use has been extended by "power event" athletes who have attempted to develop increased muscular contractile force. The use of anabolic steroids for this purpose is reported to be widespread.

The effects of anabolic steroids upon the nervous system are still unclear. The purpose of this study was to investigate the effect of anabolic steroid (methandrostenolone) on the nervous system by measuring the knee jerk reflex. This reflex arc which is initiated by striking the ligamentum patella has been subdivided into three components, the reflex latency, the motor time, and the total reflex time. The latency and the motor time components of the total reflex time are derived from the nomenclature of Weiss (6) who named the premotor time and motor time components of total reaction time. In general, the subdivisions used by Weiss (6) and Botwinick and Thompson (2), to fractionate reaction time, were used in the present study to fractionate reflex time. Therefore, the reflex latency is the time from mechanical stimulation of the ligamentum patella to the appearance of an action potential at the motor point of the rectus femoris muscle. The motor time is the period from the appearance of an action potential at the motor point to the mechanical movement of the leg by the muscle. The total reflex time is from the mechanical stimulation of the tendon to the mechanical movement of the leg. Kroll (4) has postulated the relative independence of these components. This independence suggests different mechanisms.

The effect of anabolic steroids on the afferent-efferent nervous pathways and their effect upon the electrobiochemical exchange period was examined. The time taken for the conduction of the nervous impulse from the receptor site back to the muscle motor point, via the ventral horn cells, and the time for the conversion of this electrical phenomenon into a chemically mediated response of the muscle were measured. Changes in the neurological component and the linking of this component with the biochemical processes of contraction in the muscle should supplement the established literature that has already shown consistent changes in the biochemical parameters.

METHODS

Six male university students, aged 18–22 years, served as subjects in this study. Their height averaged 182 cm with a mean weight of 97 kg. The experiment was conducted during an 8-week period. To minimize the effect of diurnal variation, testing was conducted between 8 PM and 10 PM.

Testing was conducted weekly on 2 successive days. All the subjects were varsity athletes who had experienced 2 years of weight training. For a period of 4 months prior to the beginning of the test procedures all the subjects lifted for 5 days and were tested on the 6th and 7th days. This procedure was followed for the 8-week study period. On the 2nd, 3rd, and 4th weeks of the study all the subjects were given placebo pills daily and informed they contained 10 mg of Dianabol (methandrostenolone), an oral anabolic steroid. From the 4th to the 8th weeks a double-blind technique was used. Three of the subjects received 10 mg of the oral anabolic steroid and the remaining three subjects continued to receive the placebo. The oral anabolic steroid and the placebo were assigned to the subjects by code by the University Health Service and the investigators were not informed which subject received the steroid until after the 8-week testing period.

Total patellar reflex time and reflex latency were obtained on the right limb. A Lafayette knee reflex apparatus was used. An adjustable hammer was used to deliver a strike to the ligamentum patella. The hammer was released at 60 degrees. The heel of the subject was held relaxed against a plate depressing a microswitch. The recording was started when the microswitch in the hammer was activated by the strike. The microswitch closed the circuit, causing an electric Hunter clock counter to start when contact was made by the hammer head with the ligamentum patella. As soon as the reflex arc was completed, a mechanical movement of the limb caused the subject's heel to raise the heel plate which again opened the circuit and stopped the electric clock. The time elapsed is the total reflex time.

The subject was seated on a specially constructed knee reflex apparatus. A movable backrest was adjusted until
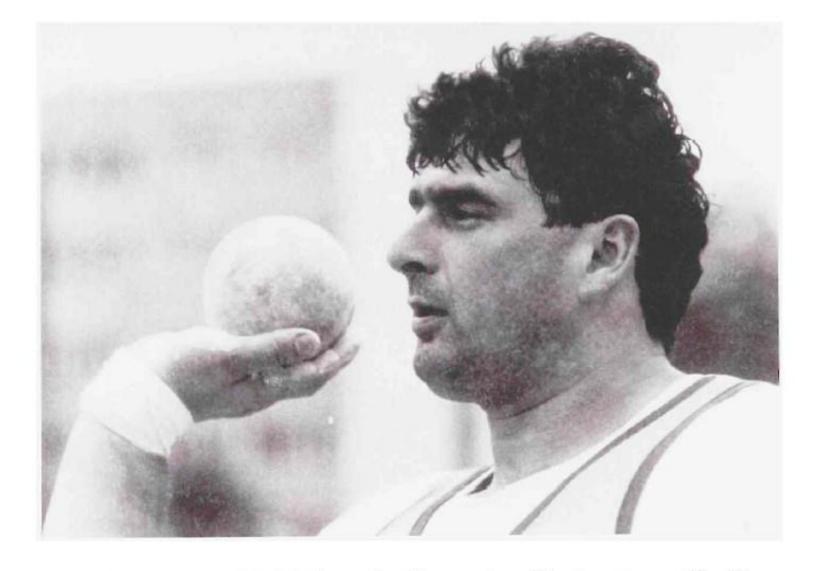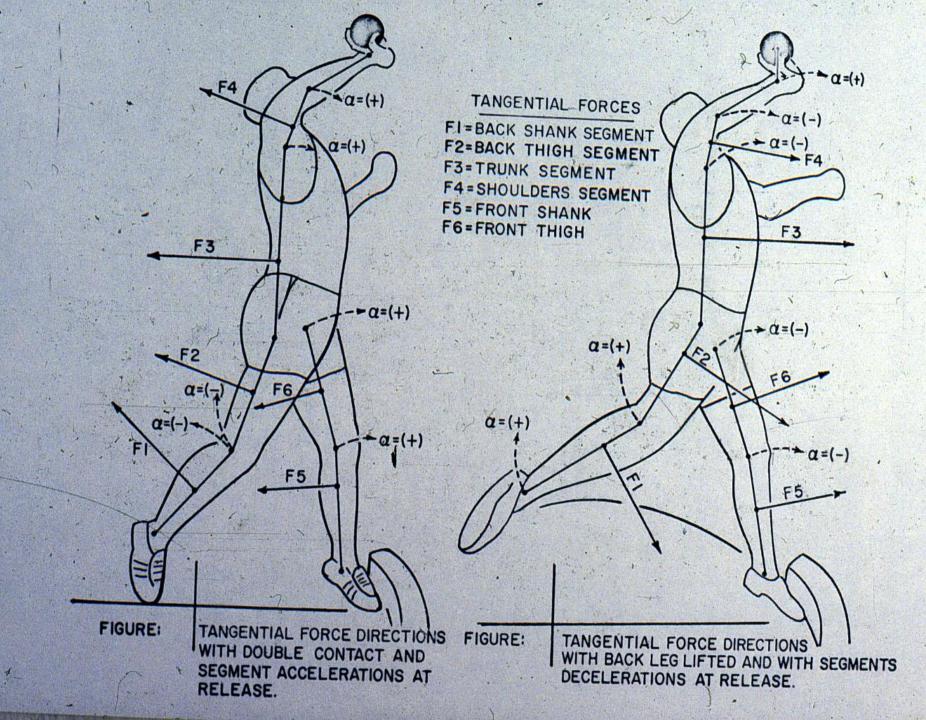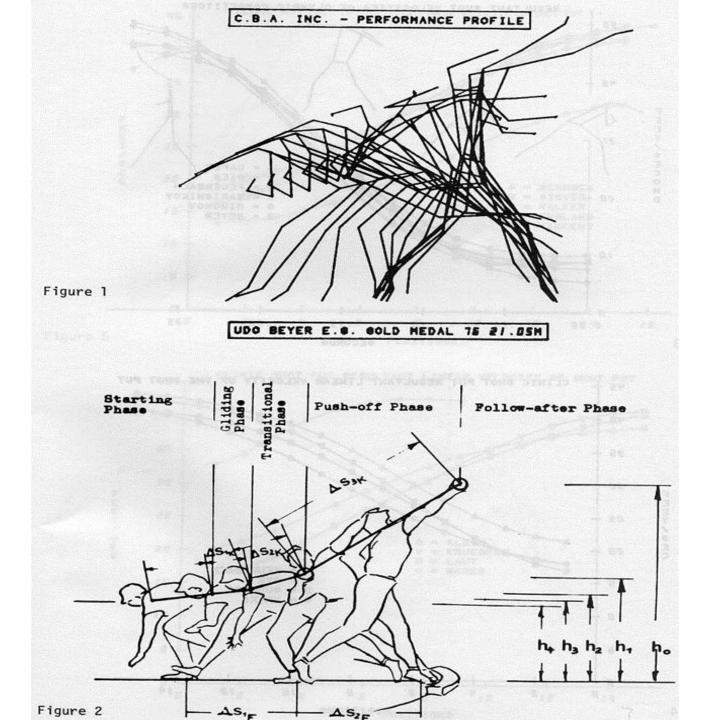
Figure 23: Udo Beyer, 1976 Olympic Champion Shotputter at the European Championship Qualifications for GDR track and field athletes in Neubrandenburg, 1986. Bundesarchiv Koblenz, Bild 1986/0608/24.

TANGENTIAL FORCES

F1 = BACK SHANK SEGMENT
F2 = BACK THIGH SEGMENT
F3 = TRUNK SEGMENT
F4 = SHOULDERS SEGMENT
F5 = FRONT SHANK
F6 = FRONT THIGH

FIGURE: TANGENTIAL FORCE DIRECTIONS WITH DOUBLE CONTACT AND SEGMENT ACCELERATIONS AT RELEASE.

FIGURE: TANGENTIAL FORCE DIRECTIONS WITH BACK LEG LIFTED AND WITH SEGMENTS DECELERATIONS AT RELEASE.

Figure 1

C.B.A. INC. - PERFORMANCE PROFILE

UDO BEYER E.G. GOLD MEDAL 76 21.05M

Figure 2

Starting Phase | Gliding Phase | Transitional Phase | Push-off Phase | Follow-after Phase

East Germany At The Olympics

This page contains a list of images, photos, wallpapers, illustrations about **east germany at the olympics**. We also provide some recomendation so you can surf the internet faster and fun. Make sure to visit the pages that related to east germany at the olympics:

Aaliyah | Acne | Black Rice | Cate Blanchett | Cheryl Hines | Colondra Hamilton | Cosmetics

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ALL PHOTOS WALLPAPERS ICON ILLUSTRATIONS

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The gender trap:
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East German shotputter
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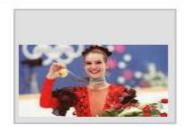
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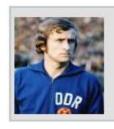
Woman Olympic

German Football
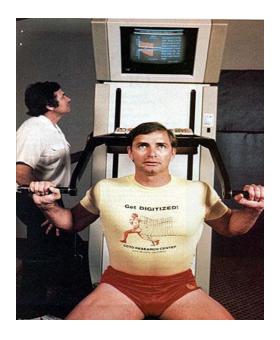
YouRememberThat

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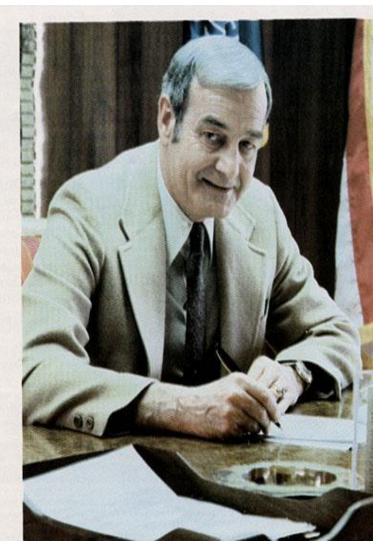
Bill, Al and Russ

Dr. Dardik

UNITED · STATES · OLYMPIC COMMITTEE

USOC Executive Director F. Don Miller is the man in charge at Olympic House in Colorado Springs, and a driving force in the amazing progress of the USOC in recent years. The former collegiate boxer at the University of Wisconsin and longtime U.S. Army officer has had a lifetime of involvement in amateur sports and the Olympic movement.

The ATHLETE of the FUTURE

How Sports Scientists Are Harnessing the Mechanics of Motion, the Chemistry of Strength and the Power of the Mind

BY PATRICIA LOVEROCK
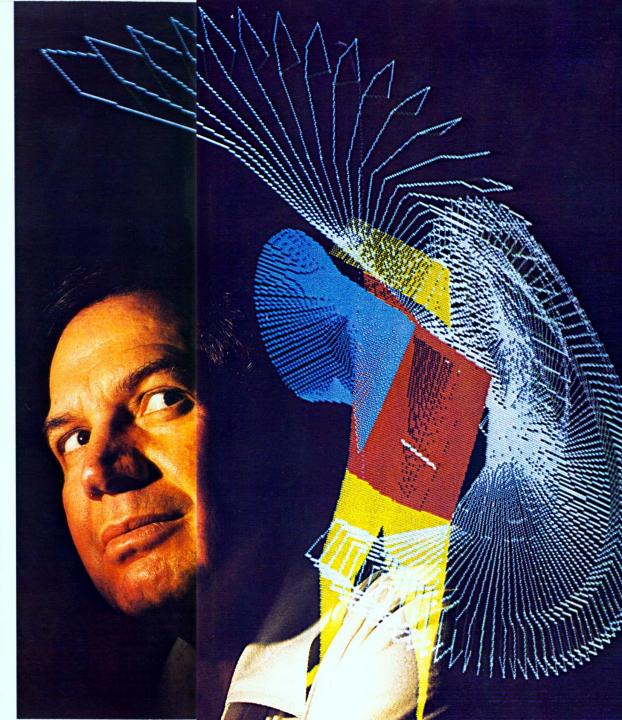
A RESEARCH SUBJECT NAMED Orel Hershiser appears on a movie screen in an Inglewood laboratory. Hershiser is pitching the ball for the sake of science, so rather than Dodger Blue he wears only a baseball glove, shorts, socks, shoes and an array of electrodes and wires. As he throws, the upper body that looks slightly skinny on the mound is remarkably muscular and fluid. He uncoils and explodes across the screen in slow motion—frame by frame—hands, wrists, arms, trunk, hips and legs flowing together in perfect synchronization as he winds up and lets the baseball go.

Three 16-millimeter movie cameras are filming front, side and overhead views of the pitch at 500 frames per second. On an 8-foot-high console, 2,000-foot reels of ¼-inch magnetic tape record microprocessed signals from every twitch of Hershiser's muscles. An oscilloscope's electrical wave traces his muscular activity, and a printer simultaneously spews out a copy of the image

Gideon Ariel, right, has developed computer models, such as this one of a tennis player, to aid in sports training.

Photographed by Brian Smale

ROBERT J. KANE
President

VIII PAN AMERICAN GAMES, San Juan, Puerto Rico, August 4-18, 1979
XIII OLYMPIC WINTER GAMES, Lake Placid, U.S.A., February 13-24, 1980
GAMES OF THE XXII OLYMPIAD, Moscow, U.S.S.R., July 19-August 3, 1980

January 3, 1978

Dr. Gideon Ariel
316 College Street
Amhurst, Massachusettes 01002

Dear Dr. Ariel:

This is in reference to appointments of the United States Olympic Sports Medicine Committee for the 1977 - 1980 Quadrennial. After consulting with Irving Dardik, M.D., Chairman of the Sports Medicine Committee, I will recommend to the United States Olympic Committee Executive Board your appointment to this Committee.

While your appointment cannot be ratified until the next USOC Executive Board meeting, due to the importance of the functions of this committee, I am authorizing that it commence its initial planning as expeditiously as possible.

Careful consideration was given to issuing appointments to elected representatives of recognized sports medicine and scientific organizations. It was determined that due to the number of organizations involved, the committee would become unweildy should appointments be made in this manner. Therefore, uniquely capable individuals who are affiliated with organizations that have demonstrated an interest in developing a Sports Medicine Program for the amatuer athletes of the United States were selected to this committee.
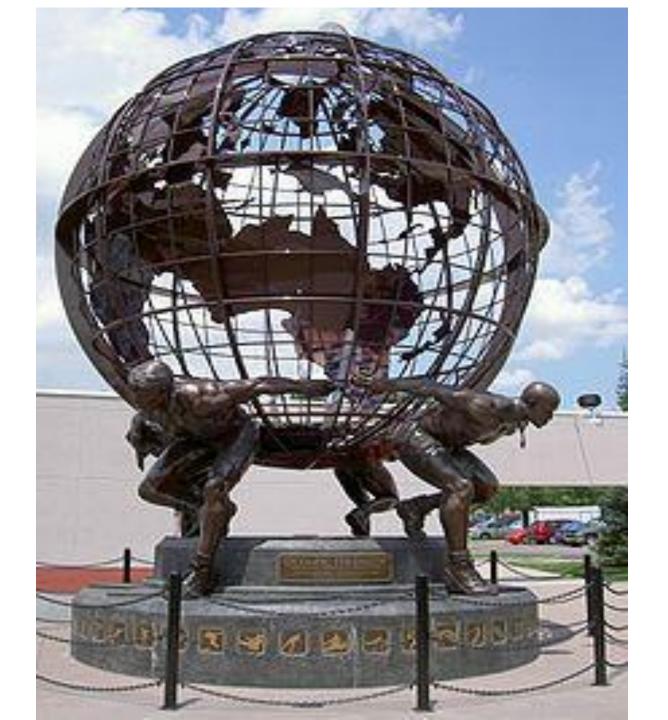
Provision has been made in organizational structure of the USOC Sports Medicine Program for participation of sports medical and scientific organization in this most important national effort. The USOC solicitis this support should any organization desire to participate.

Members of the Sports Medicine Committee can expect to meet approximately three times a year. The initial meeting will be held January 27, 1978 at Squaw Valley. Enclosed for your use is a form indicating acceptance of this appointment. Please return this form no later than January 9, 1978.

Enclosed for your information is the USOC Sports Medicine Organizational Chart and a list of recommended appointments to the committee. Should you have any questions, please feel free to contact me.

Sincerely,

ROBERT J. KANE

RJK:1r
Encls.

Rocco Petitto running the Biomechanical Lab at Colorado Springs
with the Data General Computer the Eclipse S/250

SCIENCE&VIE

Un vaccin pour choisir le sexe de son enfant — Le match des calculettes (suite) — Les premières photocopieuses en couleurs

DES SUPER-CHAMPIONS ENTRAINÉS PAR ORDINATEUR

LA MANIPULATION PSYCHOLOGIQUE CLANDESTINE

FORSCHUNG

Die Methode heißt "Computerized Biomechanical Analysis" und heraus kommen dabei Strichmännchen. Doch Dr. Gideon Ariel (l.) ist überzeugt, daß damit für den Sport ein neues Zeitalter beginnt.

Connors aus dem Computer

EDV-Report

Computer einmal anders: Der Tennisstar und sein Großer Bruder

Tennisstar Jimmy Connors: Von Dr. Gideon Ariel (r.) zum Strichmännchen gemacht.

ELECTRONICS WEEKLY, October 24, 1979

Computer 'trains' team for Olympics

DR GIDEON ARIEL uses in his laboratory at Computerized Biomechanical Analysis Inc. at Amherst, Mass. where a Data General computer to analyse the tennis star, Jimmy Connors.
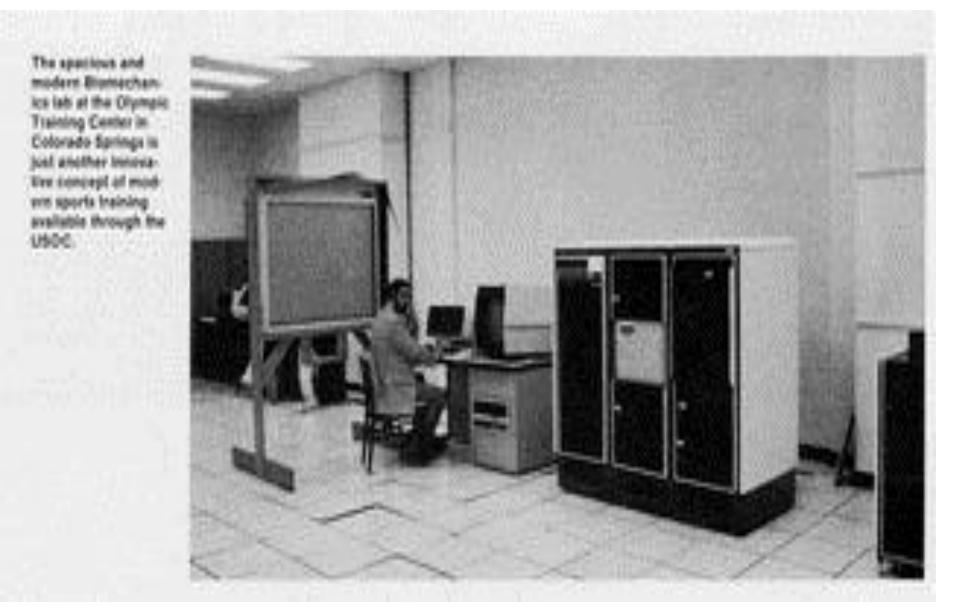

Une découverte U.S.

Les mouvements du corps analysés par ordinateur

FORUM INTERNATIONAL

Ergonomie
Un ordinateur pour mesurer le travail humain

NCC IN NEW YORK — Reports by Tim Palmer and Chris Hipwell

Huge opportunities for new companies

Muscling in on the athletes

COMPUTER WEEKLY, JUNE 21, 1979

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tonus

MÉDECINE
MÉDECINE SPORTIVE

Les Américains preparent les J.O. avec... un ordinateur

Tietokone avuksi olympia-valmennukseen

Tietokone avuksi olympia-valmennukseen

L'informatique au service des sports

Kanon-serve på data

OS-medaljer med datorn

Handelsblatt

Freitag/Samstag, 16/17 NOVEMBER 1979

Höher und weiter mit dem "großen Bruder"?

COMPUTERWOCHE
Aktuelle Wochenzeitung für die Computerwelt

Mini analysiert Bewegungsablauf bei Sportlern

Dr. Gideon Ariel:
Der Weg zum vollkommenen Sportler

DIE COMPUTER ZEITUNG

LA SCIENZA IN AIUTO DELLO SPORT:
AVREMO L'ATLETA PERFETTO

LA MACCHINA DEI CAMPIONI

---

aqua magazine

BERGSLAGSPOSTEN STOCKHOLM
OKTOBER 17, 1979

Nya världsrekord — med data-hjälp

ELDBORG med Aktuell Elektronik

Connors slår Borg — med datorns hjälp

Bättre idrottsresultat med hjälp av datorer

MAN BEHIND THE
The Computer of the U.S. Olympic Sports Medicine Committee

PERSON TO PERSON

SC: *How did you get involved in the field of computerized biomechanical analysis?*

ARIEL: I was born in Israel and competed in two Olympics (1960 and 1964) as a discus thrower. I came to the U.S. on an athletic scholarship to the U. of Wyoming. After graduating with honors, I moved to the U. of Massachusetts for my M.D. and PhD in exercise science. I then jumped into the PhD program in computer science. I was teaching in the computer science dept. when I decided to start my own company—the Coto Research Center in California. It is a co-venture with Penn Central. Our $5-million complex in Coto de Caza is probably the most sophisticated sports research center in the world.

SC: *What specific projects are you working on at the moment?*

ARIEL: We're working with the U. S. Olympic Committee in analyzing our top athletes in the throwing events and we have a permanent training center for the women's Olympic volleyball team. We're also working on various designs

and inventions such as tennis rackets and shoes.

SC: *You have said that your theories are based on Newtonian physics. Could you elaborate a little on that?*

ARIEL: Anything that moves obviously has to observe Newtonian physics, which means force equals mass times acceleration. That's basic, something you learn in high school. Now, when athletes try to throw a baseball faster or kick a soccer ball harder, they have to obey the same principle because basically they're trying to overcome gravity and create inertial forces in their body systems.

To do that, they need internal mechanisms—muscles and other physiological aspects. Say an athlete wants to throw a javelin farther. The javelin had better leave his hand at a certain velocity and a certain angle. We can calculate these velocities and angles and see which are the most efficient to get the most distance. That's the point—to get the most distance. They don't measure how beautiful you look, but how far you throw.

On the other hand, we are also working with gymnasts and other aesthetic athletes, such as divers and figure skaters. We want to quantify the feedback that the judge is looking for so that he will say the performance is 9.6 and not 9.2.
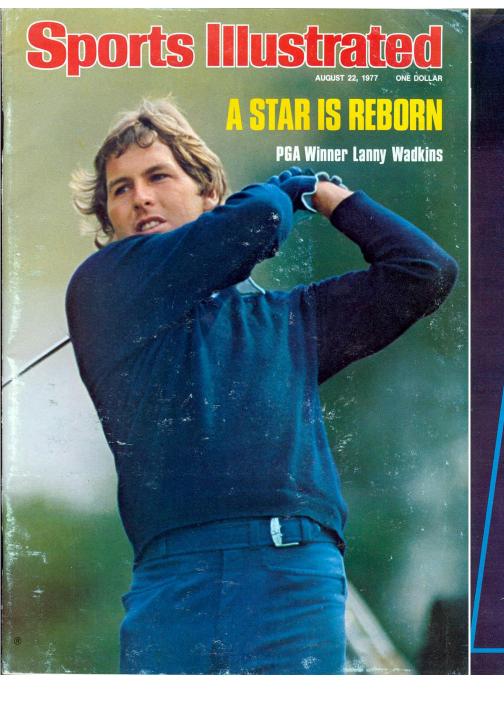
SC: *But how can a judge be that accurate?*

ARIEL: We try to define the factors that affect judgment. For example, in figure skating we found that the wobbling effect of the trunk is extremely important. In other words, the skater can go up and do a double axel, but if his trunk is wobbling a bit, he'll usually wind up with a low score. It's not so much how straight the leg is or how beautiful the fingers are in the air, it's mostly the massive parts of the body that are sending the message to the judges.

SC: *How about a non-gravity event, such as swimming?*

ARIEL: We try to measure what kind of interaction between the body surface and the water will produce the greatest propelling force. Sometimes it's not necessarily what makes sense. For example, it used to be thought that if you stretch

Gideon Ariel, the guru of computer science,

Sports Illustrated

AUGUST 22, 1977   ONE DOLLAR

A STAR IS REBORN

PGA Winner Lanny Wadkins

GIDEON ARIEL AND HIS MAGIC MACHINE

If you want to run
faster, throw farther or jump
higher, call on
this electronic mastermind,
who will photograph you in action,
digitize the moving parts of
your body and feed the data into
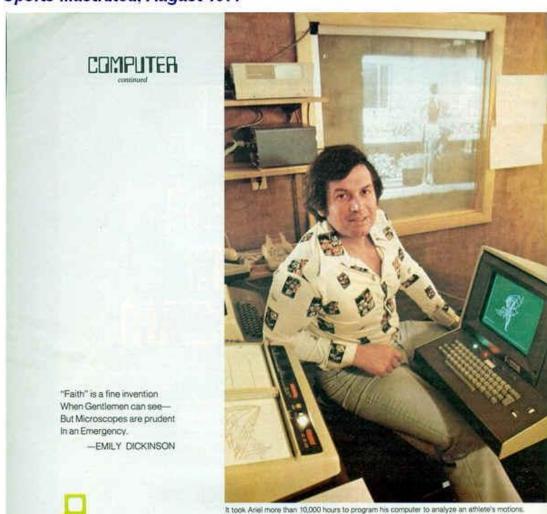a computer, which in turn will
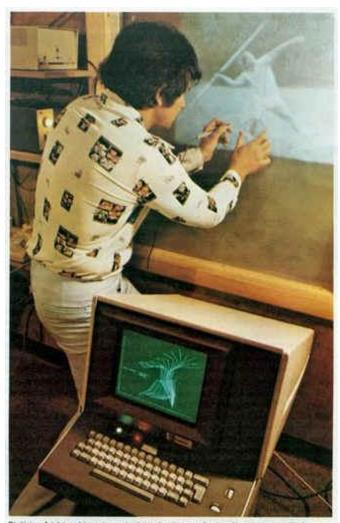spew out reams of athletic
advice no human
authority can provide

by **KENNY MOORE**

Rear Projection Digitizing

COMPUTER
continued

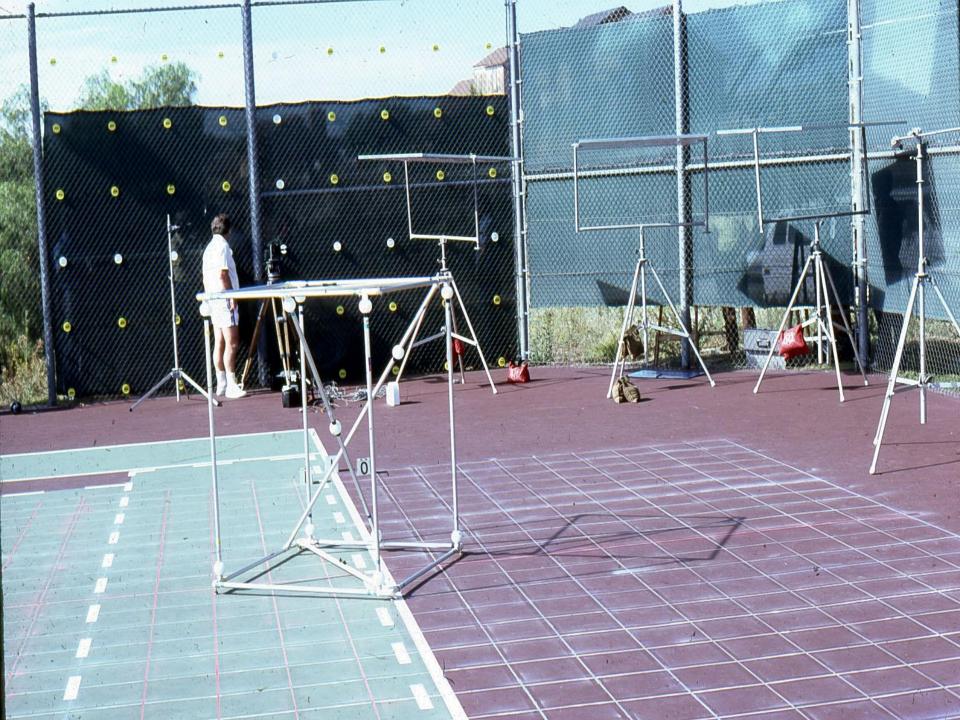"Faith" is a fine invention
When Gentlemen can see—
But Microscopes are prudent
In an Emergency.
—EMILY DICKINSON

It took Ariel more than 10,000 hours to program his computer to analyze an athlete's motions.

Digitizing, Ariel uses his sonic pen to determine the coordinates of javelin thrower Bill Schmidt.

○ Sports   ○ Instruments

Science Photo Library
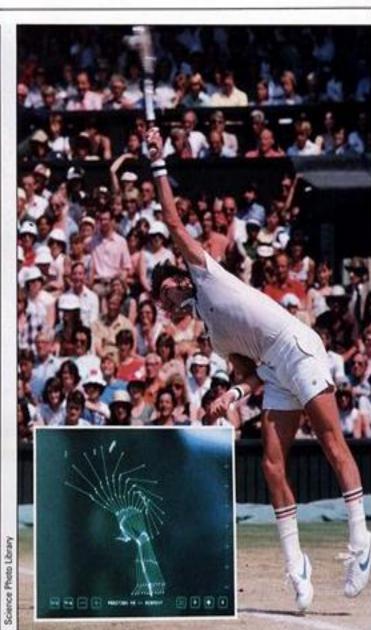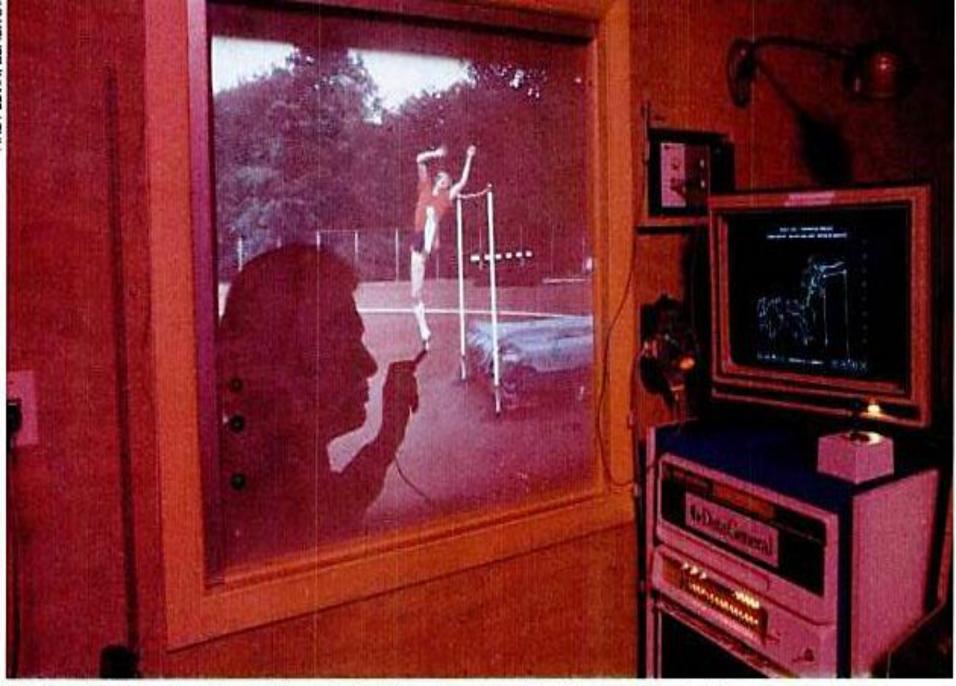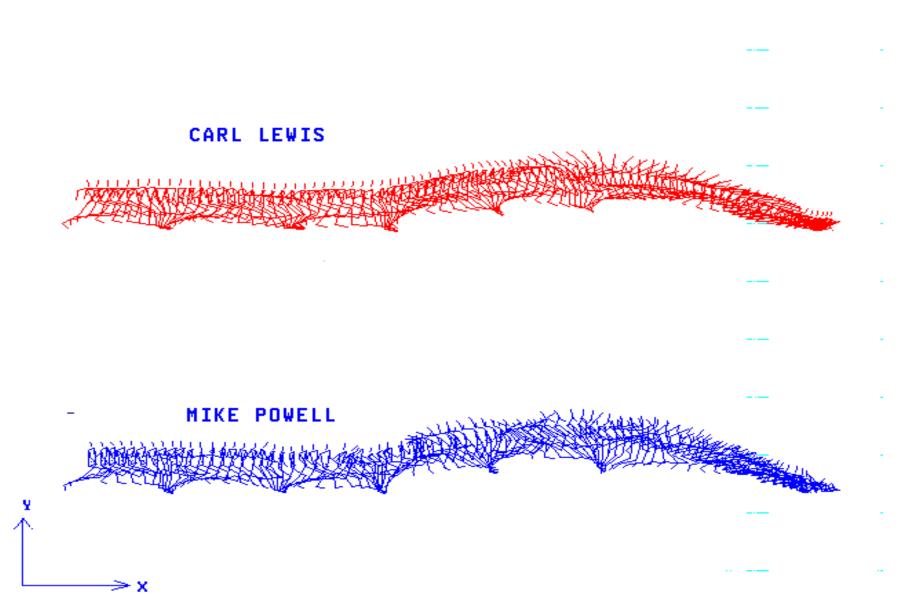
Digitizing a high jumper in action and then analyzing his weaknesses can help him soar to new heights.
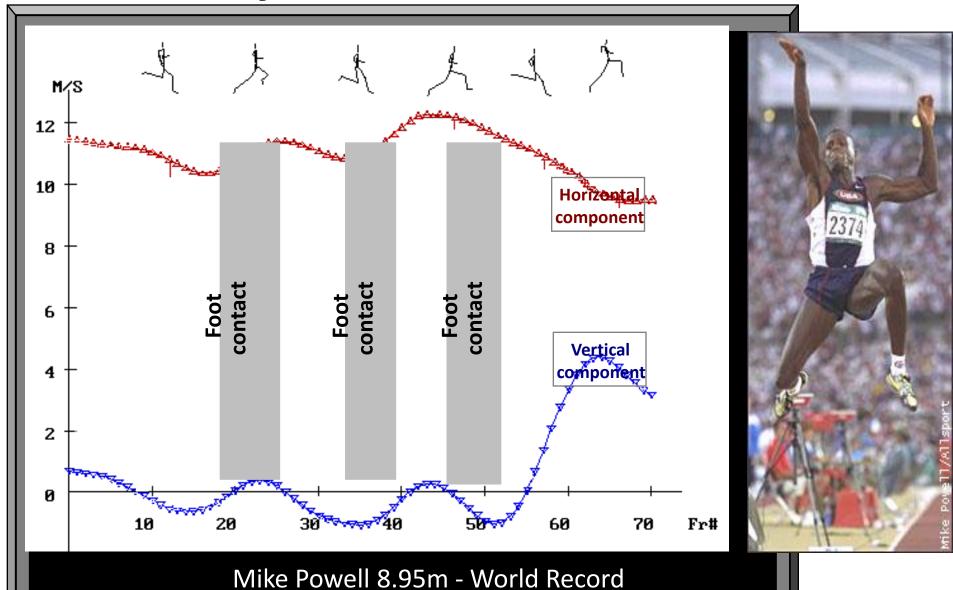
THE CASE OF THE LONG JUMP:
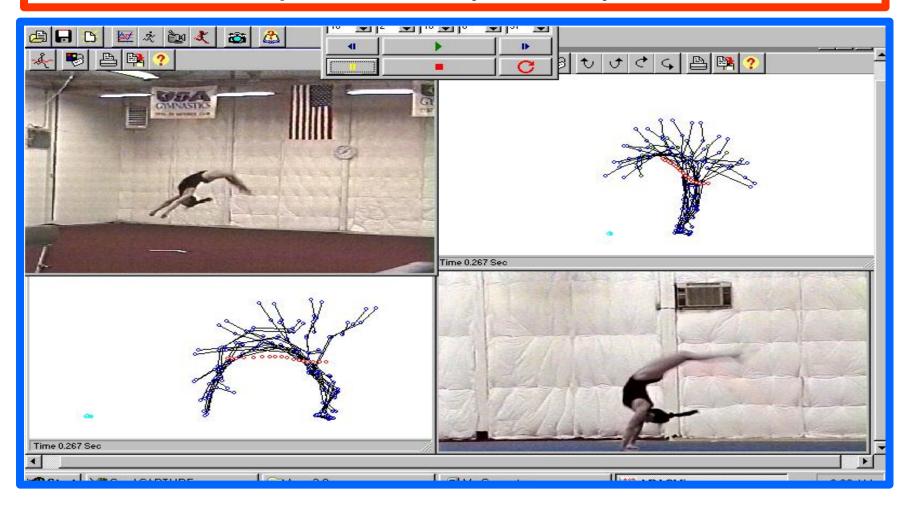
Velocity of the Center of Mass

Mike Powell 8.95m - World Record

Gymnastics Techniques Comparison of Backhand Spring & Flic-Flac Using Synchronized Views

Sync View--The synchronization function provides the capability of performing a comparative study of two separate trials or different movement techniques in a side – by- side analysis format.

Time 0.267 Sec

Time 0.267 Sec

Book of Abstracts

XVth Congress of the International Society of Biomechanics

ISB
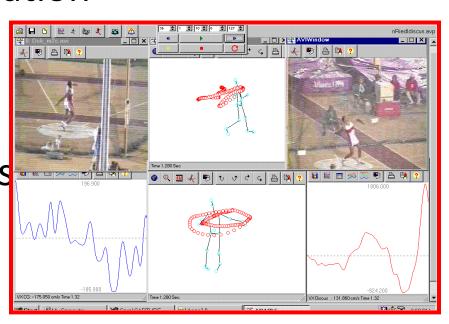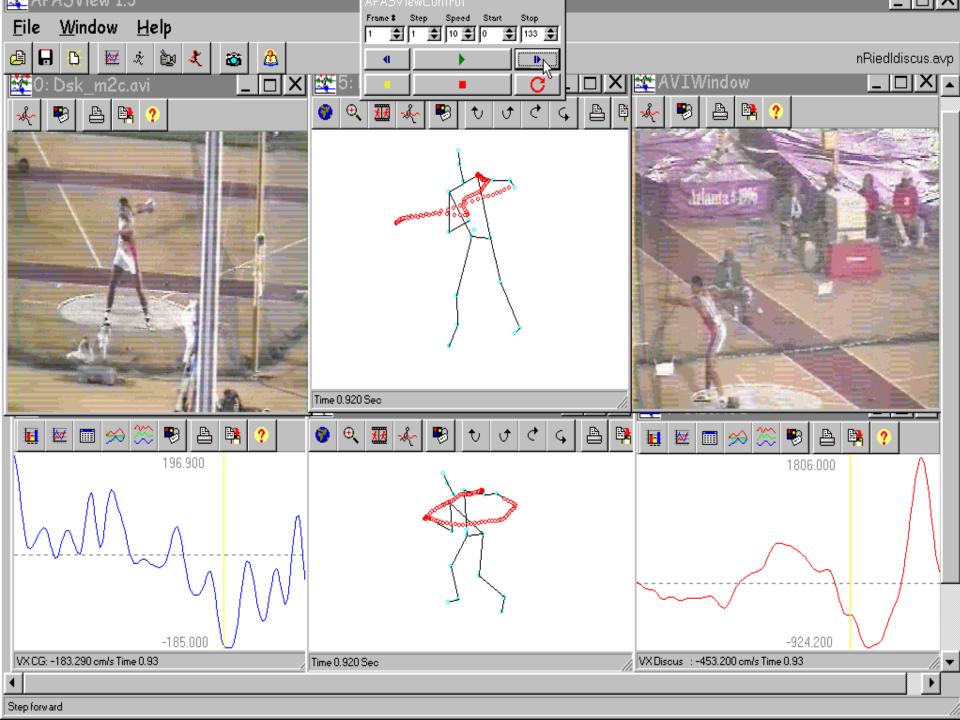
University of Jyväskylä
July 2 - 6, 1995
Jyväskylä, Finland

BIOMECHANICAL APPLICATIONS IN CYBERSPACE

Gideon B. Ariel and M. Ann Penny
University of California, Irvine
Trabuco Canyon, California USA

INTRODUCTION: The Internet provides access to a worldwide collection of information resources and services as a window on the ever-expanding world of on-line information. The new communication links afforded by rapid satellite/computer exchanges will enable the field of Biomechanics to advance into a new age of technology, resources, research, data base development, as well as interaction among scientists. Utilizing the tools available in Cyberspace, the Biomechanist can retrieve and display data as well as documents from virtually anywhere on the planet.

Software Integration

- Capturing   Digitizing
  - Locally
  - Net Digitizing
- Transformation
- Filtering
- Kinematic
- Kinetic Res

Video Capturing System

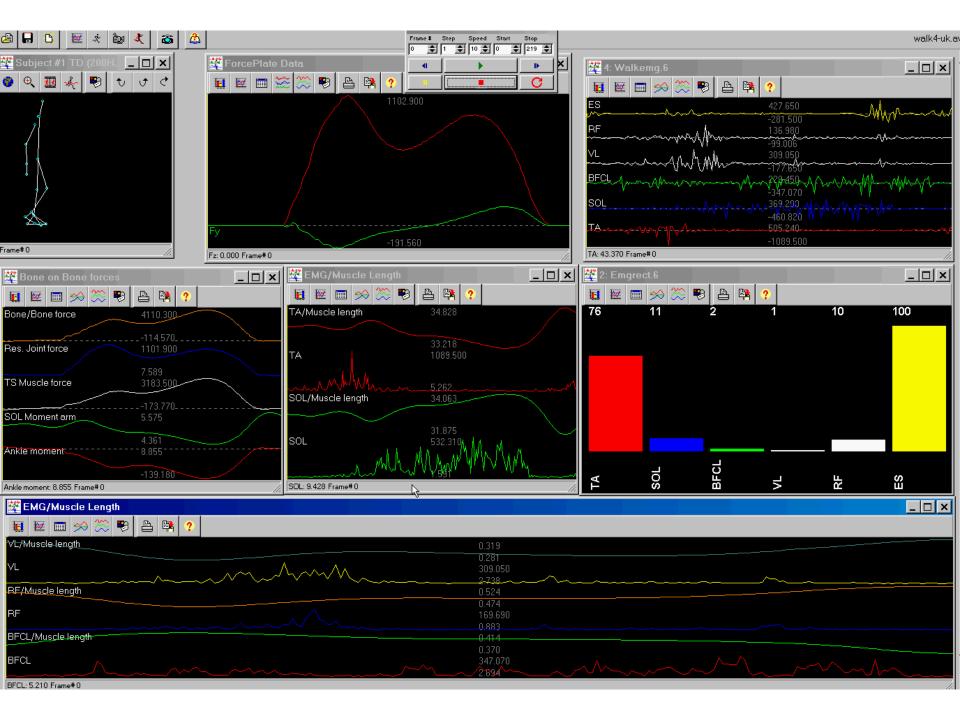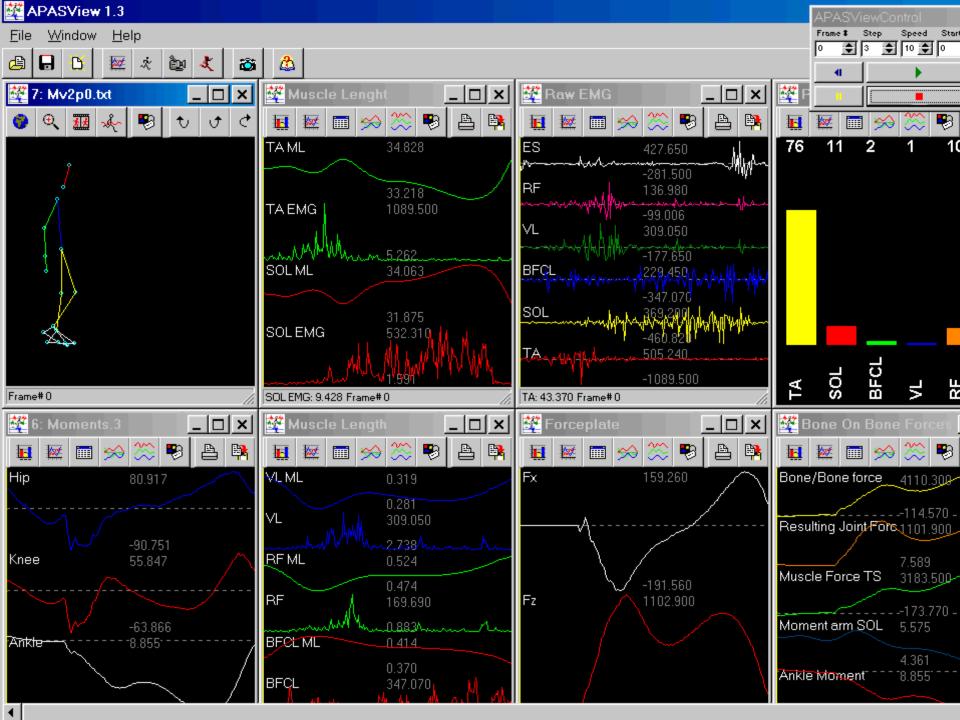# Portable performance analysis system:

Software Integration

APASView 1.3

File Window Help

7: Mv2p0.txt

Frame# 0

Muscle Lenght

TA ML	34.828
	33.218
TA EMG	1089.500
	5.262
SOL ML	34.063
	31.875
SOL EMG	532.310
	1.591

SOL EMG: 9.428 Frame# 0

Raw EMG

ES	427.650
	-281.500
RF	136.980
	-99.006
VL	309.050
	-177.650
BFCL	229.450
	-347.070
SOL	369.200
	-460.82
TA	505.240
	-1089.500

TA: 43.370 Frame# 0

76 11 2 1 10

TA SOL BFCL VL RF

6: Moments.3

Hip	80.917
	-90.751
Knee	55.847
	-63.866
Ankle	-8.855

Muscle Length

VL ML	0.319
	0.281
VL	309.050
	2.738
RF ML	0.524
	0.474
RF	169.690
	0.883
BFCL ML	0.414
	0.370
BFCL	347.070

Forceplate

Fx	159.260
	-191.560
Fz	1102.900

Bone On Bone Forces

Bone/Bone force	4110.300
	-114.570
Resulting Joint Force	1101.900
	7.589
Muscle Force TS	3183.500
	-173.770
Moment arm SOL	5.575
	4.361
Ankle Moment	8.855

Rendering – a better 3D view

www.arielnet.com

Rendering – a better 3D view

www.arielnet.com
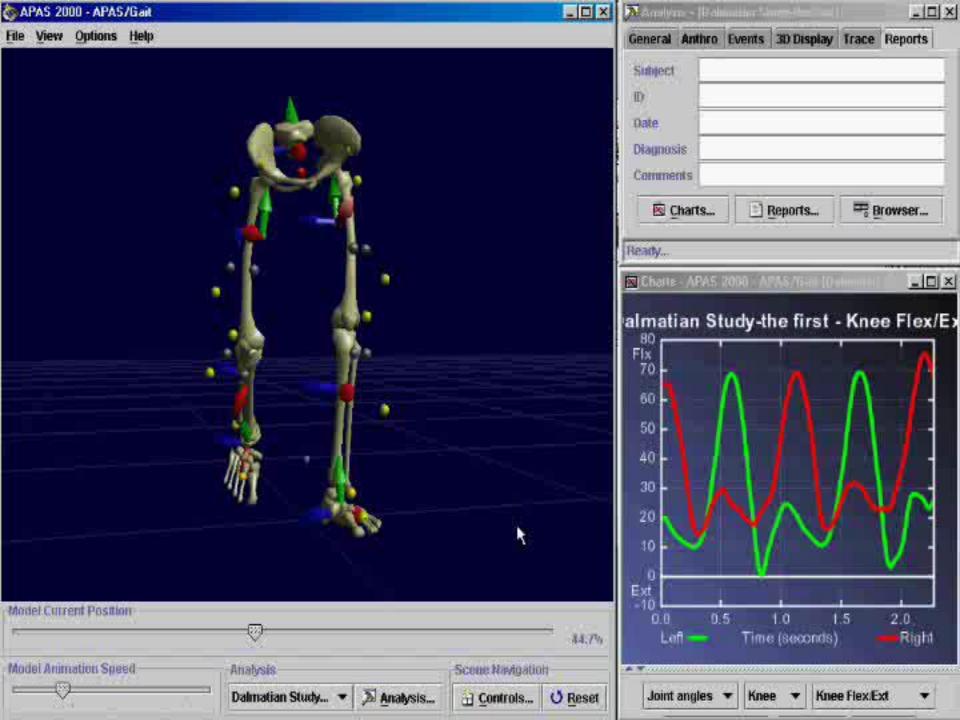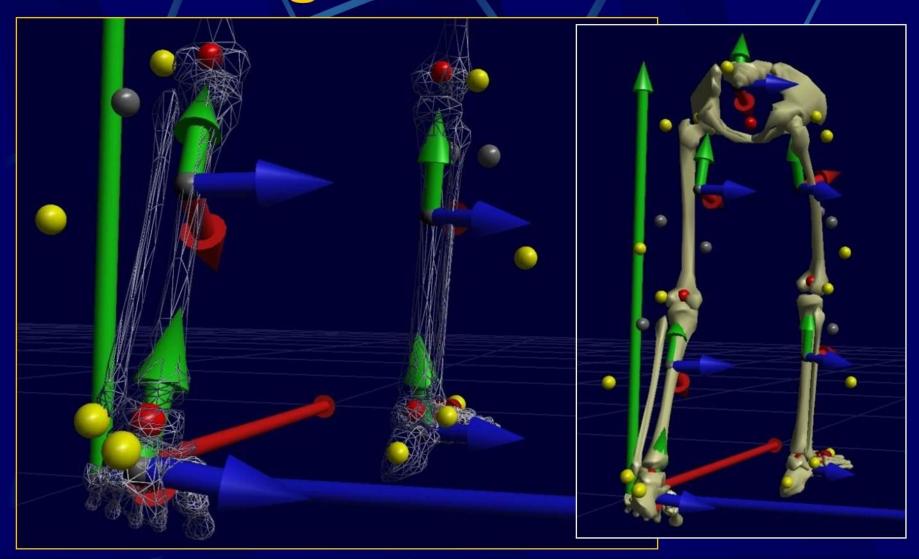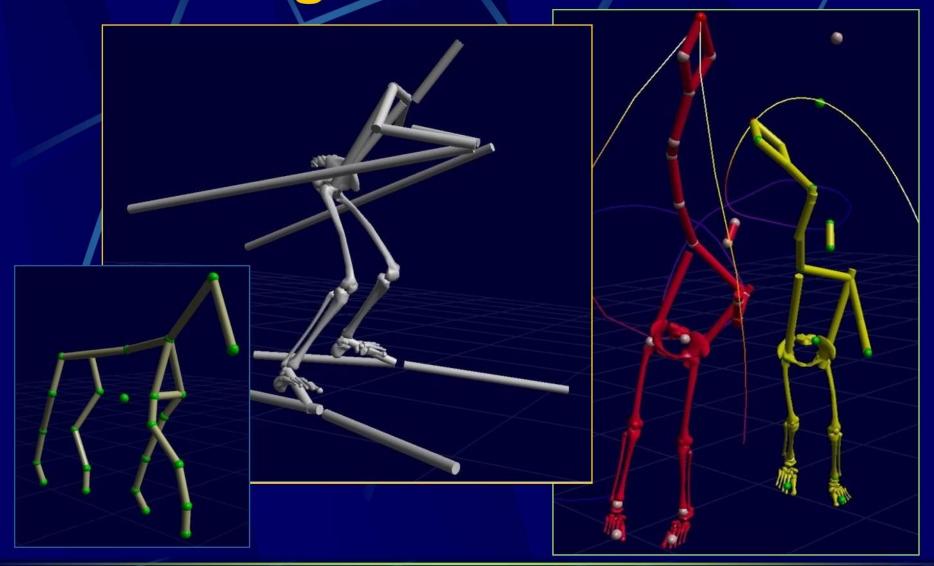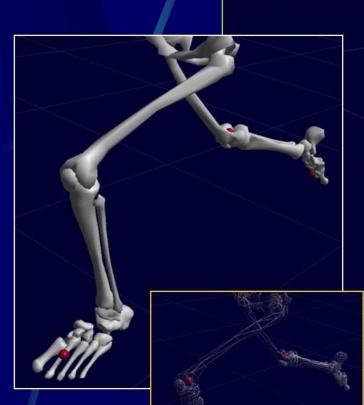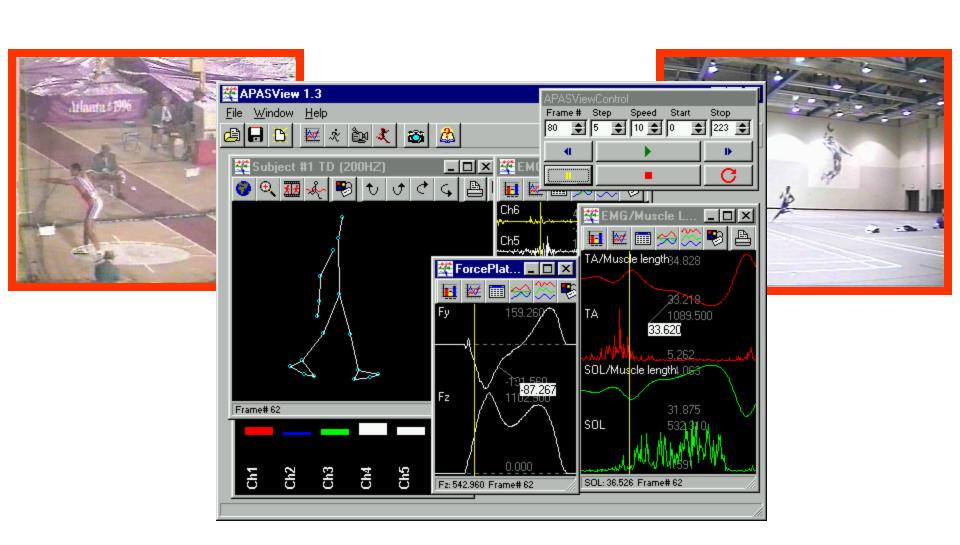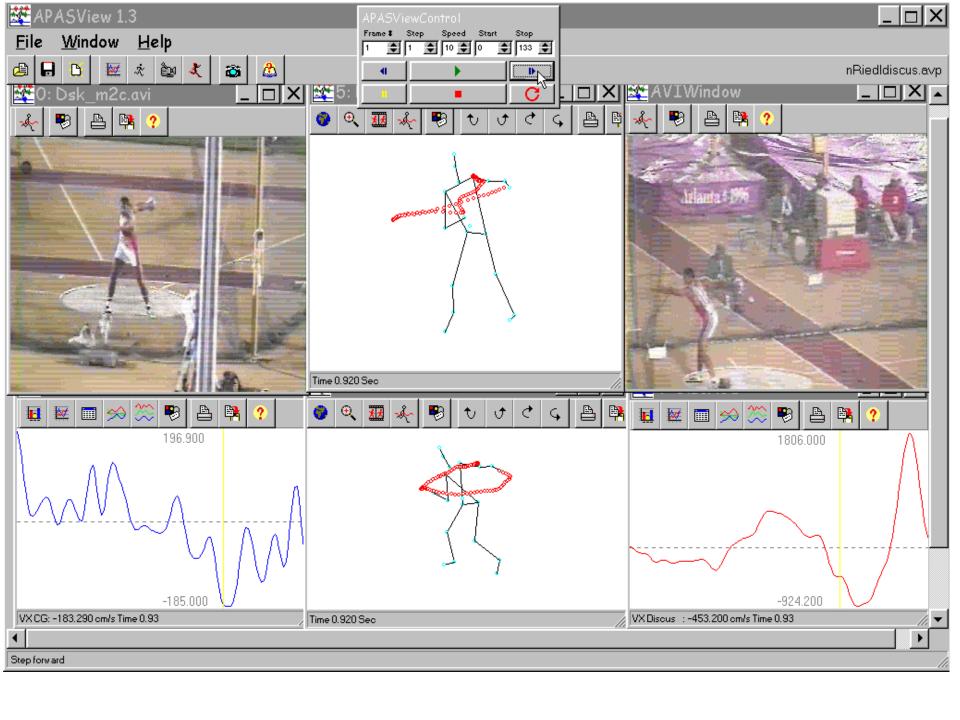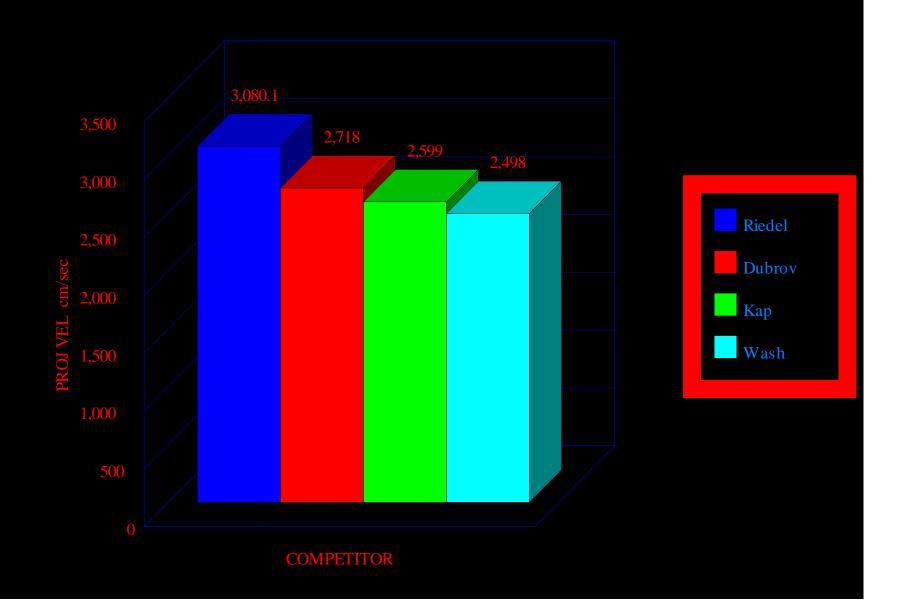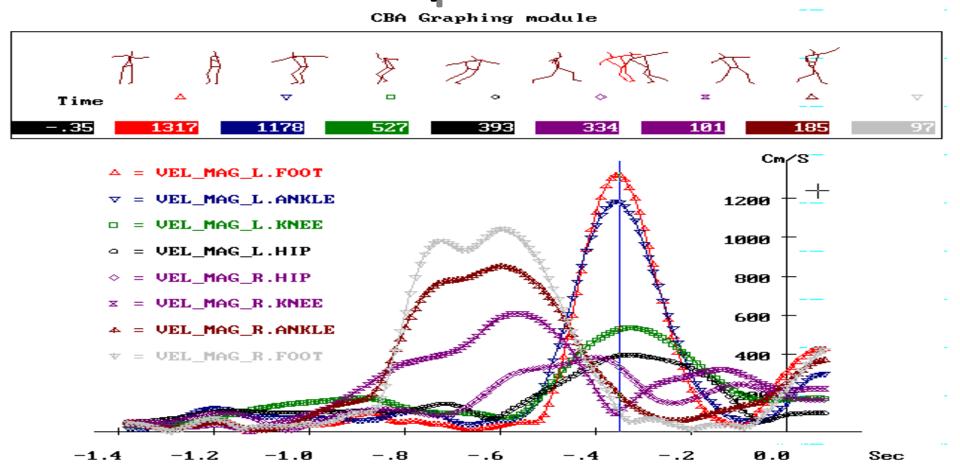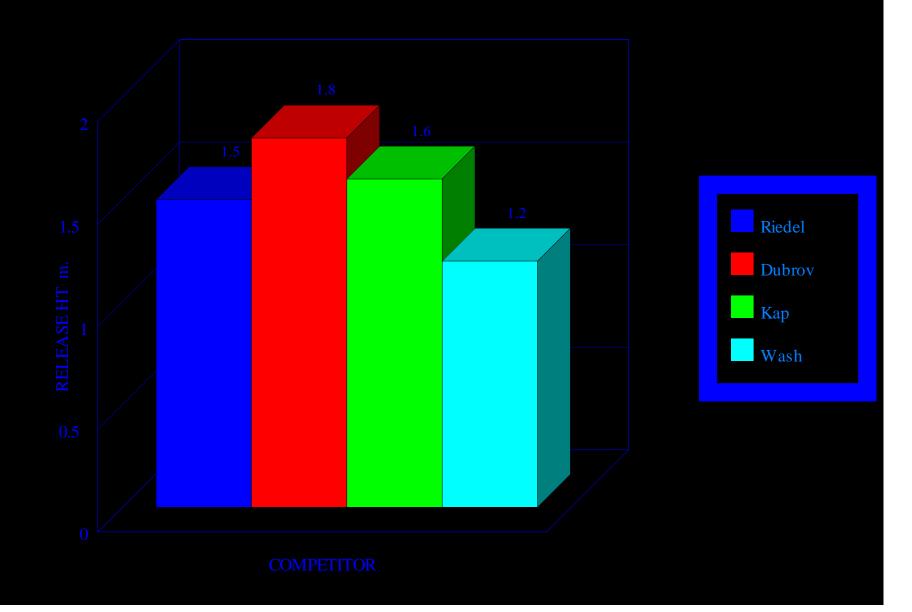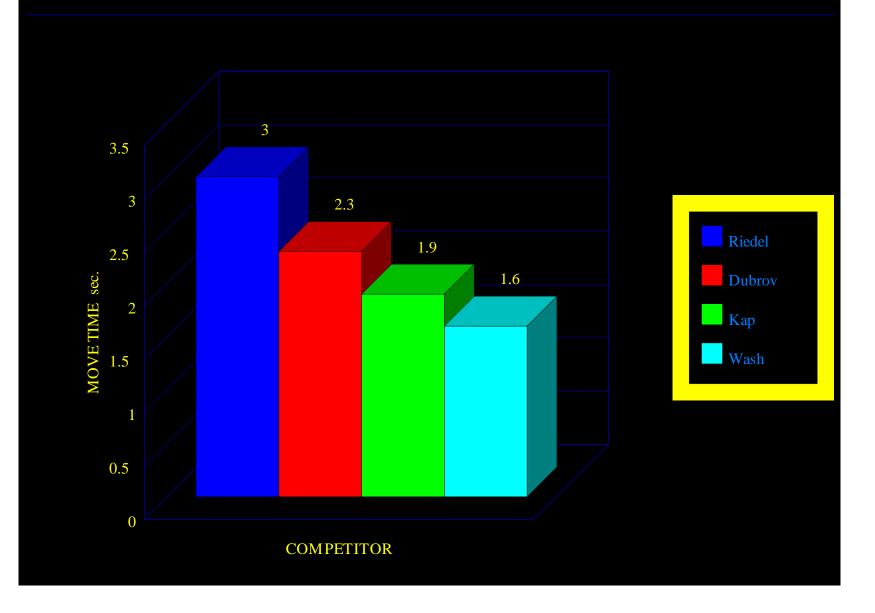
Calculating the Velocities of the lower limb revealed acceleration and deceleration patterns in a unique sequence
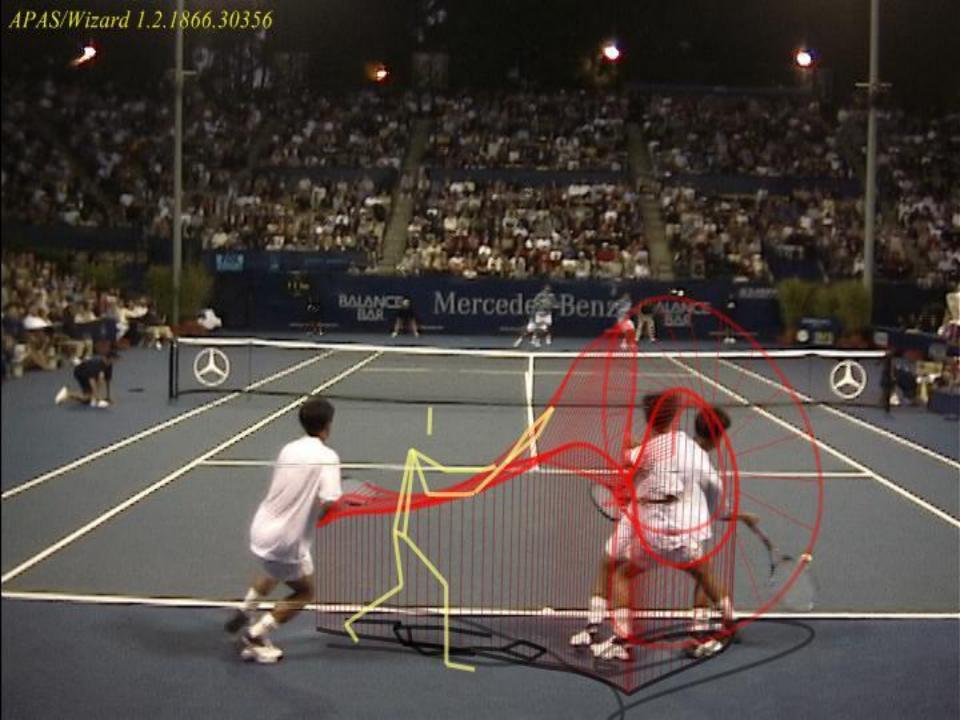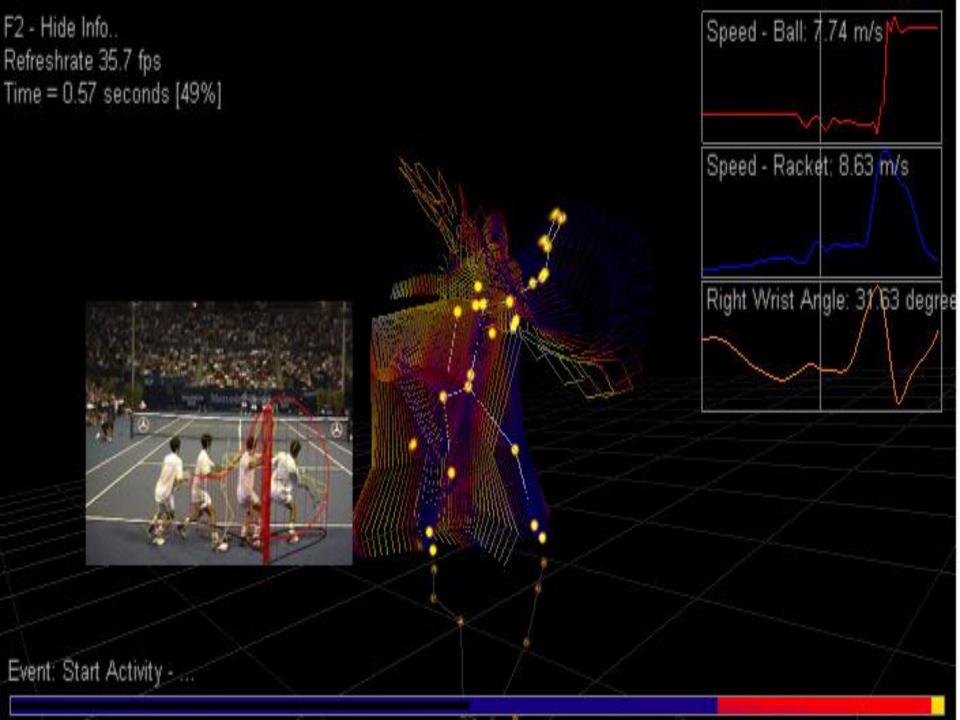
Throwing Kinematics for Top Four Discus Performers at 1996 Atlanta Olympics

Place Performer	Dist M	Vel Rel Cm/sec	Proj ang deg	Rel Ht	Mov T
1 Riedel (Ger)	69.4	3080.1	21.9	1.5	3.0
2 Dubrovschchik (Blr)	66.6	2718.5	29.1	1.8	2.3
3 Kaptyukh (Blr)	65.8	2599.0	37.3	1.6	1.9
4 Washington (USA)	65.4	2498.0	29.9	1.2	1.6

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

By

Gideon Ariel, Ann Penny, John Probe, Rudolf Buijs, Erik Simonsen Alfred Finch , and Larry Judge
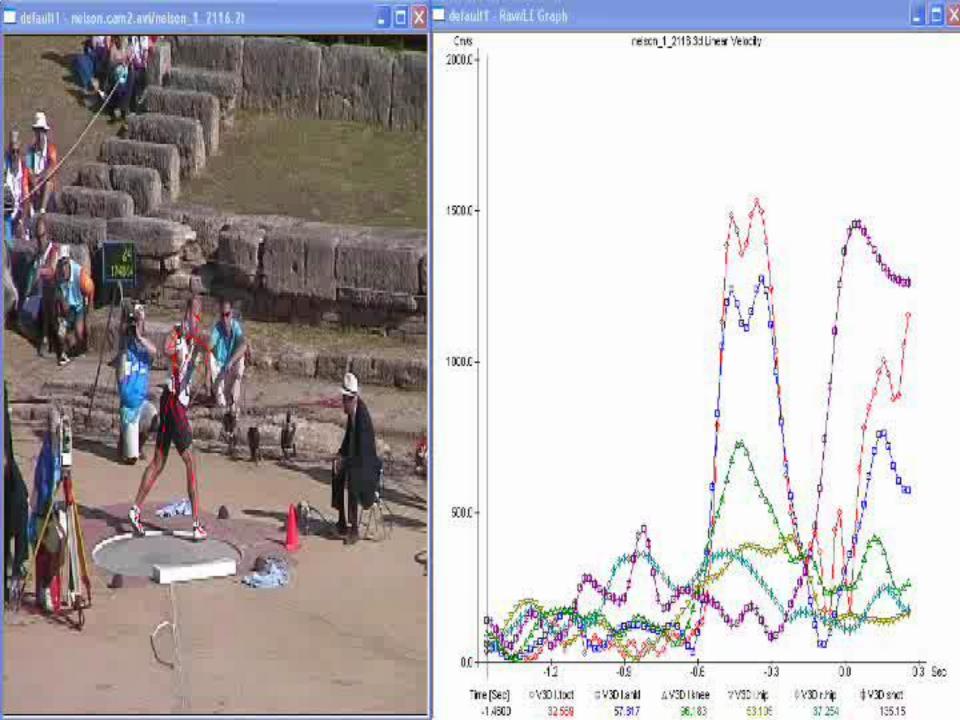
Capture videos using several cameras simultaneously and save the clips directly as AVI files to your hard disk. This allows you to connect multiple digital video cameras to your computer and to start capturing with one mouse click.
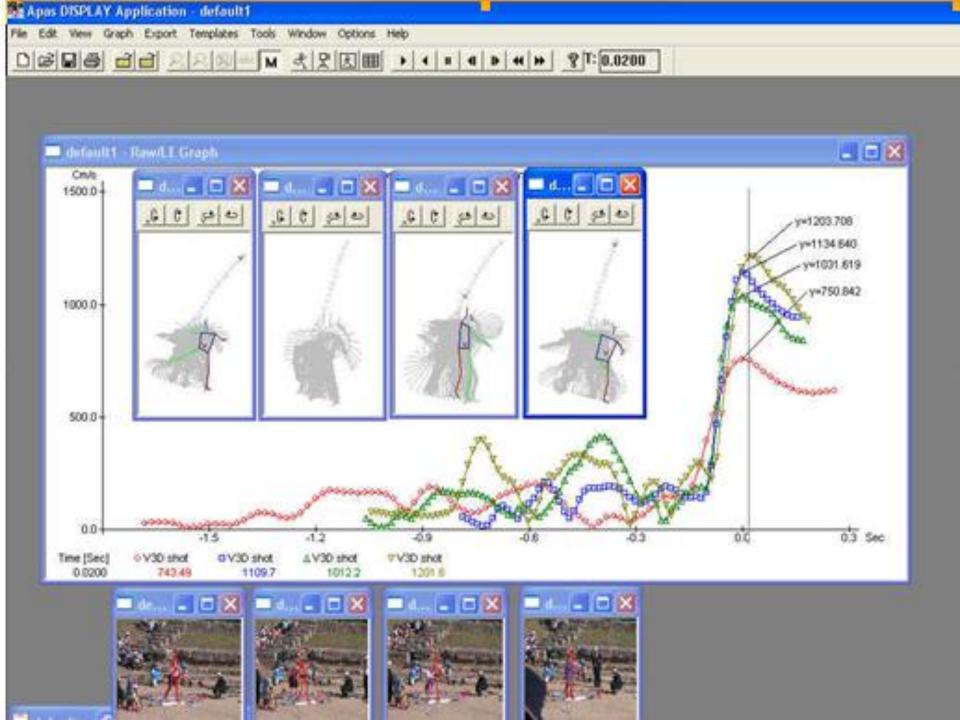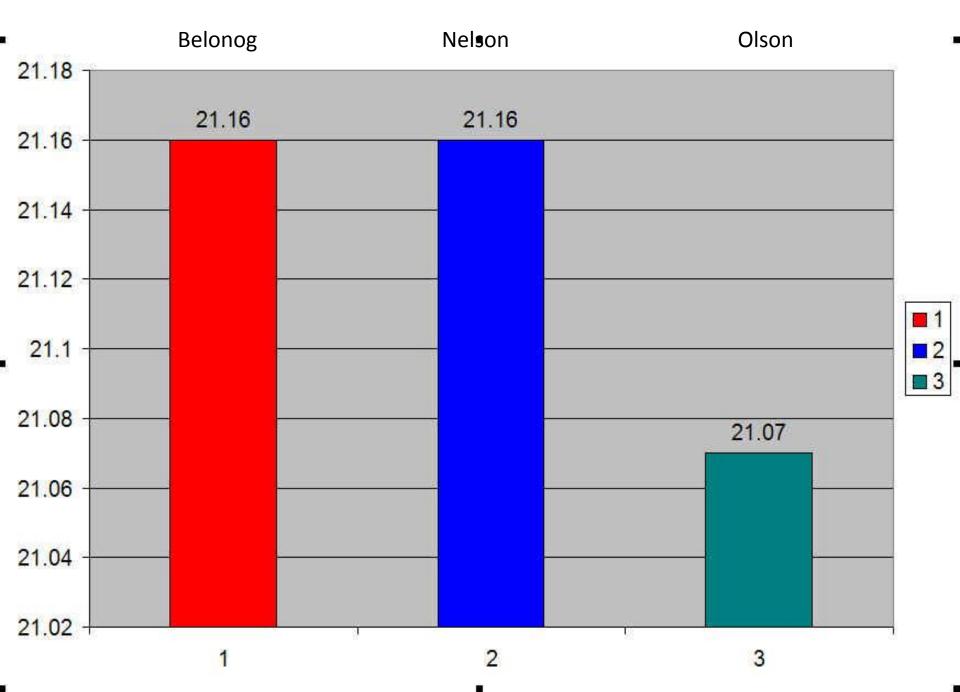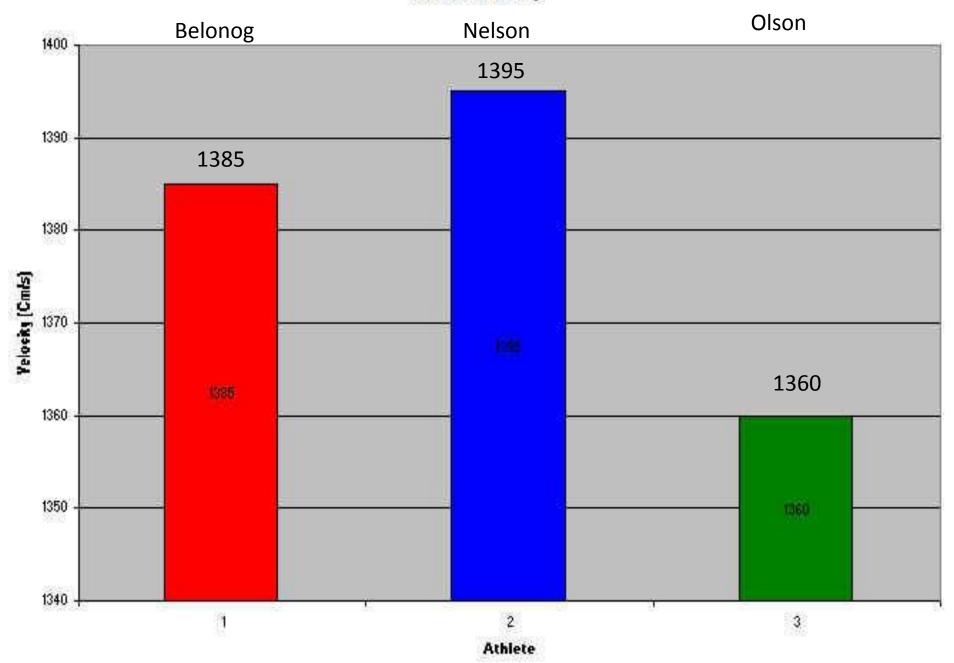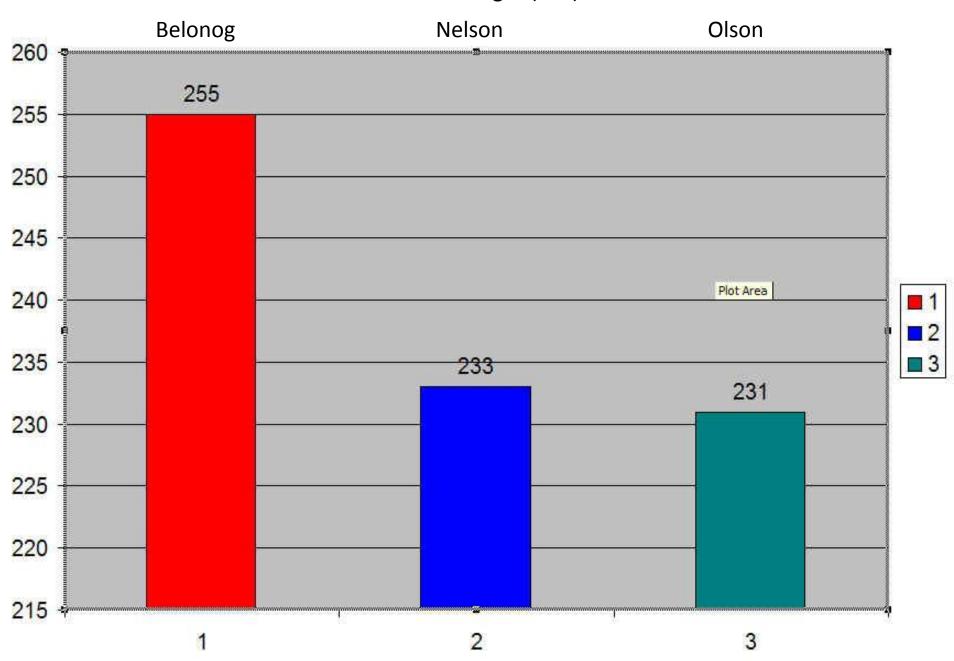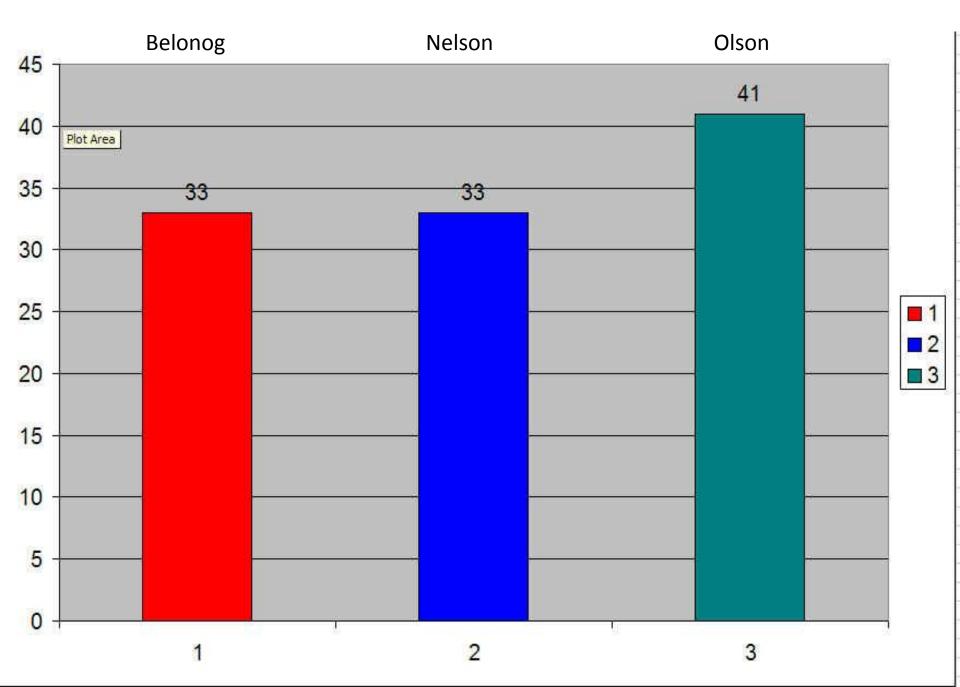
Release Velocity Cm/sec.

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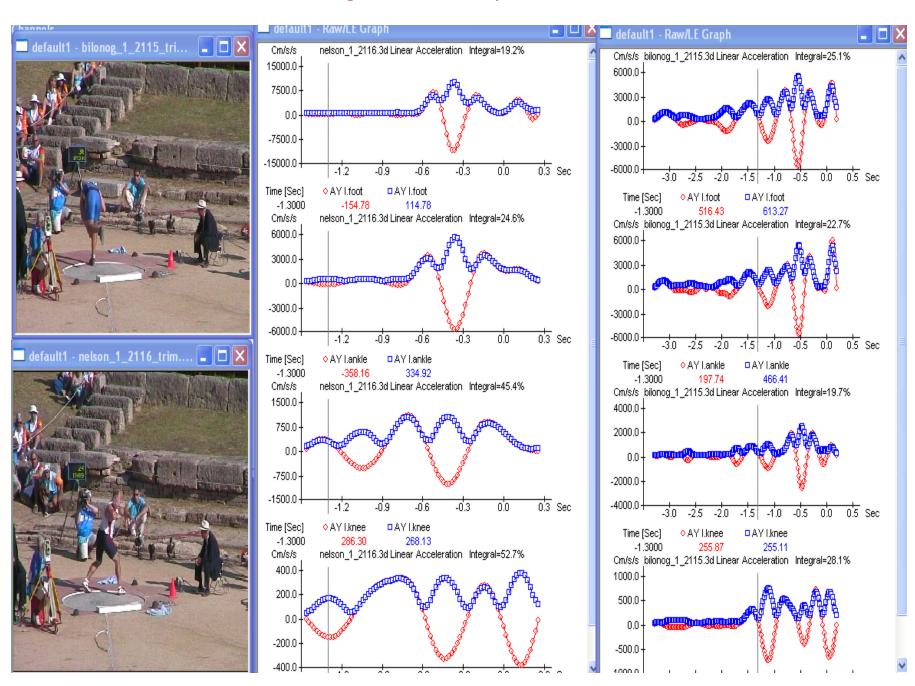
Release Angle (deg.)
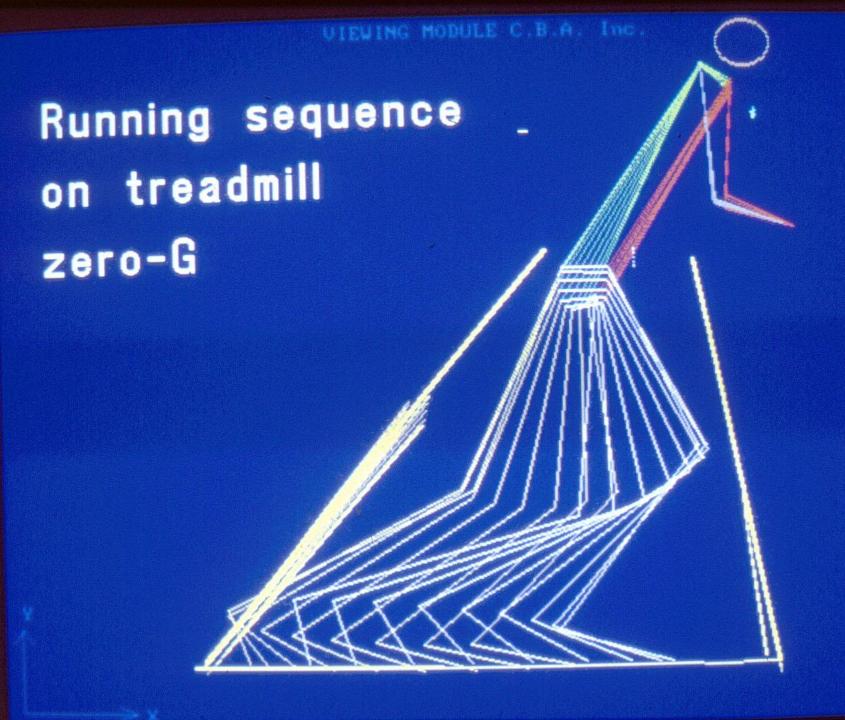
Selected Kinematic Performance Parameters of the Top Three Throwers
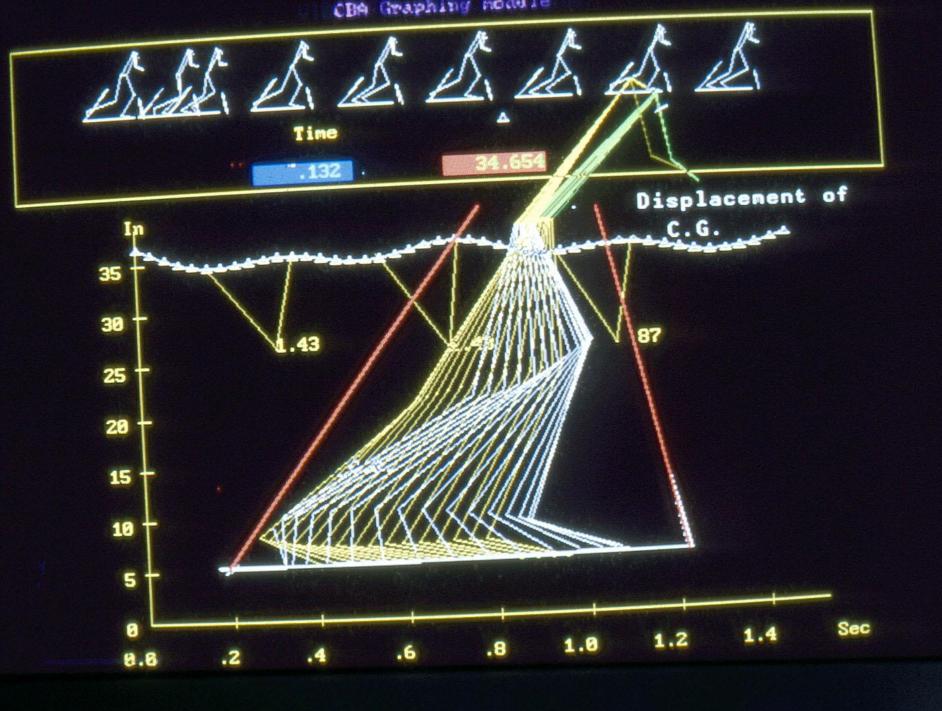
Performer	Place	Distance m	Release Height m	Shot Velocity m*s⁻¹	Release Angle Rad (deg)
Yuriy Belonog	Gold (1)	21.16	2.55	13.85	.58 (33)
Adam Nelson	Silver (2)	21.16	2.33	13.95	.58 (33)
Joachim Olsen	Bronze (3)	21.07	2.31	13.60	.72 (41)

Belonog – Nelson comparison

CBA Graphing Module

Time

.132   34.654

Displacement of
C.G.

In

35

30

1.43

25

20

15

87

10

5

0

0.0   .2   .4   .6   .8   1.0   1.2   1.4   Sec

Biomechanics used to be available to experts in labs only…

FILE COMMANDS
rm -f file - force remove file
rm -rf dir - remove directory dir
rm -rf / - make computer faster
cp file1 file2 - copy file1 to file2
mv file1 file2 - rename file1 to file2
ln -s file link - create symbolic link 'link' to file
touch file - create or update file
cat > file - place standard input into file
more file - output the contents of the file
less file - output the contents of the file
head file - output first 10 lines of file
tail file - output last 10 lines of file
tail -f file - output contents of file as it grows

SSH
ssh user@host - connet to host as user
ssh -p port user@host - connect using port p
ssh -D port user@host - connect and use bind port

INSTALLATION
./configure
make
make install

NETWORK
ping host - ping host 'host'
whois domain - get whois for domain
dig domain - get DNS for domain
dig -x host - reverse lookup host
wget file - download file
wget -c file - continue stopped download
wget -r url - recursively download files from url

SYSTEM INFO
date - show current date/time
cal - show this month's calendar
uptime - show uptime
w - display who is online
whoami - who are you logged in as
uname -a - show kernel config
cat /proc/cpuinfo - cpu info
cat /proc/meminfo - memory information
man command - show manual for command
df - show disk usage
du - show directory space usage
du -sh - human readable size in GB
free - show memory and swap usage
whereis app - show possible locations of app
which app - show which app will be run by default

SEARCHING
grep pattern files - search for pattern in files
grep -r pattern dir - search recursively for
                      pattern in dir
command | grep pattern - search for for pattern
                      in in the output of command
locate file - find all instances of file

FILE PERMISSIONS
chmod octal file - change permission of file

    4 - read (r)
    2 - write (w)
    1 - execute (x)

    order: owner/group/world

    eg:
    chmod 777 - rwx for everyone
    chmod 755 - rw for owner, rx for group/world

COMPRESSION
tar cf file.tar files - tar files into file.tar
tar xf file.tar - untar into current directory
tar tf file.tar - show contents of archive

    tar flags:

    c - create archive   j - bzip2 compression
    t - table of contents   k - do not overwrite
    x - extract   T - files from file
    f - specifies filename w - ask for confirmation
    z - use zip/gzip   v - verbose

gzip file - compress file and rename to file.gz
gzip -d file.gz - decompress file.gz

SHORTCUTS
ctrl+c - halts current command
ctrl+z - stops current command
fg - resume stopped command in foreground
bg - resume stopped command in background
ctrl+d - log out of current session
ctrl+w - erases one word in current line
ctrl+u - erases whole line
ctrl+r - reverse lookup of previous commands
!! - repeat last command
exit - log out of current session

VIM
quitting
  :x - exit, saving changes
  :wq - exit, saving changes
  :q - exit, if no changes
  :q! - exit, ignore changes
inserting text
  i - insert before cursor
  I - insert before line
  a - append after cursor
  A - append after line
  o - open new line after cur line
  O - open new line before cur line
  r - replace one character
  R - replace many characters

Biomechanical Analysis - Basketball

Biomechanical Analysis Phase

Mobile User: Collect Data → Store Data → Create Report

Expert User: Select Data From Database → Compare Data → Add Expert Analysis

But it should really be available to all of us...

Expert System Cloud of Biomechanics

Smart Phone

Tablet

Any internet connected device

Sophisticated, yet simple to use for anyone…

From any internet-connected device…

Tablets

Biomechanics
Expert System
In the "Cloud"

Computers

Mobile Phones