

60-SECOND SUMMARY

HOT OFF THE PRESS

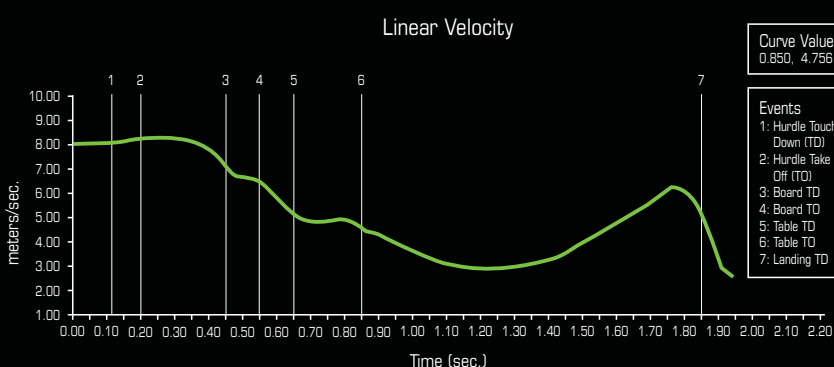
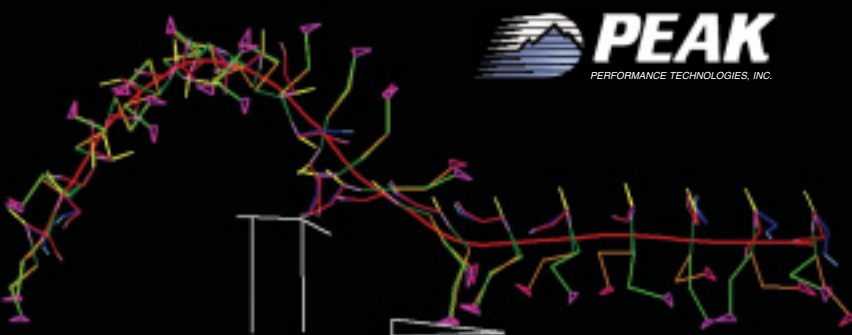
DIRECTORY



# OLYMPIC COACH

FALL 2004 • VOLUME 16 • NUMBER 3

Message from the  
**DIRECTOR OF  
COACHING and  
SPORT SCIENCES**



Center of Mass Resultant, 2D Linear Velocities

## SPORT BIOMECHANICS and Engineering

Improving Olympic **WEIGHTLIFTING PERFORMANCE** in the **TRAINING ENVIRONMENT**

**INSTRUMENTED RUNWAY** and the Assessment of **FORCE GENERATION**

**SKELETON TRAINING—**  
A Scientific Approach

**TIMING:** In Sports—  
It's **EVERYTHING**

Diagnosis of **LOWER EXTREMITY STRENGTH and POWER** via **VERTICAL JUMPS**

**WHICH MUSCLES?**

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#### COVER IMAGE

Stick figure representation of Roche Vault (2.5 Front Combination) performed by an elite male gymnast. Analysis made possible through software donated by Peak Performance Technologies, Inc.

Message from the  
**USOC's**  
**DIRECTOR OF COACHING**  
and **SPORT SCIENCES**

by  
**PETER DAVIS, Ph.D.**


**W**hen you are reading this edition of the Olympic Coach magazine, I think you will agree with me that we have a collection of very talented individuals working for the USOC Coaching and Sport Sciences Division. This edition focuses on one side of the Division...the Sport Sciences staff. This staff has a "can do" attitude toward solving problems that elite level coaches and athletes confront on a day to day basis. It really does not matter which of the three centers (Colorado Springs, Chula Vista or Lake Placid) that you visit you will find dedicated scientists working with elite athletes and coaches.

Olympic medals are won by the narrowest of margins (sometimes measured by thousandths of a second), so the accuracy and speed of information that coaches need to train athletes becomes critical for optimal performance. With the narrowest of margins for victory, comes the narrowest margin for error. Coaches want to easily understand and use technology to aid their athletes. To this end we seek scientists and technicians who understand sport and coaching but are also experts in various disciplines. At the three training centers we employ all the "traditional" sport scientists—Sport Physiologists (4), Sport Psychologists (4),

Biomechanists (4) Strength and Conditioning coaches (5), Engineer, Engineering technician, and Performance (Computing and Video) Technology staff (4). Between them they provide basic service support for summer and winter coaches and athletes as well as develop new technology and equipment. In addition, they are a learning resource for coaches to help with planning and integration of services and learning new technology as it comes onto the market.

Besides developing some of our own technology, we are fortunate to have access to a number of corporate providers who help us out with technology and services to cover bases that we cannot cover. Without partners such as Peak Performance Technologies, Inc. from Centennial, Colorado, Polhemus and Advanced Motion Measurements out of Vermont, Dartfish, Panasonic and Gateway, we would be limited in our ability to assist our elite level athletes.

We hope that this edition of *Olympic Coach* will remind U.S. Olympic athletes and coaches that we have a comprehensive and expert staff who can help Olympic staffs and NGB's with designing and delivering excellent programs and that when they have a thought or question in their head asking "I wonder how to do that?", or "I wonder if it would be possible to do...?" The next step would be to call one of the Coaching and Sport Sciences staff and bounce the idea off them. My bet is that between them and our various national networks we can find the answer.

One of our mottos is "Find a way to make it happen". If we know what you need then we can find a way. 



by WILLIAM A. SANDS, Ph.D.

# SPORT BIOMECHANICS and ENG and ENGINEERING

**S**port is performed using forces and torques, applied in many directions, with exquisite timing, and consuming large amounts of energy. When discussed in these terms sport is an application of physics. Sport biomechanics and engineering (SBE) are applied physics.

There are many different approaches to the study of sport. When the sport-related questions are framed in terms related to force, technique, speed, coordination, and timing—you are well within the areas of SBE. Modern SBE deals with three primary areas called “kinematics” which refers to a description of motion, “kinetics” which is the study of the forces underlying motion, and the means of measuring these things. Kinematics has been traditionally studied qualitatively and quantitatively via high-speed film, and more recently, video. The cover of this issue of *Olympic Coach* shows an example of kinematic analysis of a difficult vault in men’s gymnastics. Kinetic analysis has been traditionally measured using load cells, strain gauges and force platforms. Measurement involves the design, construction, and implementation of sophisticated instruments that can measure time, position, velocity, acceleration, force, torque, temperature, and many other factors.

The primary goal of SBE is to help coaches and athletes “see better.” Like much of science in the last century,


advancements have been linked to our ability to see better, more precisely, from unusual vantage points, and in formats beyond the human eye. X-ray, telescopes, microscopes, MRI, PET scans, infrared thermography, radar, lasers, and many other technologies have expanded our ability to see better than ever, and SBE applies these technologies to sport. As our ability to see sport performance more clearly and precisely improves, we find that the traditional lines dividing sport science into physiology, biomechanics, psychology, motor learning and control, medicine, and so forth have become blurred—especially the lines between and SBE and physiology, motor learning and control, and medicine. As such, SBE has become more tightly integrated with other disciplines.



## AT THE USOC WE NOW FIND THAT SBE:

- uses high speed video and computer digitization to render athlete performance in two or three dimensions and producing extremely precise measurements of athlete motion while training or competing,
- builds custom timing systems that can render times accurately to 1000th of a second in virtually any training and performance setting that allows coaches and athletes to see the timing characteristics of almost any performance,
- builds custom sensing equipment to measure and allow coaches and athletes to see the most subtle aspects of performance such as oar forces and position in a rowing shell; position, speed, and force of the barbell in weightlifting; or accelerations and forces in a standard punching bag for boxing and taekwondo.
- uses electromyography to see and analyze muscle electrical activity and to determine whether learning drills and skills are muscularly similar to the real skill or whether an injured athlete’s muscle activity has returned to levels comparable with the non-injured side,

- uses new magnetic field generators and sensors to obtain information about motion in six dimensions in real-time (while the athlete is actually performing, and therefore no delay for data processing) allowing a computer to generate a robot image that moves precisely the same way the athlete moves. The computerized robot can be programmed to provide audible feedback tones when the athlete is in a specific position or range of positions. Thus, the athlete can see him/herself perform as the robot, while the specific body positions, speeds, and angles can be preprogrammed so the computer tells the athlete when they’re doing it right versus doing it wrong,
- builds and uses new video-overlay systems so that any kind of pertinent performance information can be placed on a video image simultaneously so that coaches athletes can see their performance along with physical and physiological data,
- in conjunction with physiology SBE designs, develops, and builds special force sensing equipment so that coaches and athletes can see their force and power performances in subtle but important ways and in real-time.
- uses high-speed video so that rapid movements can be slowed down and studied in clear slow-motion. Standard video is often incapable of resolving the more subtle aspects of performance that are only visible with high-speed cameras.

SBE is not just about technique although technique is still central to its goals and purpose. SBE has expanded its reach to many areas that open new horizons for coaches and athletes to see better, understand better, and thereby perform better. 



What if an instrumentation system were designed for measuring performance variables of elite weightlifters performing the Olympic lifts of Snatch and Clean & Jerk? Such a system has been designed and developed by the Sport Biomechanics and Engineering staff in Colorado Springs and installed for use by the CSOTC resident USA Weightlifting coaches and athletes.

# IMPROVING OLYMPIC WEIGHTLIFTING

## Performance in the Training Environment

by Sarah L. Smith, Ph.D. and Thomas M. Westenburg

The instrumentation system is known as the *Weightlifting Video Overlay System*, and it measures the following variables *in real-time* (or as the motion is actually being performed):

1. Movement paths (trajectories) of both the left and right ends of the barbell
2. Velocities of both ends of the barbell
3. Vertical forces exerted through both feet of the weightlifter.

These six variables are the relevant, meaningful, and appropriate measures of weightlifting performance as identified by National team weightlifting coaches.

Video images are *simultaneously* overlaid and *synchronized* in time with the above measured variable values throughout the entire lifting movement sequence. An analysis of weightlifting technique is available for the coach and athlete immediately after the lift has been completed (Fig1a. and 1b.). Figure 2 displays one video frame and the measured variables at the end of the lifting sequence.



Figure 1a. *Weightlifting Instrumentation System* in operation.



Figure 1b. Analysis feedback by coach to the athlete.



Figure 2. Display of synchronized video and measured variables during one moment in time at the end of the lifting motion.

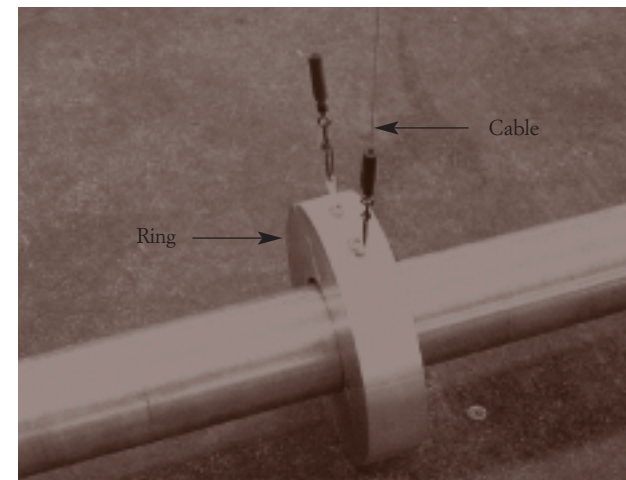


Figure 3. Ring on one end of the barbell and two cables.

### EQUIPMENT COMPONENTS

The system consists of both specialized hardware and customized software integrated with a laptop computer. A video monitor is used to show the captured motion images and corresponding numerical information so that the coach can review and analyze technique with the weightlifter.

To measure left and right bar end trajectories, a ring with two fine stainless steel cables is positioned on both ends of the barbell. Each of these two cables attaches to a positioning sensor on a frame mounted above the lifting platform; Figure 3 shows one of the rings and the two cables. The trajectory paths and velocity values of both ends of the barbell are determined by the positioning sensors from the movement of the cables during the lift. By using two positioning sensors for each ring, up-down and front-back motions of the bar are measured.

Vertical force data are collected from two AMTI force plates that are installed in a regulation weightlifting platform. Two force plates (one under each foot of the athlete)

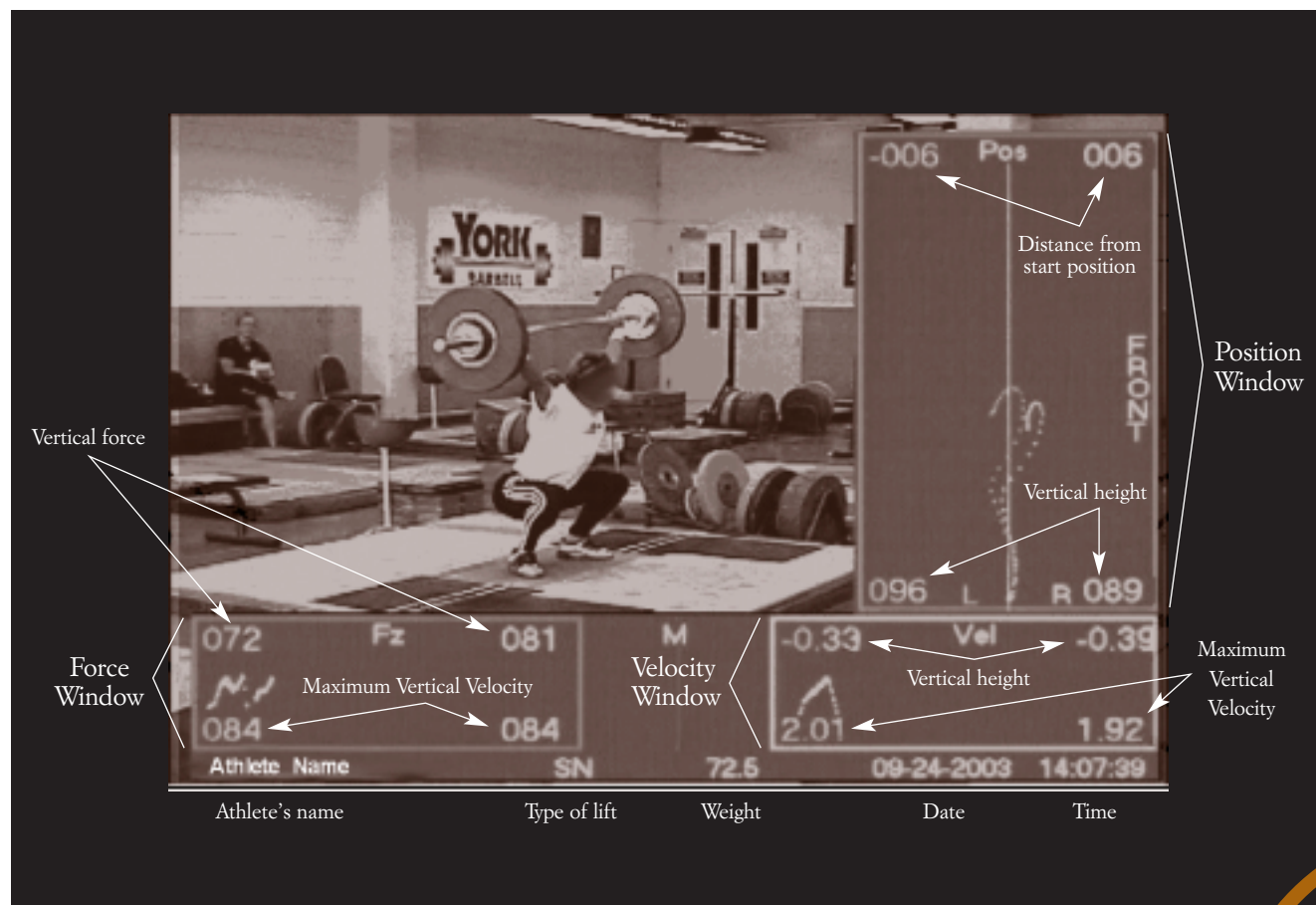


Figure 4. Real-time display of video image and measured performance variables.

are used so that discrepancies in the amount of force generated through each side of the body can be measured. An amplifier for magnifying the force signals was custom designed and integrated with the signals coming from the four positioning sensors.

Both customized and commercially available software provide for the integration of video images as well as trajectory, velocity, and force data. Feedback of the results of lifting technique is available within seconds of the completion of the lift.



### DISPLAY OUTPUT

The *real-time* display simultaneously shows all the measured variables of weightlifting performance in addition to the video image from the athlete's lifting sequence. Refer to Figure 4 for relating the following comments about the information collected during a lifting performance.

Video of the lift is seen in the main window along with graphs of the data for vertical force ( $F_z$ ), bar velocity ( $Vel$ ), and bar position ( $Pos$ ). Vertical force and barbell velocities are graphed versus time; barbell position is graphed with respect to the center of the barbell just prior to the lift off from the platform. In all three graph windows, numerical values and graph lines would be coded green and white for the left and right measures, respectively.

In each graph window, the numerical value for the variable at the current moment in the lifting sequence is shown. Additionally, the corresponding maximum value is displayed in the " $F_z$ " and " $Vel$ " graph windows. In the " $Pos$ " graph window, both vertical and horizontal magnitude values (in centimeters) are shown with respect to the location of the barbell center just prior to liftoff.

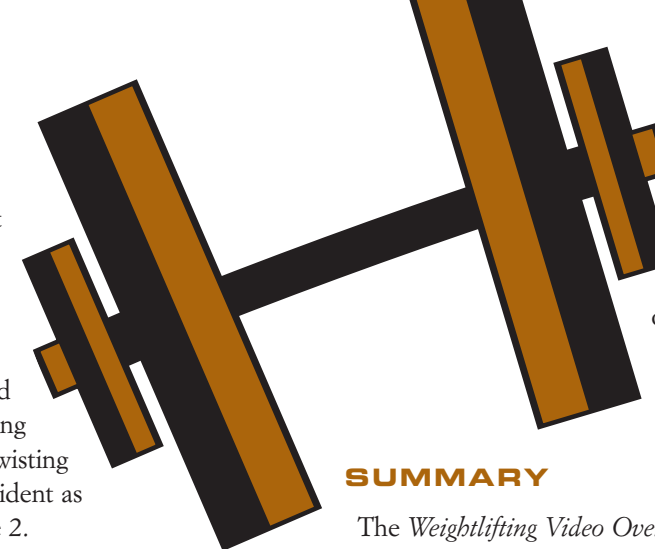
Other information shown in the display includes the athlete's name, lift type (Snatch or Clean & Jerk), and the amount of weight being lifted. Date and time of the data collection are also displayed.

### INTERPRETING THE NUMBERS

From the " $Pos$ " window shown in Figure 4, the lifter has moved the left and right barbell ends to a height of 96 and 89 cm, respectively, above the platform. The left barbell end has moved 6 cm behind the starting position whereas the right barbell end has moved 6 cm in front of the starting position. The athlete has initiated a twisting motion which becomes even more evident as shown at the end of the lift in Figure 2.

Left and right bar velocities as shown in the " $Vel$ " window are -0.33 and -0.39 meters/second, respectively. The negative signs indicate that the bar ends are moving downward. Maximum left and right bar velocities are 2.01 and 1.92 meters/second, respectively; these numbers indicate that the lifter is moving the left side of the bar slightly faster than the right side. The velocity curves are so similar that it is almost impossible to distinguish between the left and right lines.

A similar interpretation exists for the vertical forces generated by the lifter. At the current lifting position, forces are



72 and 81 kilograms under the left and right foot, respectively. A maximum force of 84 kilograms has been obtained through each foot. Both force curves are nearly identical indicating symmetry.

### SUMMARY

The *Weightlifting Video Overlay System* provides coaches and athletes with objective measures of lifting performance along with synchronized video images for the entire lifting movement sequence. The feedback of performance results is available immediately after the completion of the lift. Both coach and athlete can review lifting technique and performance measures in normal, half, or quarter speed. Frame-by-frame playback as well as repeated viewing is also available. Athletes and coaches are provided a CD or video tape for subsequent study of lifting performance.

This system offers weightlifting coaches a way to help their athletes improve their lifting technique based upon objective measures of lifting performance and a qualitative analysis of technique. It provides a unique combination of information that can not be seen by the naked eye. The needed technique corrections can be suggested by the coach before the athlete's next lift. This lift can then be reviewed so that the coach and athlete can evaluate whether or not the weightlifting performance shows improved execution. 📺



# INSTRUMENTED RUNWAY AND THE ASSESSMENT OF FORCE GENERATION

by Kathleen E. Costa—Sport Biomechanist

Olympic Training Center, Chula Vista, California

## WHAT'S NEW AT THE OLYMPIC TRAINING CENTER IN CHULA VISTA?

The Olympic training center in Chula Vista, California has been outfitted with a new instrumented runway. One of the horizontal jumps runways on the track has been instrumented with fourteen force plate mounts, covering almost forty two feet. Once installed, the force plates are level with the track surface and allow the biomechanics team to measure three dimensional ground reaction forces that the athlete generates during the ground contact phase of running.

## WHAT ARE GROUND REACTION FORCES AND WHY ARE THEY IMPORTANT?

In a running task, ground reaction forces are forces that the athlete generates at the foot-ground interface during each foot contact. Force plates allow these forces to be measured in three directions; anterior-posterior (forward and backward), medial-lateral (left and right), and vertical. Every foot contact is an opportunity for athletes to change or maintain their momentum. Therefore, being able to measure ground reaction forces during a skill allows biomechanists to assess an athlete's momentum control strategy during the phases of their skill. In other words, how the athlete pushes against the ground and the results of these pushes on movement of the athlete's body.

## HOW HAS THIS TECHNOLOGY BEEN USED IN THE PAST?

Prior to the addition of the fourteen new force plate mounts, the horizontal jumps runway included one force plate mount at the end of the runway just in front of the sand pit. A force plate has been installed in this position to measure ground reaction forces during long jump take-offs (1996, 1997; Figure 1), and during the first step of a sprint start (2002; Figure 2).

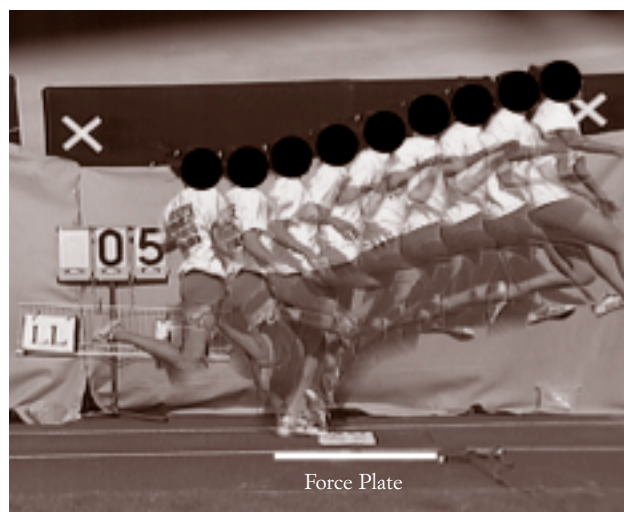


Figure 1. Long jump take-off with force-plate installed within the track, used to measure ground reaction forces generated during the long jump take-off.



Figure 2. Sprint start performed from blocks positioned just in front of force-plate installed within the track. Force plate was used to measure ground reaction forces generated during the first step out of the starting blocks.

**LONG JUMP TAKE OFF.** During the take-off of a long jump, the athlete becomes a projectile. The path of the athlete or the distance of his/her jump is determined by a combination of vertical momentum (which provides the time in the air), and horizontal momentum (which provides his/her horizontal distance traveled). Each athlete must determine and generate the most efficient combination of horizontal and vertical momentums to maximize the jump distance. Measuring his/her ground reaction forces enables the biomechanics staff to measure and analyze how the athlete is redirecting the horizontal momentum generated during the approach in order to achieve optimum flight and complete the long jump.

**SPRINT START.** One of the goals of the sprint start is to generate the maximum amount of horizontal momentum. In order to do this, the athlete must generate large anterior-directed (forward) ground reaction forces during each step. Ground reaction forces have been measured during the first step of the sprint start in order to understand just how each athlete generates these forces. When combined with video and computer storage and analyses, the ground reaction forces can be used to calculate the mechanical loading imposed on the legs. As a result, the biomechanist can help the coach and athlete identify and optimize his/her lower extremity power generation strategies used in the sprint start.

## WHY INSTRUMENT A RUNWAY? HOW WILL THIS TECHNOLOGY BE USED IN THE FUTURE?

Having more than one force plate along a runway allows the biomechanics team to understand momentum control and redirection during multiple phases of an event (Figures 3 and 4). For example, with this unique extended instru-



Figure 3. Three force plates installed in the new runway.

mented runway we will now be able to measure ground reaction forces that will help us understand performance mechanics during:

- the hop, step, and jump phases of the triple jump,
- the penultimate step in addition to the take-off step of a long jump, and
- the acceleration phase of the sprint



Figure 4. Final runway awaiting a data collection.

Acknowledgement: The biomechanists at the U.S.O.C. would like to thank Dr. Melvin Ramey and his colleagues of the University of California–Davis for his engineering expertise and construction of this truly unique tool for high performance track and field athletes.

# SKELETON TRAINING— A Scientific Approach

by Derek M. R. Kivi

At the United States Olympic Training Center in Lake Placid, New York, sport science is helping the athletes in the sport of skeleton take their training to a higher level. Using the bobsled/skeleton outdoor push track, the high speed treadmill, and biomechanical analysis projects, scientists are developing new training techniques and expanding the knowledge about this sport.

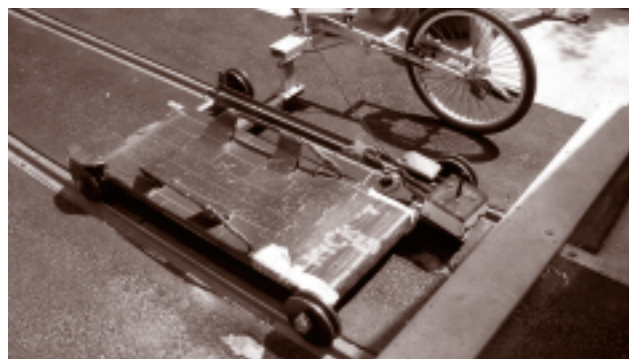


Figure 1a. Modified skeleton sled.



Figure 1b. Skeleton athlete at push track.

## THE PUSH TRACK

The outdoor push track allows skeleton athletes to practice their starts during the off-season. The push track resembles the start seen at standard bobsled/skeleton tracks—a nearly flat acceleration section (15 meters in length) followed by a 50 meter downhill slope. A skeleton sled, modified with wheels, rolls down the track on two steel rails (see Figures 1a. and 1b.).

In order to provide immediate feedback and measure start times, the Biomechanists and Engineers of the Coaching and Sport Sciences Division developed a system that records and displays both split times and sled velocity. For time measurement, an infrared emitter is connected to the sled and reflectors are located at 5 meter intervals along the entire length of the track. As the sled rolls down the track, the interval times are telemetered (transmitted) to a receiver that is connected to a computer. Velocity is measured using an instrumented wheel connected to the sled.

The wheel rolls with the sled and the velocity is transmitted to the receiver and the computer. The data is then displayed on the screen, providing the coaches and athletes with real-time feedback.

Time, velocity, and video data for a skeleton athlete are seen in Figure 2. On the right of the screen, interval distance, interval time, and near instantaneous velocity are displayed (from left to right). At the bottom of the screen, a graph shows the sled velocity (top line) and the interval times (bottom line) for the start. At the “200” mark on the graph (just prior to the 20 m mark of the bottom line), note there is a small deviation in the top velocity line. This indicates the point at which the athlete loaded (changed from running and pushing to lying) onto the sled and is a result of an unintentional pulling of the sled backwards underneath the body. An ideal loading movement for skeleton would have the athlete diving onto the sled with a velocity equal to or greater than the sled itself, resulting in no decrease in sled velocity or, if possible, an increase in velocity. Video is captured using a video overlay system which allows the athletes to see their starts immediately after each trial. This combination of simultaneous time/velocity/video collection has proven to be an extremely useful and beneficial training tool. This system is another example of video “overlay” instrumentation designed and developed by the Biomechanics and Engineering staff.

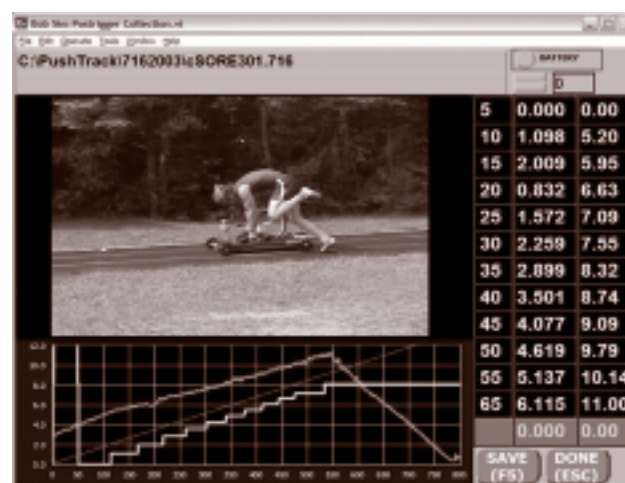


Figure 2. Skeleton push track start data.



Figure 3a. Skeleton athlete running on treadmill.



Figure 3b. Skeleton athlete after loading onto sled.

## THE HIGH SPEED TREADMILL

The high speed treadmill located in the Sport Science Laboratory at Lake Placid had previously been used exclusively as an instrument for physiological testing. We recently, however, have been incorporating the treadmill into the skeleton training program as a tool to help improve maximum running speed and to practice loading onto the sled. The treadmill is one of the largest in North America (8' x 10'), and easily accommodates both the athlete and the sled. A skeleton sled, modified with rollerblade wheels, is tied securely to the treadmill. While the treadmill is moving at a slow speed, the athlete runs upright along side of the sled, then bends down and begins to push (Figure 3a.). The treadmill is then accelerated slowly and the athlete loads onto the sled at an appropriate speed (Figure 3b.). DartTrainer™ is used during training sessions in order to provide the athletes with immediate visual feedback about their running position and their load. The benefit of using the treadmill for skeleton training is that athletes can focus on specific aspects of their starts. They can perform multiple repetitions in a short period of time to develop proper technique for running with and loading onto the sled.

## BIOMECHANICS RESEARCH

Despite skeleton's long history and status as an Olympic event, no in-depth analysis has been done in the sport. The Biomechanists of the Coaching and Sport Sciences Division have initiated two scientific investigations to learn more about start technique and to determine how athletes can improve their start times.

In the winter of 2004, video was collected at the FIBT World Championships in Königssee, Germany and at the United States Skeleton National Championships in Lake Placid, New York. The focus is to understand differences in start technique between males and females and between

athletes of varying abilities. Variables such as the number of steps taken during the start and their relationship to start time, flight and contact times, and step frequency were examined. The results of this investigation showed that the differences between genders and between abilities were seen primarily in the first five steps of the start and the last five steps before the load.

A second analysis project was undertaken to quantify the kinematics of the skeleton start. High speed video (120 Hz) was collected during the 2003 Skeleton National Team Trials in Lake Placid. Data processing was completed using a Peak Motus 8.0 motion analysis program, with variables such as step length, flight and contact times, step frequency, and joint angles being measured for the first three steps of the start. Figure 4 shows the collected video (top left), digitized stick figure model (top right), and a graph displaying the left and right knee angles during the first three steps of the start. The vertical line on the graph identifies the point on the graph that corresponds with the video and stick figure.

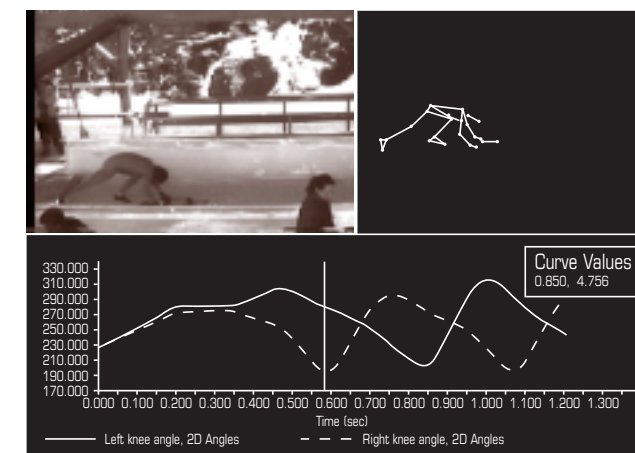


Figure 4. Kinematic analysis of skeleton start.

Comparisons were also made between athletes with different starting techniques. Skeleton athletes start in either a “one-foot” or staggered foot position with the rear foot pushing against a start- or push-block and the front foot gripping the ice, or a “two-foot” position in which the athlete pushes with both feet on the block. The results of the analysis showed that despite differences in knee and trunk angles off the block and differences in step length and step frequency for the first three steps, start times for the two techniques were similar.

## SUMMARY

The Biomechanists and Engineers of the Coaching and Sport Sciences Division are working to provide skeleton coaches and athletes with immediate qualitative and quantitative feedback as well as empirical data. As the team prepares for the upcoming World Cup season and the Winter Olympics in 2006, sport science will be there to help keep skeleton on the cutting edge of training and performance.

# TIMING: IN SPORTS— IT'S EVERYTHING

by Sarah L. Smith, Ph.D. and Thomas M. Westenburg

**WHY** is timing important in sport performance? In many sports, winning is based upon the time to complete the race. Time is the actual gauge for measuring sport performance, and the best time wins!

While race time is indicative of winning performances in many sports, timing is a critical component of all sport skills. Most sport or movement skills have the following characteristics:

1. Rhythm
2. Cadence
3. Temporal or timing phases as defined by key events during the motion
4. Defined time interval(s)
5.  $Ft = m(v_{\text{final}} - v_{\text{initial}})$

With respect to the above equation, motion of any mass (m) does NOT occur unless force (F) is exerted over a time interval (t). This equation also describes a very important relationship: the impulse-momentum relationship. If time equals zero, there is no change in velocity and thus no movement of the mass.

In events in which time is the critical indicator of sport performance, it is of some interest to be able to measure how much time it takes for an athlete to move over a defined distance. Through training, conditioning, and improved technique, an athlete's time over a specific distance in a timing trial protocol should be reduced. Measures of time allow the coach to evaluate individual performance, compare performances over the training and competition seasons, and motivate athletes to perform at even higher levels.

So if timing is that important, HOW is time measured and are the timing values accurate? The most traditional methods of time measurement include the stop watch, pace clocks, speed traps, and radar. Other more sophisticated equipment includes commercial timing systems as

well as video systems with time code generators (TCGs) and VCRs with frame counters.

Combining the best of all these methods is the *Timing System with Video* designed and developed by the Sport

Biomechanics and Engineering staff in Colorado Springs. This system is versatile in terms of its capability of measuring time, provides for the recording of video images of the motion being timed, and is accurate to 0.001 sec. The timing system is computer operated, and an example of how the system operates is displayed on the computer screen shown in Figure 1. The system is capable of obtaining timing measures for reaction, laps, and agility as well as time between known distances. Because the system is portable, versatile, and adaptable, it operates in a variety of sport environments.

## EQUIPMENT COMPONENTS

The system consists of both specialized hardware and customized software integrated with a laptop computer. The basic hardware includes sensors connected to electronic timing boxes via cables that are interfaced with a computer. A digital video camera connects via FireWire to the computer for image capture.

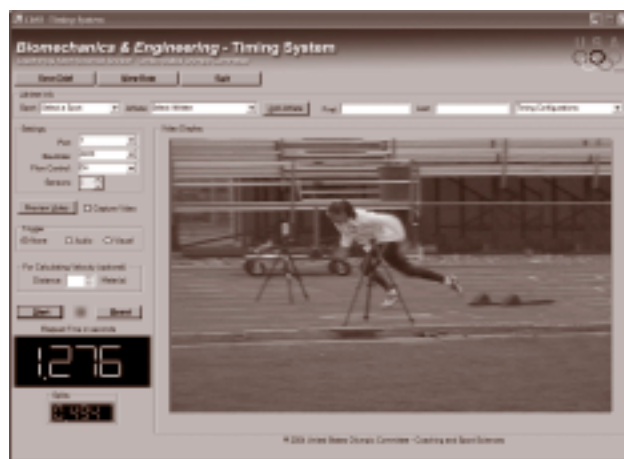


Figure 1. Timing System Computer Screen Example.



Figure 2. Types of sensors and timing hardware.

The design of the system incorporates visual, auditory, and pressure sensors which allows the user to set up a protocol to measure movement sequences in the testing environment that are appropriate, relevant, and meaningful for a specific sport skill. Different types of sensors and timing hardware are shown in Figure 2. In its simplest configuration, the system can be set up to determine the time taken by an athlete to move from point A to point B as well as record the video images of that motion. Beams from two timing light sensors, aligned with their reflectors and mounted on tripods, are set up at some prescribed distance. As an athlete passes in front of each successive timing light, the beam is broken; the computer software interprets the light interruption and calculates the time between two light interruptions. If desired, average speed of the athlete moving between the two timing lights can then be determined. A maximum of 20 sensors can be incorporated into the system, for example at each 5 meters in the 100m dash.

## DISPLAY OUTPUT

Prior to beginning the data collection, the user needs to specify the athlete's name and sport affiliation. If this information is not in the data base, it will need to be provided. Once the athlete is ready to be timed and the video camera is focused on the athlete, the "Start" button is selected, and the timing data and video images are captured. After the athlete passes through the last timing sensor, the timing and video data are saved for subsequent processing. Immediate review of both the motion and the timing values are available.

On the computer screen, both elapsed and split times are displayed. As an athlete moves through each timing sensor, the times are updated in the display area. The elapsed time is shown in large letters and is readable when viewed in an outdoor environment. Using the display shown in Figure 1, the time of 1.276 seconds represents the time from an auditory start signal until the beam of the first timing gate is broken. The split time of 0.494 seconds represents time from the auditory start signal until the athlete's rear foot leaves the starting block.

## INTERPRETING THE NUMBERS

The starts in Short Track Speedskating are critical to the race performance. By measuring reaction time, five two-meter intervals from the start line, and times at specific locations around the rink, athletes and their coaches can

assess their performance in this critical part of short races. An example of how the timing system is set up for obtaining the above time values is shown in Figure 3. The timing data collected may be analyzed, presented, and studied in a variety of ways. One appropriate way might display all the start trials on a given day for each athlete tested. Additionally, the athletes can compare their trial times against the mean value for all team members as well as against the best individual start time for that training session. Consistency in the average value of an athlete's total number of trials over several testing sessions is also of interest. A typical graph of actual start timing data for one athlete is presented in Figure 4.

The reaction time from the start signal until the first light beam is broken, time around the first curve, and time down the first straight away are all indicative of start performance. Without knowing these values with a high degree of accuracy, athletes and their coaches are unable to evaluate the effectiveness of their training and conditioning program as well as analyzing their start technique.

## SUMMARY

The electronic timing system with video capture can be a useful tool for measuring and assessing athlete performance because both the motion and timing data reflective of that motion can be studied. With visual, auditory, and pressure sensors, timing of a variety of movement skills can be accomplished. The planning of an appropriate and relevant timing protocol and regular implementation into the training environment, timing information can provide the necessary facts to assess performance.

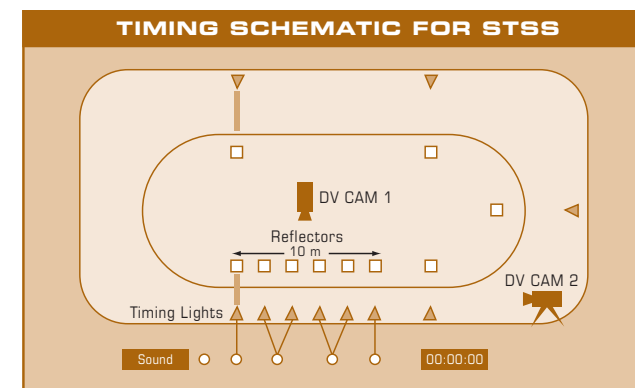


Figure 3. Timing Set-up for Short Track Speedskaters.

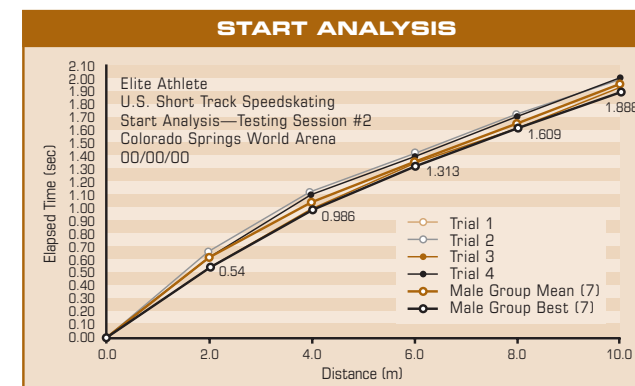


Figure 4. Example of Timing Data for STSS Athlete.

# DIAGNOSIS OF LOWER EXTREMITY STRENGTH AND POWER VIA VERTICAL JUMPS

by William A. Sands, Ph.D.

and Prue Cormie

The vertical jump test is a long-established method used to demonstrate explosive lower body strength and power and remains a valuable tool for athletes and coaches today. Due to advances in technology, today's sport scientists are getting much more detailed and accurate information from conventional vertical jump tests. Vertical jumps have been measured via switch mats and jump and reach apparatuses, and while these methods are valuable, there are several limitations to these methods that can be overcome by using a force platform.

At the Olympic Training Center at Colorado Springs, jump performances of athletes are being tested by using a portable one-dimensional force platform (PFP) (Major, Sands, McNeal, Paine, & Kipp, 1998). The PFP is small and mobile, so that the apparatus can be taken to the athlete. Custom software automatically analyzes and extracts information from the force-time curves that are generated by any type of vertical jump. Figures 1-3 show the types and values of data extracted from typical force-time curves obtained from different types of vertical jumps.

There are three basic types of jumps on which athletes are tested (Fig 1-3): static jump (SJ), countermovement jump (CJ), and drop jump (DJ). These jump tasks can be varied to increase the breadth and depth of information obtained by adding weights (e.g., holding dumbbells), using an arm swing or not, dropping from various heights, and/or modifications of the performance instructions (Young, Pryor, & Wilson, 1995). By extracting precise,

reliable and valid information from different types of vertical jumps, the sport scientist can diagnose lower extremity strength and power information that can help coaches and athletes determine the current status of the athlete's lower extremity and indications of where training should go in the future (Marina & Rodriguez, 1999; Schmidtbleicher, 2002).

SJ-type jumps reflect concentric only contractile capacity of the lower extremity. CJ-type

jumps reflect contractile capacity, recruitment, synchronization, and some elastic character of the lower extremity. DJ-type jumps reflect reactive characteristics of the lower extremity. Moreover, by adding weights to the SJ-type jumps one can obtain a performance curve of the lower extremity's ability to produce high forces with external loads and thus lower speeds. The CJ-type jumps add an eccentric/stretch-shortening cycle to jump performance at moderate speed. The DJ-type jumps can reflect reactive and ballistic characteristics of strength and power at very high speeds and with varying loads dependent on the height of the drop prior to impact.

Lower extremity profiles are constructed from performance comparisons across these different types of jumps and their different performance task demands (M. Marina, personal communication). For example, in bobsleigh tryouts we found that athletes trained in powerlifting were relatively superior in SJ parameters while their CJ and DJ jump parameters were poor relative to other athletes. Powerlifters tend to train with high loads and at slow speeds. Athletes in the tryouts who trained more explosively, typically track and field athletes, were superior at CJ-type and DJ-type jump parameters while they were relatively inferior to the powerlifter in SJ-type jump parameters.

The PFP provides a simple, portable, and relatively inexpensive means of measuring lower extremity strength and power. Sport scientists use the force-time information from different types of jumps performed on a PFP to create an athlete-specific profile of lower extremity strength and power that appears to be sensitive to different training modes and methods.

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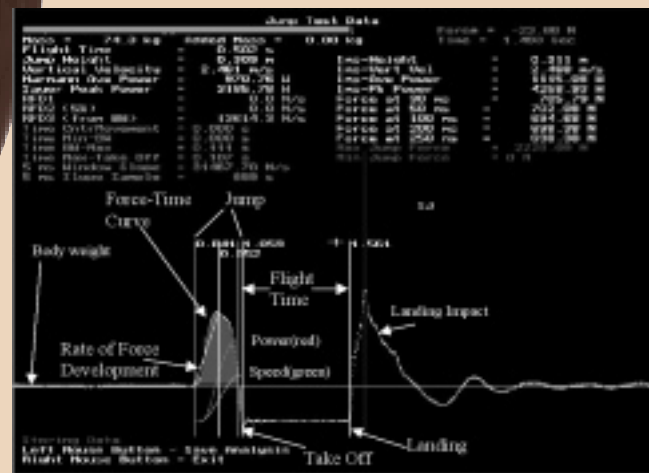
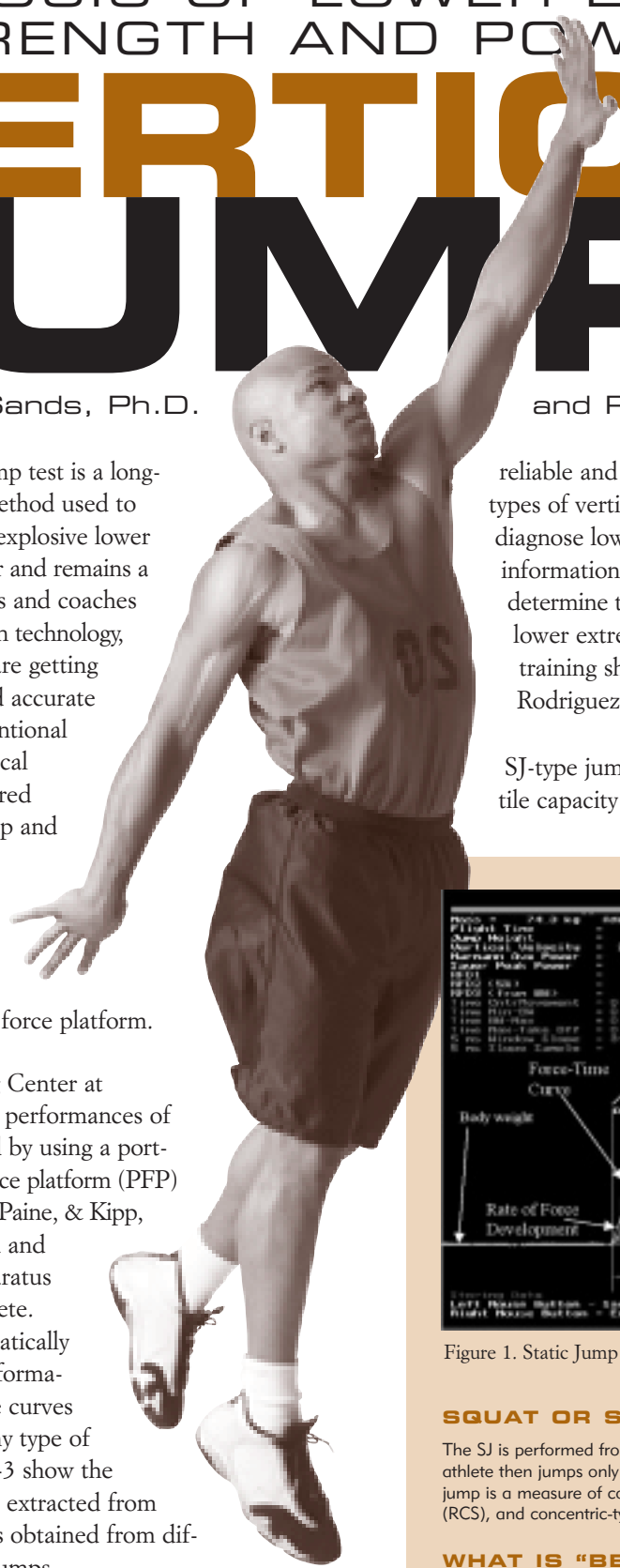


Figure 1. Static Jump Information

### SQUAT OR STATIC JUMP (SJ)

The SJ is performed from a static squatting position on the force platform. The athlete then jumps only upward, avoiding any countermovement. This type of jump is a measure of contractile capacity (CC), recruitment and synchronization (RCS), and concentric-type force production.

### WHAT IS "BETTER?"

Generally, we'd like to see a high maximum force (taller blue area), steep rate of force development (RFD) and long flight time. Flight time is directly translatable to jump height. We would also like to see a high power value which is based on the areas defined by the blue and green filled-in-spaces.

### OTHER STUFF

The graphics above also depict a number of other values that can be important for performance. The vertical white lines indicate the time involved in each

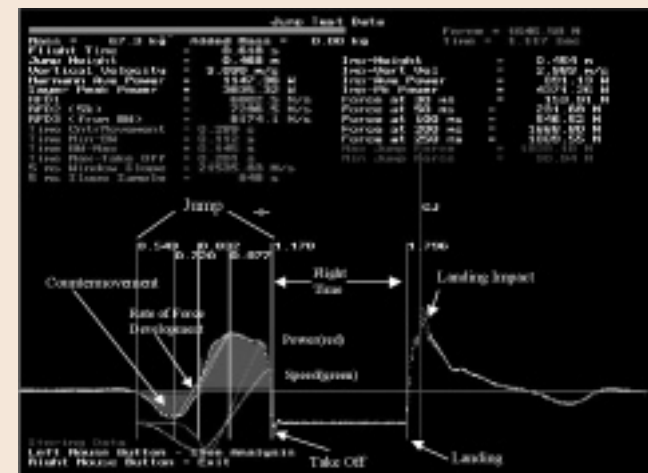


Figure 2. Countermovement Jump Information

### COUNTERMOVEMENT JUMP (CJ)

The CJ is performed from a standing position on the force platform. The athlete quickly descends by bending the knees and hips and then jumps upward. The countermovement is shown by the red area in the graphic to the right. This type of jump is a measure of contractile capacity (CC), recruitment and synchronization (RCS) and "elasticity" (CE). This jump uses a stretch-shortening cycle.

### WHAT IS "BETTER?"

Generally, we'd like to see a high maximum force (taller blue area), steep rate of force development (RFD) and long flight time. Flight time is directly translatable to jump height. We would also like to see a high power value which is based on the areas defined by the blue, red, and green filled-in-spaces.

phase of this type of jump. These can be important for sports like ski jumping where timing of each phase is crucial to realize the optimum body position and forces at the moment of take off from the jump. In general, we would also like

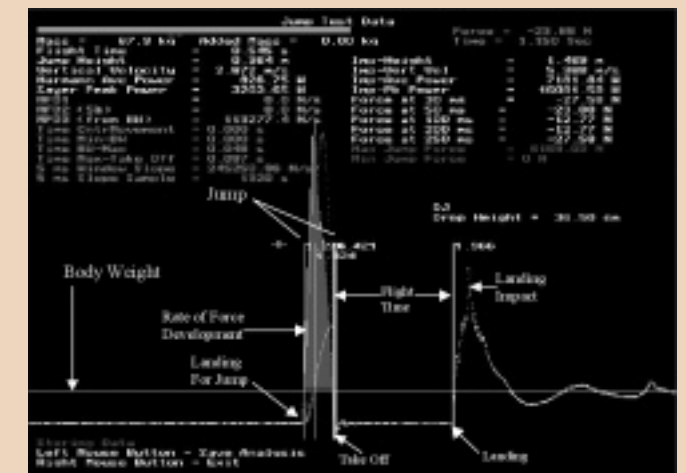


Figure 3. Drop Jump Information

### DROP JUMP (DJ)

The DJ is performed from stepping off a block (in this case from 36.5 cm) on the force platform. The athlete then "punches" or quickly rebounds to a jump upward. This type of jump is a measure of reactive (CR) and blocking (CB) abilities. This jump uses and maximizes a stretch-shortening cycle.

### WHAT IS "BETTER?"

Generally, we'd like to see a high maximum force (taller blue area), steep rate of force development (RFD) and long flight time. Flight time is directly translatable to jump height. We would like to see a jump pattern that looks like a narrow triangle.

to see a fairly narrow but high force-time curve which demonstrates superior force capability and explosive development of that force.



William A. Sands, Ph.D.

Head—Sport Biomechanics and Engineering

**S**kills have a unique signature of muscle involvement. Skilled movement requires certain muscles to be active, producing tension, while other muscles remain relaxed or semi-relaxed so that they might support movement without interfering (Basmajian & DeLuca, 1985; O’Connell & Gardner, 1963; Enoka, 1994; Clarys & Cabri, 1993). Clearly, if you contract your bicep and your tricep simultaneously (muscles on the front and back of your upper arm), movement will be hampered because these two muscles are aligned to move the forearm in opposite directions—thus they oppose each other. One of the important problems faced by coaches and athletes is knowing which muscles are active and which are not so that conditioning exercises can be designed to enhance those movements and muscles that are directly involved in a skill. Training your quadriceps (thigh) muscles with the intent of increasing your speed in a pull-up simply won’t work.



Figure 1. The Maltese.

At the Olympic Training Center in Colorado Springs, this problem has come to light among male gymnasts attempting to learn and perform a skill on the still rings called a Maltese. Imagine yourself lying prone (on your stomach) on the floor with your arms down by your sides, palms facing the floor. With straight elbows lift your entire body off the floor about an inch so that your entire body is in a straight line, parallel to the floor, but only about one inch above it and hold this position for three seconds. That is roughly what you do in a Maltese except the rings are free to move, so you have to stabilize yourself on a near frictionless support and hold your body horizontal. This is clearly, not a task for ordinary mortals. However, the Maltese is a very valuable skill for male gymnasts in international competition in terms of difficulty. Therefore, time spent learning and becoming strong enough to perform the Maltese may be worth the effort (See Figure 1).

Due largely to the high difficulty value of the Maltese, the men’s gymnastics team was curious if the drills and conditioning exercises that they’ve applied to teaching and learning the skill actually target the appropriate muscles. In order to determine which muscles are active we first performed a kinesiological (study of human motion) analysis that simply used applied anatomy to determine which muscles could possibly be involved due to their line of pull. We then applied a device called an electromyograph which involves placing skin surface electrodes over appropriate muscles and detecting the electrical activity of these muscles. If there is a lot of electrical activity (as seen on a computer screen), then the underlying muscle is active during the movement and should probably be a target for strengthening activities. If a muscle shows little or no activity we can safely ignore the muscle in conditioning exercises.

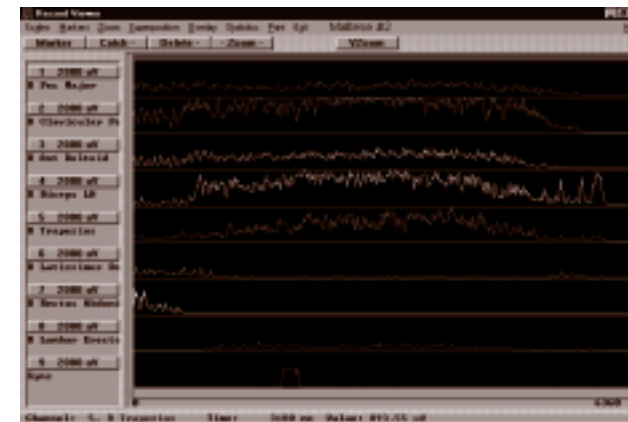


Figure 2. EMG record for a Maltese.

We began by testing the activation of the sternal portion of the pectoralis major (lower chest muscle), the clavicular portion of pectoralis major (upper chest muscle), biceps (because it is also a shoulder flexor - i.e., raises the arm forward and upward), rectus abdominus (the “six-pack” muscle on the abdomen), anterior deltoid (front shoulder muscle), upper trapezius (shoulder and neck muscle that raises the shoulder girdle), latissimus dorsei (large muscle of the back that moves the arm downward and backward), and lumbar erector spinae (central back muscle in the low back that serves to extend and stabilize the lower spine). These muscles seemed logical choices based on line of pull, and included muscles that were of interest to the coaches (i.e., rectus abdominus and latissimus dorsei) (Clarys & Cabri, 1993).

Figure 2 shows an example of the data for one athlete performing a Maltese. We were able to test four athletes on the U.S. National Team who could already perform a Maltese and thus served as the “gold-standard” for what the muscle activity for a Maltese should look like. Note in Figure 2, that the higher the squiggly line representing raw electrical activity, the greater a muscle is activated. Figure 3 shows an example of one of more than a dozen drills and exercises that were tested in order to see if the muscle activation of these teaching activities were similar to a Maltese based on whether the muscle activation pattern was the same or similar. Note in Figure 3, that in spite of being

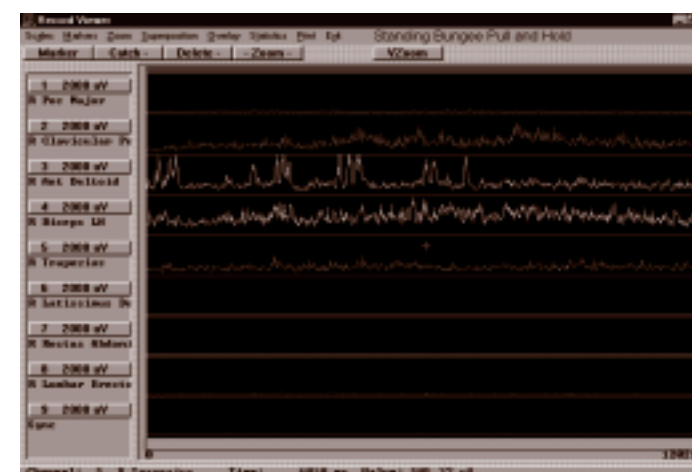


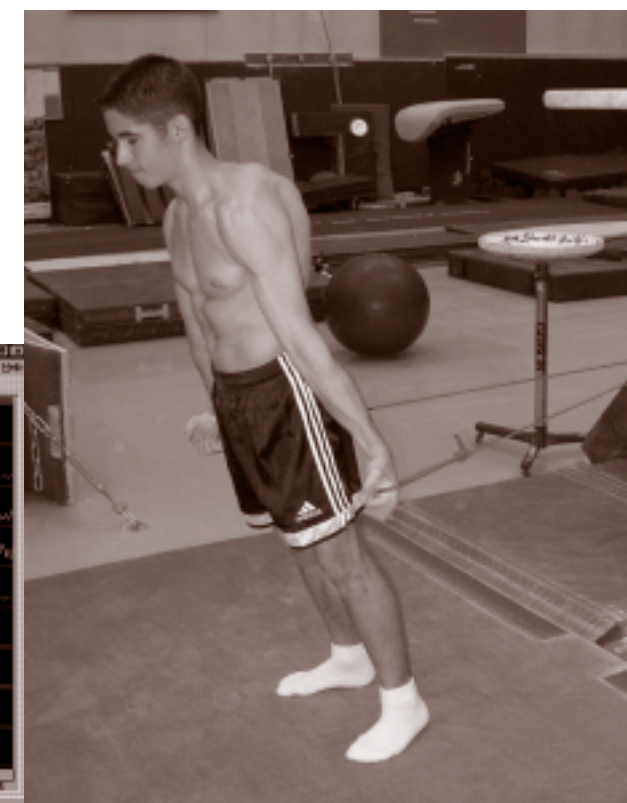
Figure 3. Pressing while standing using stretch tubing.

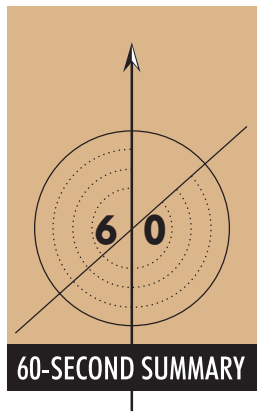
a common teaching drill for the Maltese, the muscle activation patterns are not the same as a Maltese. Coaches and athletes were somewhat surprised at times to find out that a drill that appeared to be a logical lead-up to the Maltese didn’t activate muscles in a manner similar to the Maltese.

Perhaps one of the most important things learned from this study was that when a male gymnast attempts to perform a Maltese, but fails to get his body level, he is not working some of the essential muscles used in the finished Maltese. This meant that relatively small body position deviations from horizontal resulted in not mimicking the target skill. Although coaches were often tolerant of Malteses that were a “little too high,” we found that the tolerance was not beneficial to the gymnast’s development because being a “little too high” transformed the muscle activity to something that did not mimic a real Maltese by activating the correct muscles. In other words, by altering the position (a little too high), the gymnast was doing a slightly inferior skill and he was doing a completely different skill. 📌

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## Nurturing Sport Expertise: Factors Influencing the Development of the Elite Athlete

by Joseph Baker,  
Sean Horton, Jennifer  
Robertson-Wilson and  
Michael Wall

*Journal of Sports Science and Medicine (2003)2, 1-9*  
<http://www.jssm.org>

### REVIEW

The authors have provided a review of literature concerning “training and environmental factors that influence the acquisition of sport expertise.” This is a well-written compilation of over 56 studies on the topic.

Quantity and quality are two of the crucial elements for the attainment of expertise. There are two general rules for the progression from beginner to expert in a given



area or sport. The first one was developed by Simon and Chase (1973) and is called the “10 Year Rule.” “According to the ‘10 Year Rule’, a ten year commitment to high levels of training is minimum requirement to reach expert level.” This concept has been substantiated for a number of sports.

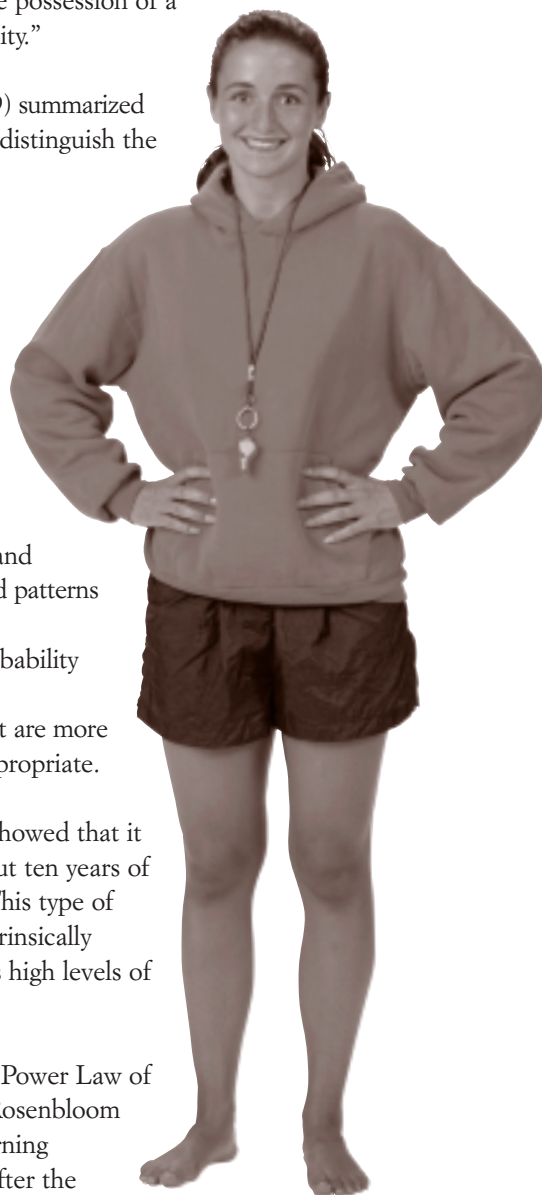
In Simon and Chase’s original study, they determined that the difference between a beginner and an expert was the manner in which they organized information. Experts are able to “organize information in more meaningful ‘chunks’ rather than the possession of a superior memory capacity.”

Singer and Janelle (1999) summarized the characteristics that distinguish the expert as follows:

1. Have greater task-specific knowledge
2. Interpret greater meaning from available information
3. Store and access information more effectively
4. Can better detect and recognize structured patterns of play
5. Use situational probability data better
6. Make decisions that are more rapid and more appropriate.

Ericsson et al. (1993) showed that it wasn’t just ten years, but ten years of “deliberate practice.” This type of practice may not be intrinsically motivating but requires high levels of focus and effort.

The second law is the “Power Law of Practice.” Newel and Rosenbloom (1991) stated that “learning occurs at a rapid rate after the



onset of practice, but that this rate of learning decreases over time as practice continues.”

The implication for the coach regarding both of these rules, is that they must continually modify activities or drills to make the athletes acquire the skill and continue to focus and refine that skill to the expert level.

Athlete’s who have access to expert coaches, gain a huge advantage. “Meticulous planning of practice is one hallmark of coaching expertise.” Voss et al. (1983) found that expert coaches spend more time planning practice and were more precise in their goals and objectives for the practice session than their non-expert counterparts.

The authors note a time motion analysis which showed that non-expert coaches spent 22% of their time on instruction, 30% in active drills and 48% in non-active practice. In a study of higher level coaches, the athletes were active 77% of the time.

In another study on coaches (Rutt-Leas and Chi, 1993), “expert coaches had the ability to extract more from the information presented (the same video-tape was presented to novice and expert coaches for review) and were able to provide fundamentally better solutions to perceived problems.” The expert coaches provided precise instruction as compared to the “superficial analysis using vague descriptions” by the novice coaches.

The more expert coaches tend to spend more time in the tactical arena versus the technical or general instructional area. Beginning coaches spent more time on technical activities.



Cote and Hay (2002) describe the beginning coach as some one who should possess “enthusiasm and facilitation skills above and beyond any technical expertise in the sport.” However, at some point, the parent will need to find a coach who has a higher level of expertise.

The question that arises from this study—does a coach need to practice coaching for ten years to become an expert coach? 🇺🇸



Far Left: Michael Phelps swims the breaststroke leg of the 20 Individual Medley prelims during the U.S. Swimming Olympic Team Trials on July 11, 2004 at the Charter All Digital Aquatic Center in Long Beach, California. (Photo by Al Bello/Getty Images) Top Left: Amy Acuff competes in the women’s High Jump Final during the U.S. Olympic Team Track & Field Trials on July 12, 2004 at the Alex G. Spanos Sports Complex in Sacramento, California. (Photo by Jamie Squire/Getty Images) Top Right: Maurice Greene crosses the finish line of the men’s 100 Meter Dash during the U.S. Olympic Team Track & Field Trials on July 11, 2004. (Photo by Matthew Stockman/Getty Images) Bottom Right: Diana Munz (L) hugs Kaitlin Sandeno after Munz won the 800-meter freestyle final and secured her spot on the 2004 Olympic team at the U.S. swimming Olympic team trials July 13, 2004.



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"Evaluation" (A variety of physical test with descriptions—GREAT SITE)—[www.brianmac.demon.co.uk/eval.htm](http://www.brianmac.demon.co.uk/eval.htm)

Nirsch Pain Phase Scale (describing athletic pain)—[www.athleticsearch.com/bonus-painscale.html](http://www.athleticsearch.com/bonus-painscale.html)

"Biochemical and immunological markers of over-training" Michael Gleeson—[www20.uludag.edu.tr/~bakan/sbtd/v2/1/v2-1.pdf](http://www20.uludag.edu.tr/~bakan/sbtd/v2/1/v2-1.pdf)

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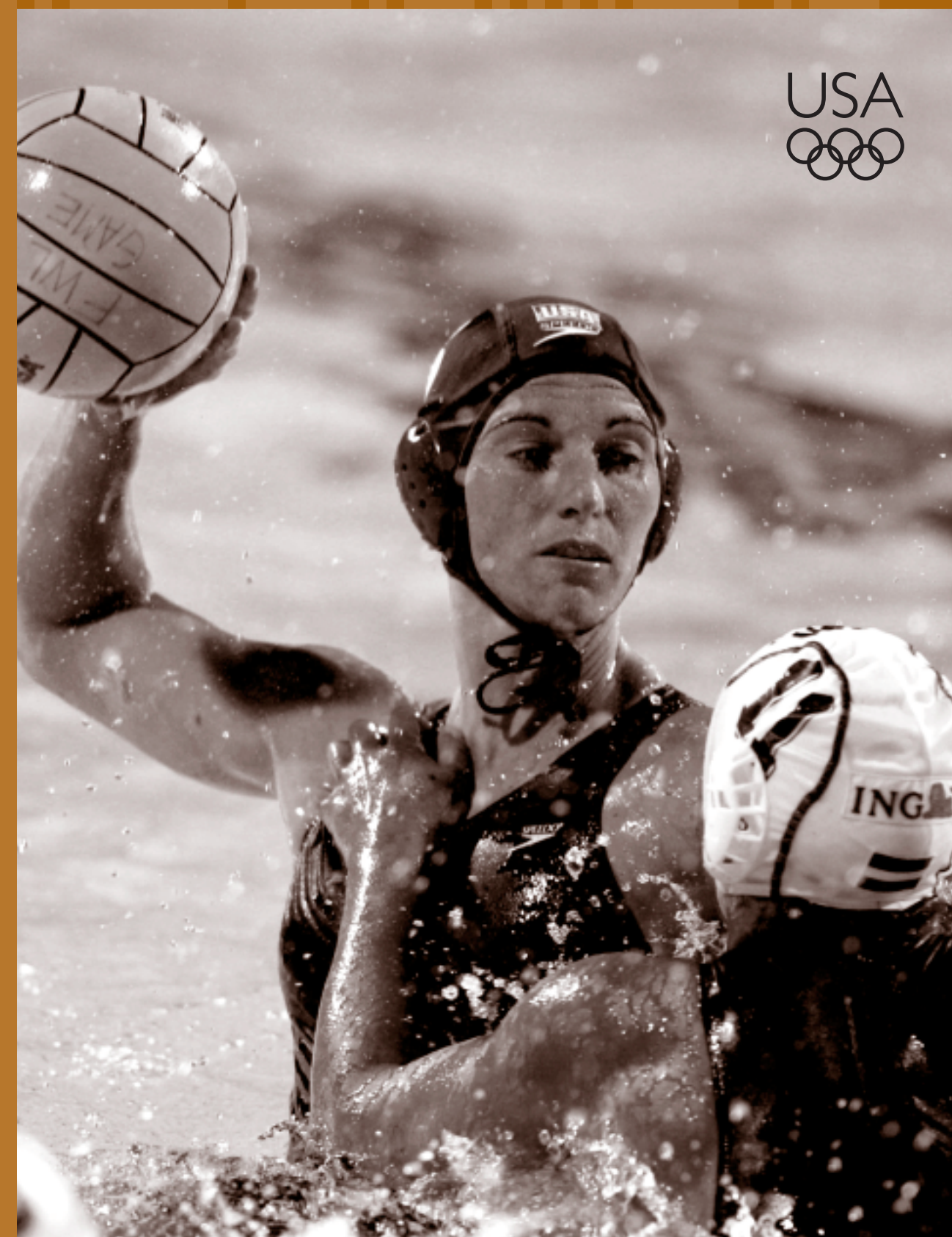
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## ERICKA LORENZ

Ericka Lorenz of the USA is defended by Agnes Valkai of Hungary during the first half of the first place game in the 2004 FINA Women's Water Polo League Super Final on June 27, 2004 in Long Beach. PHOTO BY DONALD MIRALLE/ GETTY IMAGES



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