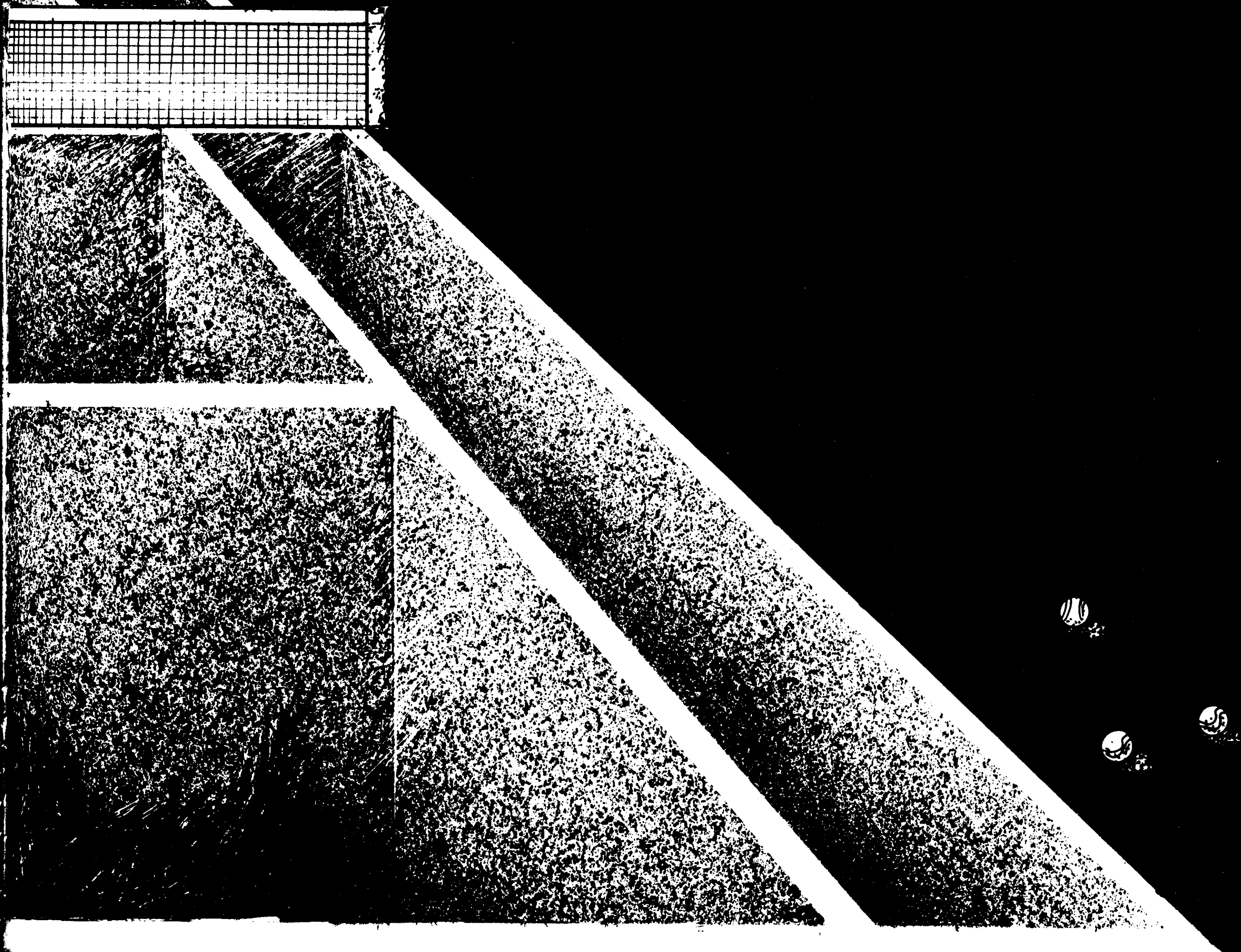
PERSONAL BEST

THE LATEST IN TRAINING FOR ATHLETIC PERFECTION

by Mark Teich and Pamela Weintraub

The world is divided into two classes of people: The few who do and the millions who wish they did. Haven't most of us brooded about the heights we *might* have achieved? If only we would have had the luxury of time, money or good fortune, wouldn't we all have followed an unswerving path to our dreams?



"Thanks to the sports science revolution the tools are out there for anyone who wants to become the best athlete he can be."

nesses. Again, this shouldn't be a shot in the dark. Just sitting down and "popping reps" on the benchpress will not guarantee anything. Like the finest athletes in the world, the rest of us can use informed guidance. And in virtually every state and most major metropolitan areas today, we can find at least one health club or training center that exercises care and precision like Lenox Hill.

For example, 26 stories above downtown Kansas City, Missouri, in the Vista Hotel, the Lifewise health club has established itself as a paragon of fitness training for surgeons, realtors and business executives alike. Working in conjunction with St. Luke's Hospital, this state-of-the-art center puts clients through a litany of rigorous scientific tests the moment they walk through the door. "We measure strength, endurance, body fat and blood fat," says exercise physiologist and nutritionist Christine Aguiar, manager of Lifewise programs in the department of health enhancements at St. Lukes. Physiologists also oversee mandatory treadmill stress tests. "Anyone over age thirty-five is tested only in the presence of a physician, and we have emergency equipment, including crash carts, in case anything goes wrong." After this extensive evaluation, Lifewise members work out on electronic and computerized machines ranging from bikes to rowers to treadmills, all of which deliver continual feedback on performance.

Aguiar also points out that it is not just high-tech, it is high touch. In other words, the atmosphere is intimate rather than grueling. For example, many of the exercise machines come with monitors that display video games and television shows. And Lifewise staffers—people with graduate degrees in exercise science, physical education or related fields—work one-on-one with club members, often monitoring their workouts every step of the way.

But conditioning can only go so far. Even the most magnificently chiseled body has to run on the right fuel. Nutrition, says Ann Grandjean, associate director of the Swanson Center for Nutrition in Omaha, Nebraska, and consultant to the U.S. Olympic Committee, has to go hand-in-hand with training. During the first meeting with Grandjean, an athlete will go through an elaborate, computerized nutritional analysis. A permanent record is then stored in the computer, and the athlete can have it updated at different times during the year.

Though her procedure varies from individual to individual and from sport to sport, Grandjean says she begins by asking every athlete to keep a three-day record of all food eaten, including such particulars as brand name and portion size. In ideal circumstances, she adds, "I also ask the athlete to record his or her diet several times throughout the year—during a buildup or heavy training phase, during the competitive season, and during the off-season. I'd also want an example of the diet at its absolute worst."

Grandjean feeds all of this information into her computer, along with the athlete's height, weight, age and sport. Her software, intricate enough to contain complete nutritional information on dozens of breakfast cereals and 45 kinds of orange juice, prints out total calories consumed, grams of carbohydrate, fat and protein in the food, and the grams, milligrams, or micrograms of specific vitamins and minerals. Through a series of bar graphs, the program quickly tells the athlete what percent of the recommended amount of each nutrient he or she is taking in.

The computer also suggests how the diet might be changed. If it is too high in fat, for instance, the computer will list the fattiest foods the athlete has eaten so he or she can avoid them. If the diet is low in niacin, the computer will list foods high in niacin.

Once the athlete knows what foods to eat, the question of how to stick to the diet still remains. Grandjean instructs competitors how to follow the computer's dictates while negotiating the jet age. "Olympic and professional athletes are traveling all the time," Grandjean says. "We teach them how to eat in the Orient or Africa, how to eat in hotel restaurants, how to eat in planes." And even when the right fare isn't on the menu, she tells her pupils to go ahead and ask for it anyway.

For those who can't make it to Omaha, Grandjean suggests investing in one of the many excellent nutritional analysis services available around the country. For around 20 dollars, many places will do a diet analysis if one simply mails them a three-day record.

Grandjean sees the day when both professional and amateur athletes will be able to tap into a computerized nutrition network that continually gets updated with the latest scientific findings. After initial counseling with a nutritionist, athletes would record their daily diet on a personal computer disc, then transfer the information to a central mainframe computer manned by experts. The computer, or the experts themselves for more complex ques-

"Soon athletes will be able to tap into a computerized nutrition network that is continually updated with the latest findings."

tions, would instantly review the data and give feedback, keeping the athletes on course.

While conditioning and nutrition serve to lay the foundation for all sports, the athlete committed to a specific sport has to build on that foundation by refining his skills. Once upon a time, that merely meant practicing a swing or pounding a ball ad infinitum as the coach or trainer looked on. Nowadays, with the advent of high-speed film and videotape, computers and digitized biomechanical analysis systems, skill training has become an increasingly precise art. Virtually all the best training centers have adopted such high-tech stratagems to study and hone performance.

In tennis, Vic Braden has been one of the most influential figures to bring this technology to bear on skills training. Notwithstanding his television persona as an affable tennis pro, Braden is dedicated to the scientific method, and he is a serious student of the minutiae of technique. At his Vic Braden Tennis College, in the lush resort community of Coto de Caza, California, he has consistently explored the most sophisticated performance technologies for educating everyone from the top competitor to the serious amateur.

Braden first realized the connection between sports and science during his youth, when he hitchhiked from his hometown of Monroe, Michigan, to see Don Budge play Bobby Riggs in Detroit. Braden had always been fascinated by the power of Budge's backhand, and he resolved to learn what made that backhand work. He punched a series of holes in some three–by–five index cards, and watched Budge play through the slits. In this way, he was able to divide Budge's body into segments, and view just one segment moving at a time. Using this ad hoc technique, he realized that his hero derived the awesome force of his backhand from the thrust of his thighs—an observation Braden has never seen made about Budge anywhere else.

That is not surprising. Until Braden came along, there was no one to cast scientific scrutiny on racquet sports. And even when Braden and his more enlightened peers began to adapt the esoteric wisdom of physics and physiology for tennis, they at first worked almost exclusively with established stars. Braden gradually concluded that serious research into tennis technique would allow world-class players to improve the precision of their game by as much as 1,000 percent. He made no bones about this, bluntly telling *Sports Illustrated* that champions such as Arthur Ashe or Chris Evert might be only one-tenth as proficient as the souped-up future stars.

Soon enough, Braden decided that his mission rested not with the small cadre of superstars, but with the nation's 160,000 to 180,000 tennis intermediates. "I just got tired of traveling from city to city trying to take care of elite athletes," he explains. I wanted to make good players out of the person on the street."

Sitting at a table in the sun at the Tennis College, Braden emphasizes his point. "I've worked with a number of physicists and engineers who could easily check out what the coach says. But most of the time, they just don't. Some coach will say, 'Throw the ball high on your serve, and you'll have a lot more time to strike it with the racquet.' Now, any physicist should know that's not true. Since the ball is dropping at the rate of gravity, the higher you throw it the faster it falls, and the less time it is in the zone of the racquet. Yet we'll have brilliant physicists come in here who have been taking that advice and throwing the ball as high as possible for years. But once in a while, one of them will scratch his head and say, 'That's not the way gravity works'."

Braden takes a research approach to training. He believes in quantifying everything his students do. The briefest walk through the rustic college grounds drives his point home. The students—suntanned, healthy men and women—appear to be like tennis players anywhere, until one notices that they are wired from head to toe. Sensors on one student's chest measure heart rate, electrodes across another one's arms, legs and face detect muscle contractions. Sonic speed guns planted along the court measure the velocity of the balls. Even the racquets are wired. Raise one too high when slamming an overhead, and it triggers an alarm. Each of these sensors is connected to telemetry, or remote measurement, devices that radio information back to a computer in the lab. Are muscle contractions during serve too intense? Is the pulse rate during rallies too accelerated? Are groundstrokes out of synch? In order to help his students, Braden has to know.

Video and high speed film also play an important part in the testing process. Once a student ventures courtside, cameras are everywhere, capturing movement, chomping it up into studyable segments and eventually spitting it out in the form of spindly green stick figures across Braden's computer screen. This "digitized" biomechanical analysis of each student's game zooms in on imperfections. Then

A digitized biomechanical analysis of a student's tennis game helps Braden to locate imperfections and refine technique..."

Braden communicates the problem and helps the student refine technique accordingly. The computer indicates in number values just how these corrections will enhance speed, power and efficiency.

"Tennis is an engineering problem," contends Braden. "If your tennis strokes are poorly engineered, and you have a great attitude, you're just a happy loser. Show me someone who's got great strokes, and it's hard to find a bad attitude. People don't often say, 'Nuts! Won again!' They can handle it. Paired with the right training, sophisticated computer technology can help almost everyone perfect his strokes in 30 days."

It can also help them to plan game strategy. The serious tennis competitor would be well advised to check out CompuTennis, created in 1984 in Palo Alto, California, by Sports Software, Inc. This remarkable system was the inspired concept of Bill Jacobson, a tennis star from the University of Cape Town in South Africa. Jacobson competed in doubles at Wimbledon in 1959, but after finishing college in the early Sixties, he went to work for IBM. He later started a company that used computers for geological exploration. Then, when his son, Mark, began playing tennis on the junior circuit in 1980, Jacobson's interest in tennis and computers merged.

Jacobson began objectively charting the hundreds of small moves and strategies that went into every game, detecting things that coaches could never discern simply by watching. Indeed, after feeding data from dozens upon dozens of matches into computers at his office, he found that coaches failed to focus on the relevant factors an astounding 80 percent of the time. The problem of serving to the ad court for instance, a problem that plagued his son, was not something a coach would have noticed, because no one had ever thought of comparing ad court serves with deuce court serves. And by using his charts to zero in on such subtleties, Jacobson found he could drastically improve a player's performance in a week or two.

Jacobson began to test his new system on a larger scale. Working with student players at two local junior colleges he proved beyond a doubt that detailed statistical analysis could indeed improve a player's game. One school ended up winning the state Junior College Championships. And at the other, Jacobson had the opportunity to work with Brad Gilbert, now one of the best players in the world.

When Jacobson started with him, Gilbert was ranked 153rd on the tour: "We discovered that his forehand, which was his main weapon and, in fact, technically superb, wasn't actually that effective during a game. We also found he needed more control of his first serve, and more time at the net." When Gilbert redirected his training and game strategy based on these insights into his performance chinks, he soon moved up to number ten in the world.

But Jacobson knew that his system still needed work. "We just weren't able to keep up with all the things we wanted to watch," he says. "At one point we had three people charting a single match by hand." So Jacobson and his company, Sports Software, Inc., went on to build a laptop computer. Working with Tom Whitney, designer of the Apple II, Jacobson came up with a data collection machine whose keys were specifically labelled to capture the nuances of the game.

On every shot, a trained data collector would enter the type of stroke, be it serve, return, volley, or groundstroke. He would push a key indicating either forehand or backhand, another to indicate the position of the player, yet another to enter the landing zone of the ball. There were even keys that could be programmed to record such esoteric information as how many times a player approached the net with a slice instead of topspin, or how many times he made a particular shot from the wrong position on the court. Finally, the operator would record the results of the shot. Jacobson's machine, dubbed the CT 120, could gather literally thousands of bits of information for a single match.

With his prototype complete, Jacobson went to see Dick Gould, tennis coach at Stanford University and began to chart the first Stanford matches in January 1983. By the end of the year, the team had improved dramatically enough to win the National Collegiate Athletic Association Championship.

From that point on, CompuTennis has continued to forge changes in the game. With his new data collection method—and his untold reams of data—Jacobson began to reanalyze how the game was played. For instance, he learned that in general players are more effective at the net than in the back court, and that goes for some of the best back court players around. Even Chris Evert, who has perennially lived and died with her groundstrokes, took the news to heart. She won the 1986 French Open largely because, after reviewing CompuTennis stats, she began approaching the net much more aggressively than usual. Jacobson had also discovered

"No computer can replace the work of the human brain—if an athlete can't control his mind, no high-tech strategy works."

that players have ten basic ways of getting to the net, and his computer analysis could tell Evert or anyone else just which approach was best.

In the past few years, unable to pass up this wealth of push-button information, Davis Cup and college team coaches have started using CompuTennis analyses not just in training, but actually to change a player's strategy mid-match. The service has also become accessible to players at all levels. Today, anyone can hire a CompuTennis representative to do the analysis for him, or rent a CT120 to do the analysis himself on a PC at home.

Not even the most complex computer brain, however, can replace the work of the human mind, and when the athlete cannot control his mind, no amount of high-tech strategy will carry him to peak performance. This vital realization, which for some reason seemed to escape athletes and coaches for decades, has recently led to a full-blown sport psychology revolution. All Olympians now have access to sport psychologists—many travel with their own private psychologists—and several pro and college teams have hired year-round team psychologists.

The most celebrated youth tennis camp in America, the Nick Bollettieri Tennis Academy in Bradenton, Florida, now has a resident psychologist, tennis pro James E. Loehr, the well-respected author of *Mental Toughness.* Through his years of research, Loehr has found that a balanced emotional state virtually always accompanies athletic success. "This emotional state doesn't come because you play well," Loehr says. "Instead, it induces a set of physiological changes that improves your level of play."

According to Loehr, most of these physiological changes can be traced to swings in the hormones and neurotransmitters, brain hormones, that affect everything from alertness and concentration to depression. An increase in the brain hormone serotonin, for instance, causes drowsiness. An increase in the stress hormones tightens muscles, decreases bloodflow to the extremities and increases respiration and heart rate, all obstacles that impede performance.

Based on this knowledge, Loehr has developed a training program geared toward 'mental toughness'—defined by him as a sort of super self-control that enables athletes to focus their attention, manage pressure, maintain a positive, winning attitude and control their energy, all without missing a beat. "We are coming to understand that the mentally tough athlete not only controls his emotions more precisely," Loehr explains, "but also his actual chemistry—the physiological and biological balance that makes one stronger and faster at some times than at others."

If Loehr can use his notion of mental toughness to help athletes control their inner chemistry, it is because he has found a window into the body. That window is the beating of the heart. He has learned, for instance, that most people sustain a more balanced body chemistry and better performance within a narrow range of heart rate. He has also learned that the best tennis players show a rise in heart rate during points and a drop in between. The rise indicates arousal, crucial for the highest level of play. The drop indicates confidence and inner calm, qualities that always boost performance in a game.

To help his players reach their peak, Loehr videotapes their performance and simultaneously records their heart rate. He then compares heart patterns to the action in the video and to a computerized, statistical analysis of every point of the match. He thus learns which heart rate is associated with unforced errors, which is associated with passing shots and which with winning serves.

"What's your heart rate when you play your best points?" Loehr asks. "What happens to your heartrate when you get angry? When you give up? When you become excessively nervous, consumed with the chemistry of fear?" Depending on age, fitness and unique physiology, the answers will vary with each individual. But once the athlete's heart rate patterns have been deciphered, Loehr's mental toughness training can begin.

By charting his students' heart rates with a heart monitor during games—and beeping them whenever they depart from the ideal—Loehr helps them adjust their internal rhythms, usually through a series of regulated techniques. One player whose heart rate stayed depressed during points, for instance, was instructed to bounce on his feet before serving or receiving, and to let out his breath when the racquet hit the ball. The result: His heart rate and his level of arousal increased and his performance improved. Players who need to lower their heart rate, on the other hand, are asked to wait an extra second or two between points, perhaps repeating a calming phrase.

"In general, the physical body and the emotional feeling states are almost inseparable. If you feel no energy, if you feel a little wimpy, your heart rate will be reduced, your hormone levels will be off balance, and your performance will be poor. I teach my students to act confident no matter how they feel.

"An athlete never succeeds just because his endurance is good or his legs are strong—what matters is a complex byplay..."

I'm teaching acting skills. It's phony in the beginning, but eventually the act becomes a trigger, inducing the correct emotions, the correct heart rate and a better level of play," states Loehr.

Even after the athlete has prepared himself, though, he cannot play his best without an equipment overhaul, too. At the forefront of the sports technology revolution is Wilson Sporting Goods in River Grove, Illinois. These days, Wilson uses millions of dollars worth of computer-aided design and manufacturing (CAD-CAM) systems to create easier-to-use equipment in a variety of sports. In CAD-CAM, the computer designs the equipment, then transmits those design parameters directly to the machine tools. The machine tools produce the equipment without need for a complex series of engineering sketches and molds.

Tennis racquets, especially, have been improved immensely through CAD-CAM. Everyone knows, of course, that tennis racquets have seen a powerful evolution in the past 15 years. Back in the early Seventies, most players were using wooden racquets. By 1975, manufacturers were introducing lighter, stronger racquets made of space-age composites from graphite to boron to Kevlar. Boron, for instance, was 20 times stronger and stiffer than traditional wood. And in 1976, Howard Head, founder of the Head Ski Company, introduced the first oversize Prince racquet, with four times the sweet spot of conventional models. The early Eighties saw infinite variations on that theme: The mid-size racquet, which offered players more control than the oversize one, and racquets with V-shaped throats to increase the elongation of the sweet spot.

It is CAD-CAM, however, that will define the racquet of the late 1980s and beyond. As Bill Dillon, Wilson computer design manager, explains it: "The tennis racquet is essentially a series of tangents, or arcs, connected together. CAD is terrific at generating and then analyzing those tangent arcs." The computer does this with what is known as finite element analysis—a software system that breaks the complex racquet structure down to small, cube-like elements called bricks. In doing so, the computer can measure such properties as stress, strain and flexion from one section of the racquet to the next.

The Wilson engineers usually start with a general racquet design, including approximate head shape and size. They program these characteristics into the computer, then use CAD to learn, for instance, where the racquet might deflect on impact, or what stress loads the structure can or cannot take. They use this information to decide what combination of composite materials to use (boron, Kevlar, graphite, silicon carbide, etc.) Then they do further analysis to learn exactly how each fiber in the racquet should be angled for maximum strength. Finally, the computer helps the engineers determine how all the component parts might best fit together: The grommet strip that protects the strings, the 64 holes that encircle the racquet, the handle and the head.

After the racquet itself is designed, Wilson engineers cast their scrutiny on the strings. The goal is to string the racquet so stress is distributed throughout. CAD can do that easily, by color coding levels of stress. The computer represents the hot spots—the high stress regions—as red or magenta and the lower stress areas appear as cooler blues and grays. One design appears on the screen, screeching with red. Dillon pushes a few buttons, slightly altering the string pattern, and the red melts into gray. "With a casual glance at the picture, we can see which design is best," he says.

The result of all this, of course, is not one new and improved racquet, but rather, a line of racquets that serves many different people in many different ways. With the ability to design racquets that cater to individuality, the next step is custom design. Toward that end, Wilson is considering a "Custom-Fit Program" in which people come in with their particular needs to have a personal racquet designed on the screen. The step after that, Dillon adds, is taking high-speed film of customers before the racquet is designed to accurately determine their biomechanical needs. Some of these new racquets may be so sophisticated that players will adjust their characteristics during play. Instead of stringing their racquets at fixed tension, for instance, future athletes will use a computerized system installed on the racquet to constantly adjust tension during play. Players will thus be able to choose one tension for serving, then another when charging the net.

No matter how the athlete ultimately harnesses technology, it is important to remember that innate talent and drive are still the most important determinants of success. Two-time Olympic hurdling champion Edwin Moses, a trained engineer who has continually used computers, high-speed film and other intricate scientific stratagems in shaping his career, says simply that the athlete himself will always be the irreducible force. "You can't use science to manufacture an athlete. Raw talent still beats mass production. My scientific approach just makes it easier to accomplish what I do."