Biomechanics: A Laboratory for Jocks

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Biomechanics: A Laboratory for Jocks

This article by Bruce Schechter, published in Discover in February 1981, discusses the work of Vic Braden, a renowned tennis teacher, and Gideon Ariel, a former Olympian and creator of computerized biomedical analysis. Together, they opened the Coto Research Center (CRC) in Coto de Caza, California, a state-of-the-art sports complex equipped with high-speed movie cameras and digital computers.

The CRC is designed to improve athletes' performance by monitoring their heart rates, motions, and exertion levels during a match. It also features special headgear that allows Braden to determine exactly where the player is looking. The center's advanced technology also extends to runners, with force-sensing plates hidden around the track to record the mechanics of their stride and footwork.

Braden and Ariel's work also includes talent-recognition testing, aiming to identify future sports superstars at an early stage. Despite potential controversy around creating "test tube" athletes, Braden insists that their goal is to provide young athletes with the best information available to help them reach their maximum potential in sports.

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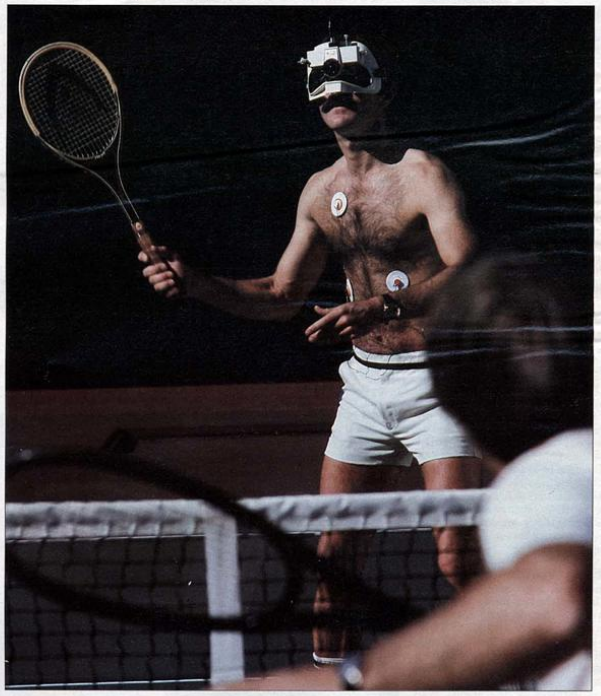
BIOMEDICINE

A LABORATORY FOR JOCKS



Tennis professor Vic Braden wires athletes and their playing fields to improve performance

by BRUCE SCHECHTER

Tennis player, left, at the Coto Research Center in Coto de Caza, California, is wired for action. Right, a computer's-eye view of a tennis player practicing his stroke

Tennis star Don Budge had a secret, and Vic Braden wanted to know what it was. Though Budge in the 1940s routinely played in broad daylight before large crowds, no one had ever understood how he was able to put so much power into his backhand shots. Braden, though still a youngster at the time, had within him the seeds of a tennis researcher. He hitchhiked from his home in Monroe, Michigan, to Detroit, where Budge was to play Bobby Riggs. By observing the action through holes punched in a set of three-by-five index cards, Braden was able to watch isolated parts of Budge's body. "I realized," recalls Braden, "that Budge drew the power for that great backhand from his thighs. I'd never seen that stated anywhere else. Don probably didn't know it himself."

Vic Braden, considered by many to be the best tennis teacher in the world, is still in the business of telling athletes what they do not know. But now, instead of index cards, he uses high-speed movie cameras and digital computers. Last November he and Gideon Ariel, a former Olympian and creator of computerized biomedical analysis, opened the $1.2 million Coto Research Center (CRC) in the recreation-resort community of Coto de Caza, 70 miles south of Los Angeles. For three decades Braden had dreamed of having such a laboratory. "I've always wanted answers I could trust," he told correspondent Bill Bruns, "not the guesswork of a coach or a player."

At first glance, the Coto Research Center looks like an ordinary, but rather posh, health club: a pair of what appear to be vacationers are having a leisurely rally on the tennis court, while a solitary jogger runs laps on a two-lane track that encircles the court. Adjacent to the court and track is a two-story clubhouse. The court is set off in a grassy amphitheater. But a closer look reveals what may be the most advanced technological sports complex in the world—a capitalistic answer to the renowned sports facility in Leipzig, East Germany.

Sensors on the chests of the tennis players are connected to lightweight telemetry devices that transmit their heart rates to a computer in the clubhouse, where a cardiologist can monitor what is happening during a match. Simultaneously, eight sonar-like sensing devices that sit around the court like owlish line judges feed the computer with information about the players' motions, which tells the doctor how hard they are exerting themselves. Braden can also fit an athlete with special headgear, reminiscent of Darth Vader, which contains a complex set of lenses that enable Braden to determine exactly where the player is looking. The device is fitted with a light source that bounces light off the pupils of the eyes and into a camera at the back of the helmet; the camera commands the same field of vision as the player. When the film is developed, a bright spot of light indicates exactly where his eyes were focused.

Runners can also wear a telemetry device—doing away with treadmill testing—while the mechanics of their stride and footwork are recorded by force-sensing plates hidden at five locations around the track. The track curves into the building, allowing for all-weather testing and high-speed filming.

Inside the building is a collection of computer-age machinery designed by Ariel, who is the director of the center, that will be used to help the professional as well as the hacker to be more efficient, more capable, and less vulnerable to injury in his sport. "We are very concerned about relating all of our research findings to the masses," says Ariel. "Our theory is that everybody is a gold medalist in his or her own body, so we want to try to allow people to reach their maximum potential in sports."

With the CRC, Vic Braden may have finally reached his maximum potential as tennis teacher *extraordinaire*. In 1971, after years of being what amounted to a cult figure in the tennis community, he opened up his own tennis school. There he taught thousands of people the fine points of the game of tennis. Before establishing the school, he pursued some of his own pet projects, often at his own expense. These included teaching blind children to play tennis. He invented a system that enabled him to call out to a blind child the position at which the ball could be hit; the child would then swing—and often connect. "My problem has always been that my ideas for research greatly outnumber my income," he laments. The bigwigs of the tennis world could not have cared less. One dubious official asked him, "What can you research in tennis, anyway?" Braden put down

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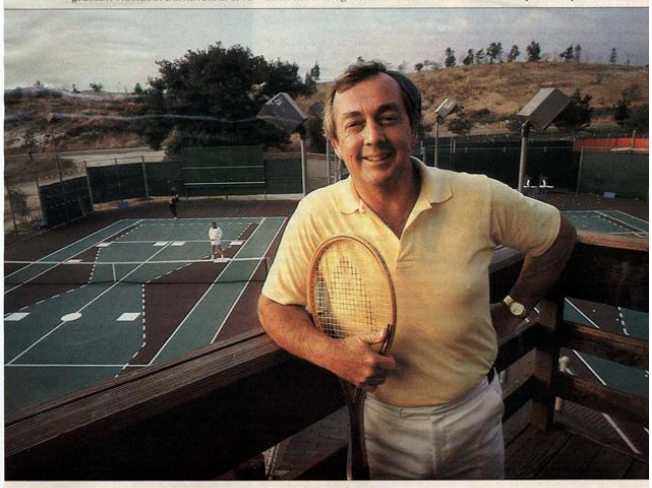
a conservative list of ideas that he wanted to investigate or confirm, and how much research time each project would require. The total research time came to 176 years.

Yet it was the sport of tennis that eventually got the research center built. "When I came here to Coto de Caza in 1974, my deal with the owners of the property was that if I could generate a certain profit with the tennis college, they would take an interest in the research center." The college thrived, and Braden's bosses—currently Arvida Corporation, the developers of Boca Raton in Florida—honored their commitment. What clinched the deal, Braden admits, was the technical expertise of his assistant: "I needed Gideon to provide the extra punch."

Ariel, a burly Israeli who competed in the 1960 and 1964 Olympics as a discus thrower and shot-putter, was still a graduate student at Dartmouth in 1971 when he founded his own company, Computerized Biomechanical Analysis, Inc., which made use of the college's newly instituted time-sharing computer system. Then Ariel moved to the University of Massachusetts, where he used that school's computer to refine his system of biomechanical analysis. In 1975, after reading a SPORTS ILLUSTRATED profile of Braden, Ariel called and arranged a meeting at Coto de Caza. Braden recalls, "I was already involved in high-speed cinematography, and I was discovering that many things being said about sports techniques by a lot of big names were simply not true—and terribly misleading. Then I met Gideon, who was already one step ahead of me by computerizing what was actually happening, working off high-speed film. So it was a perfect marriage. We started talking about our dreams for a research center at about four in the afternoon, and when I thought it was time for dinner, it was about three in the morning. We were ten or fifteen years ahead, thinking about what was going to happen to sports, and the kind of research we could be doing," recalls Ariel. "I told Vic I couldn't see a better place in the world to have a research center like this. It took us five more years, but we had this dream and we didn't let it go until it happened. Now we must make it work."

If enthusiasm and ingenuity are enough to make it work, then the Coto Research Center will triumph. The two-story building houses comprehensive computer-equipment hubs, laboratories, exercise and workout areas, shower facilities, offices, and conference and projection rooms. About the only thing that it does not

Tennis teacher *extraordinaire* Vic Braden at his sports complex



have is room for improvement.

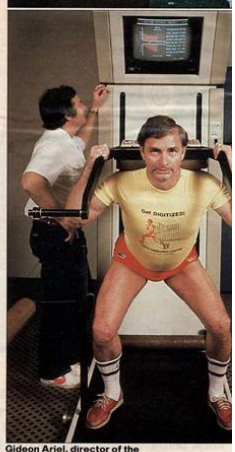
One of the unique aspects of the center is that an athlete can be filmed inside the facility, close to all the monitoring equipment, while performing in a realistic situation. A net comes down from the roof, allowing the athlete actually to hit a golf ball, pitch a baseball, throw a discus, or even, presumably, toss a caber. There is a trap door in the roof to allow filming from above, which provides an excellent perspective for studying the efficiency of body movement. Placing an athlete in laboratory conditions turns out to be the ideal way to assess his performance. Explains Ariel, "He doesn't have to concern himself with distance or accuracy. He just focuses on technique."

But Braden and Ariel also plan to monitor top athletes in competition, taking their high-speed cameras to track meets, tennis tournaments, basketball games, and other athletic events to film their students under stress. Braden, who holds a graduate degree in psychology, is interested in knowing what happens "when the adrenaline is flowing differently. When we take an athlete into the lab, does he perform and execute the same way?"

The system that allows these differences to be gauged accurately is a product of both modern technology and a century-old solution to the problem of the hand being quicker than the eye—as are the foot and the arm and the leg. In 1872 Leland Stanford, the founder of Stanford University, bet a friend $25,000 that a race horse at one point during his running gait had all four feet off the ground. To settle the bet, the two men hired Eadweard Muybridge, a well known photographer of the period, to take pictures that would either confirm or refute Stanford's hypothesis. In those days the wet-plate photographic process was too slow to provide proof, but Muybridge persisted and in 1878 set up a series of 12 cameras that were triggered successively as a galloping mare broke through a series of fine black threads. The resulting photographs proved conclusively that Stanford was right; at one point in each cycle of the gait of a galloping horse, all four legs are indeed off the ground. More than 100 years later, Ariel and Braden filmed Spectacular Bid, the 1979 winner of the Triple Crown, in action. Instead of 12 photographs they took thousands, which not only confirmed Stanford's conjecture but unambiguously showed the Thoroughbred's owners why Spectacular Bid was so spectacular. Since the results of this research could be valuable to handicappers and trainers, Spectacular Bid's owners—who paid for the research—have decided to keep it top secret.

Filming is the first of a series of carefully coordinated steps in the analytical process at Coto. After the film is developed, it is scanned and fed into a computer-digitizer. This process produces little stick figures, enabling Ariel to study an athlete's motions in sequence on the computer screen in three dimensions. He can compare this motion with that of a "model" motion stored in the computer's memory—a tennis stroke, say—and then suggest corrections. Biomechanical analysis by the computer reveals how the motion can be changed in order to achieve the greatest effect. "For example," explains Ariel, "in trying to optimize the performance of an athlete like Jack Nicklaus, once we had his basic swing digitized, we could begin experimenting right on the screen. We might say, 'Jack, we really think you could hit the ball farther by putting your knees in a different position.' We would change the stick figures and the computer could then calculate if we were right. Knowing this, Nicklaus could go to work on adopting a different knee position. He doesn't even have to hit the ball, and we can tell him if this change can help." To prove this principle, Braden and Ariel have begun similar analysis and training of Tim Gullikson, who is rated number 46 in the rankings of the world's top tennis players. If Tim takes to the training, Braden believes, he could soon be giving the likes of Borg, McEnroe, and Connors a run for their money.

One area of research by Ariel and Braden that is certain to be controversial is their work in talent-recognition testing, the early identification of sports superstars. The Soviets and East Germans, in particular, are already using such testing, but many Americans rebel against the idea of "test tube" athletes. In answer to the question, "Do you really want to make robots out of athletes?" Braden replies, "I feel that we owe every youngster proper exposure to the best information we have available. If we're going to make measurements (and every coach does), let's make the best and then give the data to the youngster, the parents, and the coach involved. My goal has always been to create independent thinkers, not robots." ▣



Gideon Ariel, director of the Coto Research Center, measures a golfer's swing (top), and gauges an athlete's strength at the computerized weight machine