Chapter 16: The Coto Research Center

In 1975, Vic Braden, a friendly-appearing man with a cherubic smile and a sunny disposition walked into my Amherst lab. I had never met Vic before this meeting, but I had heard several stories about him. Vic attained his degree as a psychologist from Kalamazoo College in Kalamazoo, Michigan, and advanced degrees from UCLA and California State, but he achieved greater fame in tennis. He was introduced to tennis at the age of 12 and had been quoted in Sports Illustrated about hitching a ride to Detroit to watch Don Budge play Bobby Riggs. His reason for the trek was to discover how Budge hit his backhand. While a student at Kalamazoo College he had served as the captain of the tennis team.

As Vic was relating these and other stories during that first Amherst visit, he described his crazy work history that began when he was very young. In fact, during college, he had lived in an upstairs closet in the athletic facility because he could not afford to live in the dorm. Times may have been
After a short time chatting with this charming, funny man, I silently wondered what he was doing in my lab. I was a discus thrower, not a tennis player. When I finally was able to ask why he was in Amherst, Vic said that he wanted me to explain a statement that I had made in one of the tennis magazines. In the article, I had described that the biomechanical analysis about a “top spin” did not mean that you hit the tennis ball on its top. In most tennis strokes, the racket face was relatively perpendicular to the ground and the swing from back to front roughly maintained that orientation. However, a “top spin” was created by tangentially hitting the ball with the racket.

To create a “top spin”, the racket moves from below the ball with an upward movement so that the racket contacts the ball with the racket face at an angle. The racket movement begins below the ball and then swings upward hitting the ball as the racket continues in the upward angle. The racket moves from below the ball up towards the sky rather than hitting from behind and continuing towards the net with the racket face nearly perpendicular to the ground which is how one would execute a normal, flat tennis stroke. The racket never “rolls” over the ball.

In the magazine article, my statement continued by describing that, “If you roll the racket over the ball, the ball will hit you on your big toe.” This was somewhat of an exaggeration about hitting yourself in the foot but I wanted to help the reader understand that the ball was on the racket for only a few milliseconds and was hit with a different movement pattern to create “top spin.” The racket face had to be properly angled to hit a “top spin”. The racket face had to be properly angled to hit a “top spin”. The racket face had to be properly angled to hit a “top spin”. The racket face had to be properly angled to hit a “top spin”. The racket face had to be properly angled to hit a “top spin”. Any movement of the arm and racket after the few milliseconds when the ball was in contact with the racket face was purely theatrical. It might look

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The Discus Thrower and his Dream Factory

Gideon Ariel & M. Ann Penny Ariel

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The Computerized Tennis Lanes and the Vic Braden Tennis College
http://arielnet.com/ref/go/4018

Ball-Racket Orientation
http://arielnet.com/ref/go/2774

Surface effect on ball spin
http://arielnet.com/ref/go/2776
impressive but it had no effect on the flight of the ball. Also, there is only a narrow range of angular displacement of the racket face in which the ball would land in the court of play.

In addition to how the racket is swung and impacts the ball, the friction that the ground imparts on the ball at contact affects how the ball will react. The ball travels through the air with a spin caused by the ground and subsequent racket contact affects this spin. In most cases, the return ball hits the ground on the opponent’s side of the court and reversed its spin. This looked like a top spin to the average player. Professional tennis players, such as Björn Borg or Rafael Nadal, are able to swing their rackets with such precision and pace that they can change the spin of the ball on impact. This skill is usually beyond the ability of the average tennis player.

Only minutes after I explained my “top spin” conclusion, Vic suddenly asked me, “Do you play tennis at all?”

“No,” I replied.

“Well, how were you able to come to such an unusual and unexpected comment about ‘top spin’?” he asked?

Ann and I gave Vic and his wife, Melody, a tour of our laboratory including the digitizing process, the force plate, and all of the three-dimensional capabilities that we had. Also, we showed them some of the research we had done for Spalding and AMF using high-speed film. Some of the 10,000 frames per second films of the tennis ball impacting the floor and sliding like a pancake as well as the tremendous distortions and vibrations the racket exhibited after being struck by the tennis ball were amazing even to a knowledgeable tennis man like Vic. We were able to answer every question he posed or described the research project that would be able to determine the answer his query.

After many hours, Vic suggested that we continue our conversation during dinner. Ann, Melody, Vic, and I talked non-stop as we drove. We discussed additional research.
Working on Tennis Rackets and Balls with AMF, Spalding and Wilson Sporting Goods
http://arielnet.com/ref/go/2777

Bill Toomey
http://arielnet.com/ref/go/1217

Merry Bignal
http://arielnet.com/ref/go/2779
projects we had performed including the development of the large head tennis racket and the differences in stringing options between gut and nylon. The large head on a tennis racket allowed the “center of percussion” to be closer to the hand for better control. The use of nylon as a stringing option was relatively new to the tennis world. We had also been involved in a research project to develop a pressure-less tennis ball. Traditional balls were sold in pressurized cans and Spalding had contracted us to develop tennis balls that maintained the same level of performance but which did not require pressure. We had accomplished this task and Spalding was marketing them as the “Australian” tennis ball.

At some point during the evening, Vic asked, “Would you like to come to my tennis college in Coto de Caza and meet the students and staff? You will also have a chance to look around the area. I think that you will love the beautiful climate and place where my facility is located. It has been called the hidden Shangri-La of Orange County” he said. We agreed that the next time I had to travel on business for the Universal Gym Company in Fresno, I would rent a car and visit him.

About a month later, I had to travel to Fresno, California to work on one of the Universal projects. I called Vic to ar-
range the meeting and he gave me directions from the airport to his tennis college.

On this trip, I had separately arranged to get together with my friend, Bill Toomey. Bill was the 1968 Olympics decathlon champion and had been named Athlete of the Year on ABC’s “Wide World of Sports”. The following year, he received the James E. Sullivan Award as the top amateur athlete in the U.S.. Bill was a terrific person and possessed a fantastic sense of humor. When we were together, I usually laughed so much that my sides hurt.

When we drove to Coto De Caza we thought we lost our way. I called Vic and told him that I thought we got lost. He answered: “then you are on the right way…” The photographs on these pages show what we saw when we arrived:

Bill had married Mary Bignal-Rand in 1969. Mary Bignal had competed in the 1960 Olympics in Rome and, therefore, was one of the foreign athletes invited to participate in the Maccabiah Games in Israel. She traveled with her British teammates to Israel in 1961 to compete in the Games during which I threw the shot put and discus. I was completely enthralled with her beauty and athletic abilities at the time and was proud to show my friends the picture of Mary and me that appeared in the Israeli newspapers. Mary was an incredible athlete. She won the gold medal in the long jump in the Tokyo Olympics and broke the world record. She also won the silver medal in the pentathlon and a bronze medal in the 4 x 100 m relay. Mary is the only female British athlete to win three medals in a single Olympic game.

Before marrying Bill, she had been married to oarsman Sid Rand, whom she agreed to marry after knowing him for only three days. They married five weeks later and had a daughter, Alison. The marriage lasted five years. In December 1969, she married Bill Toomey and this marriage lasted 22 years. When I visited them in Laguna Beach, California, they had two adorable daughters, Samantha, and Sarah.

I stayed with Bill and Mary the evening before we drove to Coto de Caza to see Vic Braden and his tennis college. As usual, Bill had me in stitches, laughing about stories from his track past. There were times that I had to beg him to stop so I could catch my breath.

Cook’s Corner
http://arielnet.com/ref/go/2780
The next morning, we left Bill and Mary’s beautiful beachside home in Bill’s vintage Rolls Royce. In the middle of the 1970s, Orange County in California was populated along the coast but, as you traveled away from the ocean, the land was covered primarily with citrus groves. There were few homes—and even fewer businesses—as the small roads led away from the beach. The narrow county road which led away from the newly constructed interstate highway twisted and turned between citrus groves and hilly terrain covered with untamed patches of sparse wild grass and cactus. The smells from the flowering citrus trees were divine and reminded me of my childhood in Israel.

Eventually, Bill turned right from the county road onto an even smaller side road. At the intersection, we noticed a ramshackle building with a sign “Cooks Corner” atop the structure. In front of the building were 50 to 60 Harley-Davidson motorcycles and riders wearing leather jackets, large helmets, and more than a few tattoos. There were more men than women, but the females had the same type of black leather, big helmets and were riding the same massive motorcycles. I could imagine this being a very scary corner on the weekend when even more bikers would roar up on their Harley’s and head for the beer inside. I assumed that Bill was lost, but he assured me that we were on the proper road.

Probably my jaw had dropped, and my eyes widen as we passed Cook’s Corner because Bill chuckled at my disbelief. “They are usually a happy group” he explained. “That is until Sunday night when they come back down the hill after a weekend of beer and other activities. Then they are either belligerent or extremely docile. The police and their paddy wagons are usually waiting for them to prevent problems with drunk drivers.”
Bill and I continued our drive past Cook’s Corner on a small narrow road that curved its way up the hill. At the crest was a magnificent expanse of wild flowers of yellows and pinks that was breathtaking in its beauty. The road plunged down just after the crest and became the most crooked road I had ever seen. Almost immediately, we were sheltered by a vast canopy of oak trees so thickly spaced that little sun penetrated through the leaves. I was beginning to realize that California was truly a beautiful and amazing place!

Our car passed from beneath the canopy of oak trees and, then, this crazy road changed again. Now we were driving in a flat valley through a county park, passed several paddy docks with relaxed horses watching us drive by, and then we traversed a dry creek bed. Little did I know that during the rainy season this road could become a raging torrent of water rather than a normal transportation corridor. The road climbed a small hill of S curves and switchbacks and then opened onto a wide spacious pasture with occasional cows and even a few small deer. I was, by now, speechless with the changes in the land and the beautiful scenes that seem to greet me at every turn.

Finally, we arrived at a small, wooden “guard” gate. Our names were listed on the log, so into the valley we drove. I gasped again at the beauty of this protected valley that opened out in front of me. There were hills, wildflowers, fences, and even windmills! California landscapes were entirely different from those which I had experienced in Wyoming or Massachusetts. Those states had greener trees and they grew in more prolific “forests”. Here in the drier western U.S., each large oak tree with vast branches which appeared to drape and shelter the ground below was isolated and stood majestically in a field alone. The hills, flowers, trees, cactus, and wild grasses repeated themselves in many permutations but with each vista uniquely beautiful. I was enthralled by it all.

I had to pinch myself to make sure I was not dreaming. Every place I looked was beautiful. We had eaten breakfast at Bill’s house while watching the surf pound the sand. Now, only 20 minutes’ drive eastward, we were in a tranquil valley of wildflowers, large, graceful trees, and, suddenly, a deer appeared at the edge of the oak grove. Bill told me that in this section of California, you could drive 2 hours in the morning to ski in the snow, and then drive back to the beach in the afternoon to bask in sunny 75-degree temperatures. At night, you could play tennis on lighted courts and there were no bugs! By now, I was sure that all of this was just a dream and I must be nearing the end! These images and unbelievably beautiful vistas could not be true. They must be dreams, mirages, or maybe hallucinations!

We drove about 5 minutes down into the valley and arrived at the Vic Braden Tennis College. We parked in front of a sprawling wooden building reminiscent of the old West, but nicely modern in upkeep with grass and trees in front. This was the clubhouse which housed the front desk for checking into the hotel, the restaurant, and showers and changing rooms. Behind and beyond this building was the swimming pool. Just beyond the pool was Vic Braden’s Tennis College.

Vic met us at the clubhouse. He gave us a tour of that building and then of his tennis college. Vic had a creative and interesting educational center. Several courts had video cameras positioned to film the students during and after their instruction period. Then the instructor would show them what their swing looked like as well as what they should do to change or improve their performance. Surprisingly, some students denied that they were the ones on the screen! Even with an accurate comparison of their attire, some students refused to accept the assessment of their swings!

Another unique educational tool was a circular series of pie segments. At the center of the circle were a series of ball throwing machines. Tennis balls would be projected towards the player who was positioned at the far end of one of the pie segments. With this arrangement, each player could practice hitting balls at different speeds according to their ability levels. The balls would be channeled back to the center of the circle for continual ball throwing cycles. The instructor could walk behind each of the players and give individualized corrections without interrupting the other hitters. It was an ingenious and efficient technique.

We were also shown a large meeting room. Vic began each day with his entertainment and informative speech. Lectures and films were shown and small groups could meet for verbal instructions before going out onto the courts to practice and receive additional instruction.
Chapter 16: The Coto Research Center

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After the tour that first day, Bill and I sat together in a small conference room near Vic’s office and talked. Bill told Vic about our work with the Olympic Committee and some of the projects that he and I had worked on during the last few years. However, I was unable to focus on the conversation and finally, I asked Vic if I could call Ann. It was 2 o’clock in the afternoon in California and 5 o’clock in Amherst. With a knowing impish grin, he handed me a phone.

“Ann, you would not believe this place. Please jump on a plane tomorrow morning and come.”

“Are you crazy?” she answered. “I have to finish digitizing which will take many days to complete.”

“You must come, please. I have found our future home whether we have a job here or not. You must come. This is it. I persisted. “You will not believe me unless you see for yourself and I am willing to risk the lost days. I know you will make up the time.”

The three of us returned to our discussion about the future of sports medicine and sports athletics until late at night. Bill finally stood up and said that his wife would kill him if we did not get back soon. I believe each of us was surprised to discover how much time had passed as we had been so enthralled in our conversation. Bill and I said our goodbyes to Vic and drove the crazy road back to his house at the beach. I was so exhausted that by the time my head hit the pillow even the exciting events of the day could not keep me awake.

The next morning, I drove my rental car to the then tiny Orange County Airport to get Ann. As we drove past the same citrus trees I had seen the day before, she said, “Gideon, this seems a little insane.”

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The next morning, I drove my rental car to the then tiny Orange County Airport to get Ann. As we drove past the same citrus trees I had seen the day before, she said, “Gideon, this seems a little insane.” But I told her to watch the scenery and decide later. Despite the difficult road and its constantly changing character, I found Coto de Caza. As I anticipated, Ann’s eyes began to widen with awe. My nature-loving partner was as shocked and inspired as I had been and her
reaction was what I had expected. As we drove through the rolling hills, under the massive oak trees, and past the vast open areas, she saw what I had meant on the phone. “Wow! This is unbelievable!” she blurted out.

After we had arrived at the main clubhouse area that provided facilities for both the residents and Vic’s tennis college, Vic joined us for a complete tour. We began with a quick lunch at the clubhouse restaurant and then a drive through Coto de Caza. The area was 5000 acres with a long, narrow, flat valley in the center and hills bordering both sides. There was one black strip of asphalt in the center of the valley floor which we followed for about two miles. The few trees we saw were mainly oaks that were hundreds of years old and their branches spread outward so that they seemed to consume a large area of space. They were not as majestically tall and massive as one would experience with a giant sequoia, but they possessed quiet strength.

We had driven about three-fourths of the valley before we turned into an oak grove with a building in the center. There was a broad covered porch and wooden walkway around the building. On the far side was an area for skeet shooting. A few people were shouting “pull” and we watched the targets splinter in the air with each successful shot. Other people were sitting around tables watching the target shooters or just chatting over beers. There were several oak trees growing through openings in the deck which provided a lovely shade for the guests. The building sold snacks, beverages, and targets for sports shooting. These were new and different activities from those that Ann and I had experienced in our quaint New England college town of Amherst. I guess now we were in the Wild West.

Vic drove us back up the valley to the tennis college. We passed some horse paddocks and the horse barn where weekend “cowboys and cowgirls” left their pristine, expensively decorated lives of law and finance to play “John Wayne”. There were fewer than 25 residential houses in the village and ten condos for people attending the tennis college.

After an excitingly eventful day, Vic took our picture on the deck of his Tennis College. He wrote “Don’t forget to digitize this” on the picture. In retrospect, the comment became a more accurate predictor than the ones you find in fortune cookies at the conclusion of a Chinese dinner. At the time, none of us knew what was to be. We never digitized the picture, of course, but it was one of the first mementos of what was to become a new life for Ann and me.

Vic and I became good friends. I did some research work for him, and we appeared together in some presentations related to tennis. One day Vic asked me: “Gideon, what would it take for you to move to Coto?”

“Vic, I would love to move to Coto. However, I have a business and some projects I am working on in Amherst plus my work at the University. How could I leave?” was my answer.

Vic persisted. “So, what would be necessary for you to move to Coto on a permanent basis?”

I had no answer to that question. Ann and I had wanted to move from what, for us, was the disagreeable climate in Amherst, Massachusetts, but we had not yet found the perfect place. From our brief experiences in California, it seemed like this was the place for us but we had to deal with the where and how. Vic’s question, however, might provide the answer to our quest.

“I have a meeting with Mr. Vic Palmieri, who is the Chairman of the Board of the Penn Central Company which owns the properties here,” he said. “If you can come to Coto during his visit, I’ll introduce you to each other. Perhaps there will be overlapping interests and we can find a way for you to have your business site here.” Vic explained.

Vic arranged a time when both Mr. Palmieri and I could meet in Coto. Vic suggested that I arrive in Coto two days before the meeting so that we could discuss the various issues we wanted to cover. As soon as I arrived, Vic and I discussed my needs for a building, housing, and some of the items I would need to arrange for my staff. Vic showed me the various constructions underway. In fact, he was confident, if I
was interested, that I could purchase two of the new condominiums that were being built as additions to his tennis college.

Finally, it was the day of the meeting. Victor Henry Palmieri was a lawyer, real estate financier, and corporate turnaround specialist. For a time, he was an Ambassador-at-Large and U.S. Coordinator for Refugee Affairs in the United States Department of State during the Jimmy Carter administration. He was born in Chicago and earned his A.B. and LL.B. from Stanford University. Mr. Palmieri was also the chief executive officer of The Palmieri Company, a general management consulting firm that had specialized in large-scale reorganizations and restructurings since 1969.

At that time, Coto de Caza was part of the vast land holdings of the Penn Central Corporation and Mr. Palmieri was working with the company for a successful emergence from bankruptcy. The task for the company was to sell their holdings for as much profit as possible. As part of the numerous holdings of the Penn Central Corporation were the subsidiaries of Great Southwest Corporation and the Six Flags Corporation. The goal was to create an increasingly attractive and visible role for Coto de Caza to elevate its standing as a desirable destination resort. To that end, any ventures that would enhance the worth of the land would be a positive step for everyone concerned. It was in this atmosphere of mutual goals that Mr. Palmieri and I met on a sunny day in what I had taken to refer to as “Paradise”.

We decided to meet at a nice restaurant not too far from Coto called “Delano’s.” I was very excited and my hands were shaking. I had a feeling that this meeting would either change my whole life or be a complete disaster. My previous meetings with Irving Pollock and Larry Graham had been very successful so I was trying to keep a positive and optimistic attitude.

Vic introduced Mr. Palmieri and me. Then we sat at a round table and ordered coffee. Suddenly, before anyone said anything, Mr. Palmieri tossed an issue of Sports Illustrated on the table and asked in a loud voice: “Gideon, how did you do this?”

“What do you mean? I do not know what you are talking about” I answered.

Mr. Palmieri opened the Sports Illustrated magazine, thumbed through several pages to find the place he wanted, and began reading:

“… It took Ariel more than 10,000 hours to program his computer to analyze an athlete’s motions… Now Ariel offers the sporting world a chance to lift itself from, as he puts it, out of ‘the dark ages’, a witchcraft business where everything is made of thin air. Over those years, Ariel transformed himself as well, from a carefree discus thrower to a compelling innovator.”

“So,” Palmieri said, crossing his legs, “Here I was sitting on the plane in first class on the way to meet you and there you are on the front cover, followed by a 9-page story. Quite an amazing coincidence, don’t you think?” he said with a smile on his face and twinkle in his eyes.

I was shocked and probably stuttered my response. “They interviewed me a few weeks ago,” I explained. “They never
told me whether they would write an article or describe how extensive it would be. I was not sure if, never mind when, a publication would be printed. But now that it is out, I am more than pleased!” I said.

At that time, most subscription magazines, including Sports Illustrated, were shipped to subscribers and businesses, including airlines, before appearing on newsstands for purchase by the general public. I had no advance warning when, or even if, Sports Illustrated would publish an article about me. They had spent nearly a week in our Amherst office but, after that time, there had been only silence.

I was especially thrilled to see that the magazine cover showed a discus thrower, created with a technique of computer-coded symbols. I instantly recognized that this unique creation was my dear friend Bill Toomey as he threw the discus in his world record decathlon performance in the 1968 Mexico Olympics. I wrote the code for this illustration in the very primitive assembly language. This was one of my projects with Dr. Wogrin at the Computer Science Department at the University of Massachusetts. To my knowledge this ASCII photo is the first one in the world to be transmitted on the “net” before the Internet. I used timesharing on the mainframe of Dartmouth College with a phone acoustic coupler at 300 baud.

Mr. Palmieri asked for more details about my life, including my education and work history. Since I did not know how much Vic had told him about our previous projects in Amherst, nor the new ones that we had performed with Vic at the tennis college, I launched into the stories with my normal gusto.

Finally, I said, “Well, Mr. Palmieri, what more can I tell you? I have a fantastic laboratory in Amherst Massachusetts with some projects running currently.”

“Could you do them here?” he asked.

“I could not perform them with what is currently here in Coto de Caza. I have a laboratory packed with computers, graphic systems, force platforms, and all of the hardware and experimental spaces necessary for technical work. None of those components or capabilities exist here in Coto.” I explained.

“What if we were to build you a laboratory according to your specifications? Can you tell me what you would need?” Mr. Palmieri replied.

This was a fun idea. I had previously only modified building such as my kitchen in Belchertown or the existing lab we had in Amherst. Now I had an opportunity to design a dream biomechanical laboratory from the beginning. I took the napkin from the table and asked for a pen. Mr. Palmieri handed me his and I started drawing the “Dream Laboratory for Human Performance.” I have no artistic talent for sketches but I could easily imagine where testing equipment and computers should be located as well as where the experimental testing centers could be. Ideas percolated in my imagination. It was a rough, crude sketch but I could describe in words what my picture may have lacked. I still have the original napkin with the research center sketch.

Obviously, I was never an architect nor an artist so the drawing made more sense with my verbal description. However, the idea was to have a two-story building with a track going through the lower floor. Force platforms could be placed at various locations on the track. They would be flush with the surface so as not to impede the runner and the cables would be funneled through underground conduits. The track would surround a general area and that center space could be used for tennis research as well as other sports. The surface would have sensors so every ball that hit the ground would send a signal to the main Data General Eclipse-MV/8000 which was the most advanced minicomputer at that time.

The track portion that ran through the first floor could also be used for projects unrelated to track. That section would essentially be an indoor lab area adjacent to the computer room. Small rooms that could function as offices or other needs would be located along the interior wall just beyond the computer room.

The computer room would need an elevated floor to enable an air-conditioned environment and would be adjacent to the indoor track lab area. In addition to the computers, special 3D monitors made by Megatek would be installed to present data in 3D in real-time.

The digitizing room would be an extension of the computer room. The projection room would lie on the farther
side of the screen and would be sufficiently long so that a film sequence could easily be projected onto the digitizer screen.

The upstairs would have a gym with cardiac equipment to measure oxygen consumption and other physiological parameters including electromyography (EMG). A large exercise room would accommodate all of the new Ariel computerized exercise equipment in addition to any other equipment or devices we might need for future research projects.

Next to the main laboratory building, in my dream research facility, would be the second building. This smaller building would have offices for Ann and me as well as additional staff offices. There would be a large room with space for a secretary or receptionist. Of course, Vic could have his office there if he wanted one.

Mr. Palmieri stopped me and said, “You know, Gideon, your dream will cost in the millions of dollars.”

“Mr. Palmieri, you asked me to tell you what would bring me here, not how much it would cost.” I said.

“And oh,” I added, “also, I do not want to have a boss. This dream should be a joint venture between Coto de Caza and Ariel Dynamics. I must be the boss and decision maker for my research center.”

Mr. Palmieri’s face reflected a flabbergasted expression. Perhaps he thought I was a lunatic. However, the Sports Illustrated article, my lengthy research credibility, the numerous television appearances, and Vic’s enthusiasm were compelling enough to overcome what might have been perceived as arrogance. Since the cost for this magnificent imagined facility would be high, I did not imagine there was any chance that the dream could come true.

Then Mr. Palmieri asked: “If we decided to do this project, when do you think we should start?”

I paused for only a moment to think and then answered, “Today is Wednesday. How about starting on Friday?”

Mr. Palmieri looked at Vic who looked tense and nervous. Could this happen? Suddenly, Mr. Palmieri extended his hand to me. I put my hand out to his and he said, to everyone’s amazement, “Gideon, it’s a deal.” All of us began laughing. I almost wondered if this was a dream, like my research center vision, or if it was true.

I was so happy that I suddenly upped the ante of what I would deliver. “Mr. Palmieri, if you are going to bring me here to Coto de Caza and build this awesome research center, I will bring the Olympics to Coto in 1984.”

“Gideon, please stop.” Mr. Palmieri responded. “You don’t need anything more spectacular for this meeting. I am more than impressed with your charisma and your outstanding capabilities.”

With Victor Palmieri and Vic Braden

“You’ll see,” I responded. I am going to bring the Olympic competition to Coto de Caza, mark my words.”

We all stood up with broad smiles on our faces. I was incredibly excited about the enormous potential which the future held for Ann and me, and our company, Vic, I am sure had his dreams. As for Mr. Palmieri, I could only hope that he did believe in me and was not merely throwing the dice and hoping for the best. In retrospect, I can appreciate his doubts and skepticism but the reality of success would be the truthful conclusion of the dream.

We left the restaurant bubbling with conversation and agreed to meet soon. Each of us had our tasks to complete to make this new research center a reality. As we walked toward our car, Vic told me that he was afraid that I had lost it all when I promised to make Coto an official Olympic Site. He said “You almost blew the whole idea with that ‘ridiculous statement.’” I made no comment but, in my mind, I was already planning the next step towards making that promise a reality.

In 1984, eight years after the meeting, the Olympic modern pentathlon was held in Coto de Caza. No one could believe that this would happen but me. My dreams seemed “crazy” but became reality nonetheless.

Vic and I drove to Coto de Caza talking non-stop about what we were going to do in the new research center. I cannot say that either of us heard what the other had in mind since my recollection is that we were each delivering our own non-stop soliloquies!

Back in Coto, we stood on the deck at Vic’s tennis college and stared at the empty lot that would be the future home of the research center. It was just dirt then, but in my imagination it was already a 21st-century futuristic laboratory for
analyzing all types of sports and human performance. I am sure that Vic and I filled the sky with the fantasies about the California research center of the future.

Soon after our return to Coto, I called the lab in Amherst. “Ann! Get ready to move to Coto. I just shook hands on a 5-million-dollar deal!”

“No way,” she exclaimed. Did you really? Yippee!”

“I will fly back tomorrow, so call Larry Graham and see if we can meet him as soon as possible. The new center will be called ‘The Coto Research Center.’” I told her. Ann promised to get everyone organized for a meeting, and made travel arrangements for my flight back to the East Coast.

During the following weeks, we met Larry Graham who was extremely enthusiastic for us and our future. Sweet and bitter would be the best description of the situation. Larry had been a mentor, an investor, and very much a father figure to Ann and me. He had been one of the most significant figures in our corporate growth and our understanding of the big world outside of our small, sheltered, academic experiences. It was tough to imagine the world without Larry backing us up and providing his wisdom.

Larry insisted that this was a deal that we must make and urged us to pursue this opportunity of moving to California and embarking on this big venture. He promised to help us arrange the most advantageous terms and, with his help, we would be successful.

Larry’s attorneys in Boston worked with those of Great Southwest Corporation (GSW) to create the Research Center dream that Mr. Palmieri and I had discussed at Delano’s restaurant.

GSW sent one of their leading corporate auditors, Mr. Collin Hatch, to examine our records. Mr. Hatch sat in our front office in Amherst pouring over our financial records. It was embarrassingly funny that every time Mr. Hatch asked us a question, Ann and I never knew the answer! We were scientists! What did we know about spreadsheets and tax forms? Fortunately, Larry was both a businessman and a banker so our records were clean and straightforward, if you knew what you were looking for, at least. Mr. Hatch gave us a clean bill and Great Southwest proceeded with the contract. I should note that nearly 40 years have passed since Mr. Hatch audited our books and today, he has been our accountant for most of these intervening years. He has become a dear and trusted friend and advisor. We are lucky to have him since we still do not know the answer to spreadsheets or tax forms.

We signed the contract and I began two years of flying back and forth between California and Amherst while the Coto Research Center was under construction. It was an amazing feeling to be the “boss”. Many had assumed that we were to be made a part of Vic’s tennis college. But there was no way that I would be responsible to anyone other than myself. I would be my own “boss” and would own 50 percent of the Coto Research Center. The Coto Research Center was a joint venture, 50/50, between me and my company and the Great South West corporation which was owned by Penn Central.

During construction, I was continually shocked at the number of seemingly trivial decisions that had to be considered with a new building. We had to decide on the number of electrical outlets and where they should be located; office window sizes and shapes; color schemes, and so it went. The building, as seen in the pictures above, began to take shape. Ann and I were thrilled about the entire project, the location, and the ability to design a sports and testing research center from the beginning.

Then catastrophe struck! The foundation was finished and most of the lower levels of the two buildings had been completed when it began to rain. I had seen rain before but nothing like this. It poured non-stop 24 hours a day for
days and days. This constant rain flooded in and under the foundation. I felt as though I was reliving the biblical story of Noah’s flood and was waiting for a dove to fly in with a branch and for the rainbow to appear!

After the sun finally showed again in a brilliant blue sky, the whole area dried. Unfortunately, the state building inspector declared the building foundation unfit. We would have to tear everything out, grade the earth again, and restart the building from the foundation. It was a setback but not the end. The construction began anew and we continued the building project.

During the days of rain, the small twisting and turning road to Coto also flooded. This happened at the location where the road crossed a normally dry creek bed. Now, with so much rain, the creek became a raging torrent and completely cut off the two sides from each other. After many days of rain, the sun finally beamed down on the still raging waters. On each side, people gathered and shouted greetings to each other with many toasts of beer and wine!

Now, Vic had quite a problem to solve. On Sunday, the participants for the next week’s instruction session needed to register at the tennis college. Many of these participants had reserved their week of tennis many months in advance. How his visitors were going cross the river was a dilemma.

Finally, Vic arranged for some of the large earthmoving equipment currently being used at the research center construction site to serve as transportation vehicles! Imagine the crazy scene of tennis players and all of their suitcases and tennis paraphernalia climbing on to an earthmover, being ferried across the turbulent creek, and climbing down on the other side to ride to Coto in whatever vehicles were available at the time! People were being transported in the beds of pickup trucks, golf carts, and with volunteers in their private cars. I am sure that these people had so much fun in such a genuinely unique experience that they continue to tell the story even today.

After the buildings had been completed, we moved the most important testing and scientific materials from Amherst. Some of our CBA staff were content to remain in Amherst primarily because of family members who were in school or had other jobs. Since communication from coast to coast was so simple, it made little difference for the execution of our projects. Also, it was easy enough to fly people during those times when we all needed to be in the same place.

We purchased anything that we required in addition to those items we brought from the East Coast. At last, the research center was finished and we were ready to continue our research projects. However, we wanted to announce the research center to the world.

We organized a splashy Open House for the Coto Research Center on November 20, 1980. We invited professional colleagues, members of the Coto community, all of the equipment vendors, as well as personnel of the companies for which we had performed research projects.

At the Open House, there must have been 500 people walking around the buildings, admiring the facility and the beautiful, sunny environment of the valley. Our visitors stuffed themselves with the delicious tasty treats and beverages. I think that was the first and last time that Ann allowed any beverages in the computer building!!

The cost was enormous, but we had extremely well-built, well-designed buildings in an exquisite setting.

Ann and I purchased two beautiful condominiums, one for us to live in, and the other for visitors. They were located within walking distance of the research center. Every morning, Ann would read her book while she and our dog, Ringo, walked to the center. I was too excited to take the time to walk, so I rode my small motor scooter.

The interior of our research center was awesome. We had state-of-the-art computers and graphic terminals in addition to the best high-speed cameras. There were eight force platforms on the track and in the laboratory.

On the outside court, we could collect data from multiple viewing angles simultaneously. We had several projects for Vic Braden that we began the day after the open house.

Our staff was small, with four people in California, and two in Amherst. But, like diamonds which may be small but sparkle brilliantly, these few scientific workers were efficient,
intelligent, and worked diligently to complete each project. They are pictured on page 362.

Fortunately, we had previously secured some projects while we were still in Amherst. This allowed us to continue working on profit-generating research in our new Coto Research Center. One of our clients, Wilson Sporting Goods, provided us with interesting and detailed project proposals. We were working on two major projects with them when we moved the laboratory to Coto de Caza so we were extremely busy even before we had our fancy open house for the Research Center.

One project was the Computerized Exercise Machine which we had begun developing several years earlier. It had been renamed “Wilson-Ariel 4000” and we were modifying the external shape as well as improving and expanding the software. We arranged the upstairs portion of the large research building into an exercise training facility. We offered free exercise training sessions for the local community members explaining to them that they would be divided into four different study types: (1) high intensity/fewer repetitions, (2) low intensity/more repetitions, (3) “fatigue” mode and (4) a control group following a normal exercise program. All of the community participants were excited to be in this research program as well as being able to exercise on our unique, futuristic exercise equipment. Interestingly, after nearly thirty years, we still meet people who participated in our exercise study. The amazing thing is that they are as enthusiastic now as they were at during the study.

There came a time in our relationship with Wilson which took the CES to the next level. This development was covered in a previous chapter. In the early days of the Coto Research Center, Wilson sponsored the CES, and its development and testing continued with great excitement.

We had other research projects that Wilson wished to pursue such as examining the effects of different colors for softballs. Projects were usually large and detailed in scope and generated research dollars for us. The income generated
from these research projects, excluding the Exercise Machine, contributed to the joint venture of the research center.

One of our more complex Wilson projects was on the flight of the golf ball. We were surprised to learn that from the 14th to the 17th centuries, hard wooden round balls were the first golf balls used. They were made from hardwood such as beech and box trees and typically made by carpenters with tools of the day. Also during this time, the “feathery” ball was developed and introduced. A “feathery” was a hand-sewn round leather pouch stuffed with chicken or goose feathers and coated with paint, usually white in color.

Obviously, there were a few drawbacks to the “feathery”. First, it was hard to make a perfectly round, spherical ball, and because of this, the “feathery” often flew irregularly. Also, when the “feathery” became too wet, its distance would be reduced as well as the possibility of splitting open when struck or when hitting the ground. Despite these drawbacks, the “feathery” was considered by contemporaries to be a dramatic improvement over the wooden ball and remained the standard golf ball well into the 19th century.

In 1848, the Rev. Dr. Robert Adams Paterson invented the “gutta-percha” ball or “guttie” The “guttie” was made from dried sap of the Malaysian sapodilla tree. The sap had a rubber-like feel and could be made round by heating and shaping it in a round mold. Because “gutties” were cheaper to produce, could be reformed if they became out-of-round or damaged, and had better aerodynamic qualities. They soon became the preferred ball for use.

Accidentally, it was discovered that nicks in the “guttie” caused by normal use provided a ball with a more consistent ball flight than when a “guttie” had a perfectly smooth surface. Thus, “guttie” makers began intentionally creating indentations in the surface of new balls using either a knife or hammer and chisel. This gave the “guttie” a textured surface. Many patterns were tried and used. These new gutties, with protruding nubs left by carving patterned paths across the ball’s surface, became known as “brambles” due to their

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resemblance to bramble fruit which Americans would refer to as “blackberries”.

The next breakthrough in golf ball development came in 1898. Coburn Haskell of Cleveland, Ohio had driven to nearby Akron, Ohio for a golf date with Bertram Work, the superintendent of B.F. Goodrich.

While he waited in the plant for Work, Haskell picked up some rubber thread and wound it into a ball. When he bounced the ball, it rebounded nearly to the ceiling. Work suggested Haskell put a cover on the creation and that was the birth of the 20th-century wound golf ball that would soon replace the “guttie” bramble ball. The new design became known as the rubber Haskell golf ball.

For decades, the wound rubber ball consisted of a liquid-filled or solid round core that was wound with a layer of rubber thread into a larger round inner core and then covered with a thin outer shell made of balata. Balata is actually a name of a tree that grows in Central and South America and the Caribbean. The tree is tapped and the soft, viscous fluid is a rubber-like material similar to gutta-percha was found to make an ideal cover for a golf ball.

In the early 1900s, golf balls underwent another alteration. Concave dimples that were concave rather than the raised protrusions, which had inspired the “bramble” idea, provided even more control of the ball’s trajectory, flight, and spin.

Dimples first became a feature of golf balls when English engineer and manufacturer William Taylor registered a patent for a dimple design in 1905. Other types of patterned covers were in use at about the same time, including a “mesh” and another named the “bramble”, but the dimple became
the dominant design due to “the superiority of the dimpled cover in flight”.

A smooth golf ball hit by a professional golfer would travel only about half as far as a golf ball with dimples does. Most modern-day golf balls have between 300 and 500 dimples, with an average depth of about 0.010 inches. The lift and drag forces on a golf ball are very sensitive to dimple depth such that a depth change of 0.001 inches can produce a radical change in the ball’s trajectory and the overall distance it can fly. Dimples have traditionally been spherical in shape, but it is possible to optimize the aerodynamic performance of other shapes as well. The HX golf ball by Callaway, for example, uses hexagon shaped dimples.

The questions we wanted to answer were, how does air affect the flight of the golf ball, and how do dimples interact or cause flight variations. The simplest explanation is that air exerts a force on any object moving through it. Holding your arm out of the window of a moving car easily illustrates this phenomenon. Aerodynamicists break down this force of the air on your arm into two components: (1) lift and (2) drag. “Drag” acts to directly oppose the motion and “lift” acts in a direction perpendicular to the motion (it is usually directed

Data collection outside at Coto Research Center

The experimental area for the golf ball flight tests including the Iron Byron
upward in the case of a golf ball). As you rotate your hand in the air stream, you vary the amount and direction of the lift and drag forces acting on your hand.

In addition to the "drag" and "lift" forces, a moving object has a high-pressure area on its front side. Air flows smoothly over the contours of the front side and eventually separates from the object toward the back side. A moving object also leaves behind a turbulent wake region where the air flow is fluctuating or agitated, resulting in lower pressure behind it. The size of the wake affects the amount of drag on the object.

Dimples on a golf ball create a thin turbulent boundary layer of air that clings to the ball's surface. This allows the smoothly flowing air to follow the ball's surface a little farther around the back side of the ball, thereby decreasing the size of the wake. A dimpled ball, thus, has about half the drag of a smooth ball.

Dimples also affect lift. A smooth ball with backspin creates lift by warping the airflow such that the ball acts like an airplane's wing. The spinning action makes the air pressure on the bottom of the ball higher than the air pressure on the top. This imbalance creates an upward force on the ball. Ball spin contributes about one-half of a golf ball's lift. The other half is provided by the dimples which allow for optimization of the lift force.

The pattern of dimples has an effect on the flight of the ball as well as the number of them. By regulation, the arrangement of the dimples on the ball must be as symmetrical as possible. However, the dimples do not all have to be the same size or be in a uniform distribution. Most golf balls on sale today have 250–450 dimples, although there have been balls with more than 1000 dimples. The record holder was a ball with 1,070 dimples—414 larger ones (in four different sizes) and 656 pinhead-sized ones.

This freedom allows designers to arrange the dimple patterns in such a way that the resistance to spinning is lower along certain axes of rotation and higher among others. These differences cause the ball to "settle" into one of these low-resistance axes, that golfers prefer, which is close to parallel with the ground and perpendicular to the direction of travel. This flight pattern reduces or eliminates "side-spin" induced by a slight mishit causing the ball to curve off its
intended flight path. A badly hit ball will still curve as the ball settles into a spin axis that is not parallel with the ground which, much like an aircraft’s wings, results in the ball banking to left or right.

We evaluated all of the information available included some of the interesting historical data. We discussed with Wilson what their ultimate objective was. Then we discussed among ourselves the most efficient and effective research design that would provide the information that was sought.

We were ready to study the effect of golf ball parameters on the initial speed, spin, and launch angle due to the ball/club impact. Typically, the golf ball remains in contact with the club for about 0.5 milliseconds when it is hit with a golf club known as a driver. During that impact time, the club face moves approximately one inch. Our research focus was to examine the response characteristics of the ball during this impact. We needed to see a few frames after contact to determine the speed, spin, and launch angle in addition to the actual impact response. Also, we needed to determine the flight pattern after impact as well as measuring the distance that the ball traveled.

We proposed to examine a minimum of five different balls that were to be hit with a minimum of two different clubs. In addition, we would examine four different variations of the same ball using only the driver to observe the effects, if any, on the flight of the ball.

To standardize the strikes on each ball from each of the different clubs, we needed a method to consistently repeat each swing of the club. The ball would have to be struck with the same amount of force and with identical club face angle if we were to identify differences in the responses of the various golf balls.
Wilson provided a machine used within the industry for this purpose. The Iron Byron is an electro-mechanical machine used by the United States Golf Association to test golf clubs and golf balls for conformity to standards. The Iron Byron is a robot named after the great Byron Nelson, whose swing was so consistent and perfect that legend has it that only a mechanical man could replicate it.

The Iron Byron can be adjusted to repeat the same swing ten thousand times which is useful for comparing the relative properties of clubs and balls. If a new model of the golf ball is submitted by a manufacturer for approval by the U.S.G.A., it is hit a few hundred times by the machine and the average distance the ball travels forms the basis of whether it conforms to acceptable limits of carry and roll for a given swing velocity.

In actuality, the Iron Byron is not an anthropoid, meaning that it is not shaped like a human being. It cannot walk or talk. If fact, it has more in common with one of those automated welding machines found on an automobile assembly line than it does with anything in a science fiction movie. It is a floor-mounted pedestal, 4 or 5 feet tall, which has a mounted swiveling machined metal arm, articulated with elbow and wrist hinges to mimic the dimensions and motion of a human swing. An adjustable sleeve at the end of this hinged arm is used to fasten the club being used during tests.

The experimental area for the golf ball flight tests are shown on page 361. These illustrate the Iron Byron, some of the cameras and computers, as well as the outdoor setting.

After several days of data collection and many weeks of processing the information, we presented an extensive, detailed report to Wilson. We had identified a number of factors that affected the flight pattern and the distance that each type of golf ball. This information was based on our detailed study without bias since Wilson personnel retained the code associated with each of the different balls. All of the Wilson scientists and product development specialists were very happy with the information we provided. Needless to say, we were pleased that they had received our dedicated efforts with such positive responses.

After the long and detailed study on these Wilson golf balls, we switched our attention to other projects. Some of these projects were for Vic at his Tennis College.

Vic was unique in his effervescent personality and attracted many exciting people to his tennis college. We collected data on famous professional tennis players, including the late Arthur Ashe, who had won three Grand Slam titles, and Jimmy Connors, a U.S. Open winner as well as holding ten Grand Slam titles. Our job was to collect data and analyze the advantages and disadvantages in these athletes' strokes.

We had an interesting project with the great and entertaining Jimmy Connors. James Scott “Jimmy” Connors
was a world number 1 tennis player from the United States. Connors won eight Grand Slam singles titles and two Grand Slam doubles titles with Ilie Năstase. He was also a runner-up seven times in Grand Slam singles, a doubles runner-up with Năstase at the 1973 French Open, and a mixed doubles runner-up with Chris Evert at the 1974 U.S. Open. He held the top ranking for a then-record 160 consecutive weeks from July 29, 1974, to August 22, 1977 and an additional eight times during his career for a total of 268 weeks. Jimmy was considered a maverick by many in 1972 when he refused to join the newly formed Association of Tennis Professionals (ATP) which was the union that was embraced by most male professional players. He made a big splash by winning the 1973 U.S. Pro Singles, his first significant title, toppling Arthur Ashe in a five-set final.

In 1974, Connors became the second male in the open era to win three or more Grand Slam singles titles in a calendar year (Rod Laver being the first in 1969 and having been joined since by Mats Wilander, Roger Federer, Rafael Nadal, and Novak Djokovic). Connors is also the only person to win U.S. Open singles championships on grass, clay, and hard courts.

Jimmy Connors won a record 109 ATP tournaments, 15 more than Ivan Lendl and 32 more than Roger Federer and John McEnroe. His career win-loss record of 1243–277 (81.77%) is second after Björn Borg (82.7%) with Ivan Lendl (81.76%) third, and he holds the record for total number of wins for a male player. Many of his records may have been surpassed by others, or will be in the future, but Jimmy was truly a great tennis star.
Jimmy Connors won three year-end championship titles including two WCT Finals and one Masters Grand Prix. He also won 17 Championship Series titles (1973–1984). He was the first male player to rank number 1 for more than 200 weeks in total and the first male player to be number 1 for more than five years in total. He is the only male player in the open era to win more than 100 singles titles during his career and also holds the record for most major quarterfinals (41) reached. Since most of the lost standing athletic records eventually fall, Jimmy’s many records will probably be surpassed. But, it goes without saying that he was an exciting player to watch.

Although Connors never won the French Open, his victory at the 1976 U.S. Open came during the brief period (1975–77) when that tournament was held on clay courts. Connors, therefore, is one of only five men (Mats Wilander, Andre Agassi, Roger Federer and Rafael Nadal are the others) to have won a Grand Slam singles title on grass courts, hard courts, and clay courts.

In today’s era of sophisticated, technology-based racket construction and string variations, Jimmy may have been forgotten. His era of wooden rackets and off-the-shelf sneakers for foot wear may place him among the dinosaurs of tennis. But his accomplishments are facts and he should be remembered as one of the greatest tennis players of all time due to his many records in the game.

Working with Jimmy Connors
http://arielnet.com/ref/go/2724

It was brought to our attention that Jimmy had a problem with blisters and pain in his feet. To know how to fix something, you must understand the problem. We began by trying to determine the causes of Jimmy’s foot problems and, with that information, we hoped to be able to develop shoes to assist in alleviating these difficulties. Connors suffered from a profusion of blisters and foot pain. One factor was his unusual foot structure. There seemed little doubt that these foot difficulties were aggravated by the excessive stresses encountered during the game’s activities.

We began by photographing him during a tournament and at a special filming session in Palm Springs, California. High-speed video was collected simultaneously from four different cameras. We even employed a camera suspended from a cherry picker to obtain an overhead angle of the various tennis strokes. I suspect that the residents were confused or amused by all of the cameras in addition to a man hanging high above the court.

We filmed various tennis strokes hit by Jimmy including his serve, forehand, and backhand volley. We also had him run at his maximum speed to different court locations to simulate trying to reach a ball. We filmed him changing directions quickly and “sprinting” to reach a distant ball as one would have to scramble to reach a strategically placed drop shot. Special close-up views were collected to facilitate examination of the shoes during these various motions.

We returned to our new laboratory in Coto and digitized the reams of film we had collected. Our motion analysis programs were used to measure both the stresses on the foot and the forces of the foot on the ground. Our intention was to determine how Jimmy ran and stopped. If we could identify particular stresses and forces that he produced, we were optimistic that we could design a shoe that would be better for his foot and playing style.

Jimmy Connors and Gideon Ariel
http://arielnet.com/ref/go/2734
The films revealed that many of Connors’ motions were extremely abnormal and unconventional. For example, (1) he moved backward without changing his body-net orientation. (2) He frequently changed direction and dragged the trailing foot on the toe. (3) Jimmy was constantly in motion and he rotated on the medial balls of the feet. (4) His foot was unstable, appearing to slip and slide, in his shoes. (5) He often landed on the medial edge of the heel and his heel tended to drift within the shoe. Other movement factors were observed which contributed to his instability within his footwear.

Based on our observations and calculations, we designed new tennis shoes for Connors that factored in his particular idiosyncratic movements. The shoe included a specially designed toe box reinforcement engineered from plastic to shield the toes. It also featured a cushioned sponge insert to minimize transmission of shock to the toes. The surface of the sole was designed to minimize rotational friction. We built in a double lace system to minimize foot movement inside the shoe. We elevated the heel slightly to reduce Achilles tendon stresses and improve stability in the “hard to get shots” that demand extended or stretching stances.

Now that we had designed new footwear that we hoped would reduce the problems that had plagued him, our task was to analyze Jimmy’s serve. His maximum serve velocity was recorded at 72 miles per hour which is well below the average velocity among professional male tennis players at that time. Our biomechanical analysis revealed that Connors could increase the ball velocity to more than 100 miles per hour with some modifications in his swing technique. To increase the velocity of the ball on his serve, we recommended that he maintain a more solid base of support with the ground until contact was made with the ball. He could do this by allowing the ball-racket impact to occur a few centimeters lower than the point where he was striking the ball prior to our analyses. In other words, his ball toss should be lower so that at impact, he could hit the ball without having to jump in the air to reach it. As we have em-

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Letter of appreciation from Jimmy’s mother

March 27, 1979

Dr. Gideon B. Ariel

Computerized Biomechanical Analysis Incorp. 316
College Street
Amherst, Mass. 01002

Dear Dr. Ariel:

Upon receipt of the report which you prepared for Jimmy I would like to take this opportunity to thank you so very much and also tell you how impressed I am with you and the report.

Both, Jimmy and I look forward to the end results, and will certainly keep in touch.

Cordially yours,

Gloria Connors

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phasized many times, you have less force when you jump into the air since you cannot “push” against air. That is to re-
peat our mantra: “you cannot shoot a cannon out of a canoe without sinking the boat!” Following our recommenda-
tions, Connors was able to overcome his weaknesses and his serve velocity improved to 90 miles per hour.

We also performed a biomechanical analysis of his backhand swing. Connors style was what we referred to as a “tracking motion”. “Tracking” meant that the forearm and hand segments function as guides rather than for ballistic, whipping actions.

We completed our analyses and gave them to Jimmy and his staff. He was quite an exciting player and person so it was a wonderfully enjoyable project for us to execute. We were surprised when we received a letter of appreciation from his mother who was also involved with the tennis management company.

We analyzed hundreds of famous tennis players in our laboratory at the Coto Research Center. We received films of players from competitions in various locations or tournaments that we were unable to travel to ourselves to collect the data. However, we could perform the biomechanical analysis of those films and create “stick figures” or “dress” the sticks with skeletal coverings.

We were quite involved with several projects to analyze sporting equipment. As part of our on-going contractual re-

Our project with Jimmy Connors was featured on CBS “60 Minutes” with Morley Safer
lationship with Wilson Sporting Goods, after concluding the project on golf balls and clubs, they assigned us a research project for tennis rackets. Fortunately, with Vic Braden involved with us, and with our background in tennis equipment for Spalding and other manufacturers, we became experts in the world of tennis.

Our knowledge was presented in an article for Wilson Sporting Goods. The article was called, “Current Research and knowledge in the Tennis Game.” In it, we pointed out that:

“Tennis is not a ball, a racket, and a player that can be considered separately. It is a series of interactions between the ball and the racket, the ball and the surface, and the racket and the player. Because of this, there are many misconceptions about the game and the contribution of each component.”

When a player is moving about on the court, he/she must absorb nearly five times the body weight in the knee and ankle joints. Thus, a player weighing 150 pounds subjects his/her knees and ankles to forces up to 750 pounds. Tennis shoes and courts, then, must be designed to have the correct energy absorption, compressive stiffness and recovery rates needed to protect the players.

In general, there are traumatic results from the repetitive shocks caused by the running and jumping motions associated with tennis. To reduce exposure to these shocks, practice devices should provide the opportunity to improve tennis skills while simultaneously lessening the stresses related to the game.

One well-recognized term in tennis is the “sweet spot” on the racket. The term refers to the center of percussion of the racket and can be quite readily calculated mathematically. It is usually found to be on the racket head somewhere between the center of the strings and the throat of the racket. This is a result of assuming the pivot point to be at the handle. Analysis of high-speed film, however, has shown that the handle-wrist-hand relationship is a fairly rigid one and that the pivot point is the shoulder. Using the whole arm as the system, then, results in a center of percussion slightly above the wrist.”
We conducted a series of tests to examine the amount of muscular involvement of arm segments during various tennis strokes. Our objective was to illustrate to Wilson the relationship of these muscles and limb segments in tennis and how they could use this knowledge to their advantage. For example, they might be able to modify the racket or change the materials in the grip. Regardless of whether they changed the equipment or not, they would be able to make their advertising claims based on objective, scientifically-measured results.

The photos on the left show some of our data collection apparatus on the muscular responses to the impact of the tennis ball on the racket. We used electromyography (EMG) to evaluate the effective muscular action on the racket. In the photographs, the EMG electrodes are seen as small dots on the forearms and white or red tags on the racket. We also collected biomechanical data to compare racket swings with and without the EMG.

One of the projects we developed was to program the throwing machines to simulate the actual the tennis ball velocity, angle, and spin of a particular tennis player. For example, by collecting hundreds of shots from Jimmy Connor, we could determine for each shot the speed of the ball, the angle of the ball, and the spin on the ball. Then, we could program a special throwing machine to simulate these shots.

The photos below illustrate hitting lanes around a central hub. Each lane had a throwing machine which was programmable to simulate a particular shot. Imagine that you play against your neighbor and he “kills” you on your backhand. Imagine that you had someone to record video of you playing against your neighbor and your backhand shots were saved into computer storage after digitizing it from the video. Then, you are assigned a lane and every shot from the machine is one of your neighbor’s hits to your backhand. You “practice” against your neighbor although he is not there and he is completely unaware that you learning how to return his hit with your backhand. The next weekend, you would
The APAS System in use
http://arielnet.com/ref/go/1134

LEAP AHEAD WITH BIOMECHANICS

The body is a machine like any other. Analyze its performance on a computer and startling things happen.

At the age of 16, former U.S. gold medalist Al Cerver was decided to make a comeback. He had quit 14 years later than his gold medal distance of 64.6 m. What is his secret?

Biomechanical analysis. Cerver is one of many athletes whose techniques have been dramatically improved by the computer-aided science designed to optimize performance.

The intriguing period Center's revolutionary success story of Gideon Ariel, director of research at Computer Biomechanical Analysis Inc. Athletic, Massachusetts, a professor at the University of Massachusetts and chairman and co-founder of the Auto Research Center. Ariel, himself a passionate exponent of biomechanics and the tens of hundreds of athletes. Biomechanics is the study of the structure and function of the body which re-

Working with athletes of all sports
http://arielnet.com/ref/go/1225

Above left: A pole-vaulter captured in an X-ray film. The image is then projected onto a screen and analyzed using computer graphics. The necessary program took 10,000 hours to write-

Gideon Ariel & M. Ann Penny Ariel

The Colors of Chaos

Building the Athlete of the Future

Researchers are deciphering the biomechanics of motion and the chemistry of strength.

By Patricia Leverette

Adapted from the Los Angeles Times Magazine
amaze your neighbor by returning his shots with your new and improved backhand. This was one of our early projects.

In addition, we developed a “reaction time machine” that indicated your reaction time to conditions on the court. Much of the training at the Vic Braden Tennis College became computerized and was operated by intelligent machines.

We provided Wilson Sporting Goods with a great deal of information about the muscular activity associated with tennis strokes. We also tested, at their request, differences between gut and nylon strings in the racket. As usual, they were pleased with our tests and thanked us for our work.

Now that we were settled in California and had ongoing projects, I invited my old friend and colleague, Dr. Irving Dardik, to our new center. He was as excited as I was and even proposed that Coto might be attractive to the U.S.O.C as a training facility. As the Head of the Committee, Dr. Dardik decided that the first meeting of the new quadrennial Olympic Sports Medicine Committee should be at the Coto Research Center.

The Sports Medicine Committee consisted of different disciplines which directly impacted Olympic athletes and their performances. Included in these areas were physiology of exercise, psychology, biomechanics, and medical applications specifically focusing on sport-related injuries. I was appointed for an additional four years as the Chairman of Biomechanics.

An additional decision was to designate the Coto Research Center as an Olympic Training Site. This was a perfect arrangement since it was good for both athletes and Coto de Caza. The real estate specialists might not have understood biomechanics or sports medicine, but they did recognize the value of the U.S.O.C and its marketability for their specific interest.

We concluded this inaugural meeting with specific directives for each member. We agreed to reconvene within three months to report our progress. We had, unfortunately, missed the Moscow 1980 Summer Olympics for political reasons which were beyond our control. To compensate for this loss, we agreed to focus enthusiastically and intensely on the 1984 Olympic Games to be held in Los Angeles. There were four years of preparation available and all of us departed the meeting with renewed determination to prepare for success.

In addition to the projects we were working on for Wilson, the Sports Medicine Committee, and Vic Braden’s tennis players, I had another task to perform.

It was time to fulfill my promise to Vic Palmieri for Coto de Caza to be selected as a venue site for the Los Angeles 1984 Summer Olympics.

The first step was to decide which sport would be the most appropriate for our location. Initially, Ann and I considered swimming. Unfortunately, we only had one pool and it was not the length required for Olympic events. It seemed unlikely that we would be able to convince the Coto developers to build more pools. Scratch that option. Next we examined the shooting events. At that time, there was a “hunt lodge” at the end of our beautiful valley which was used for skeet shooting. We would have to construct other target areas, spectator seating, and address safety issues. Again, it did not seem that a shooting event was a viable option.

Suddenly, while perusing the list of Olympic events, I realized that the modern pentathlon would be a perfect
choice. The modern pentathlon consists of five events: fencing, 200-meter freestyle swimming, show jumping, pistol shooting, and a 3200-meter cross-country run. The sport has been a core sport of the Olympic Games since 1912 but has undergone several modifications to its format over the years.

The origins of the modern pentathlon have been disputed. On the one hand, Baron Pierre de Coubertin, the founder of the modern Olympic Games, claimed that he created the sport. On the other hand, Viktor Balck, the President of the Organizing Committee for the 1912 Games, demonstrated that he made use of the long tradition of Swedish military multi-sports events to create a modern pentathlon. The name derives from the two Greek words “penta-” for “five” and “-athlon” for “contest”. The addition of “modern” to the name distinguished it from the original pentathlon of the ancient Olympic Games which consisted of the “stadion” foot race (which was an ancient running event), wrestling, long jump, javelin, and discus. As the events of the ancient pentathlon were modeled after the skills of the ideal soldier of that time, the modern pentathlon created the contest to simulate the experience of a 19th-century cavalry soldier behind enemy lines. That soldier had to ride an unfamiliar horse, fight with pistol and sword, swim, and run.

In the 1912 Games, with only officers competing, they were permitted to use their own horses. Since there was no official international federation for the modern pentathlon, an IOC committee was set up for the sport, making use of the expertise of IOC members. The event was first held at the Stockholm 1912 Summer Olympic Games, and was won by a Swedish athlete Gösta Lilliehöök.

The modern pentathlon has been on the Olympic program continuously since 1912. Except for the fencing competition, athletes do not directly compete against one another in the five events. Athletes gain points for their performance in each event and scores are combined to give the overall total. This is similar to the procedure for the decathlon in track and field.

For the Los Angeles 1984 Summer Olympic Games, each event was held and completed on a single day, beginning with the equestrian event. The second day, all competitors completed the fencing portion. These were followed by a day of
swimming and, lastly, a day of shooting. The final day, all athletes competed against each other in the cross country run. The winner would be the individual who completed the run with the fastest time. The start was staggered due to the large number of participants and they were positioned according to their performance results on the previous four events.

Coto de Caza had everything necessary for this event. Although the United States had never won a gold medal in the modern pentathlon, maybe we could provide the best venue and hopefully produce an Olympic champion. The modern pentathlon has been considered by some as possibly the most mentally and physically demanding of all Olympic sports because it requires proficiency in five very different athletic skills: fencing, riding, swimming, shooting and running.

Now I had to find a way to bring the sport to Coto de Caza. The first step was to identify the members of the modern pentathlon’s governing body and convince them that our location was the perfect choice for their sport. I flew to Colorado Springs, CO, for a regularly scheduled meeting of the Sports Medicine Committee. Fortuitously, there was a meeting of the heads of the different sporting events as well as a number of international governing bodies from around the world scheduled to meet at that time. One of the inter-
national groups was from Sweden and, conveniently for my interests, the head of the modern pentathlon was Swedish and among the attendants.

I was able to speak with a few members of the Swedish committee and explained what Coto de Caza had to offer to participants of modern pentathlon. They were quite interested since I was able to describe a location where the five event locations were in close proximity. Normally, the individual event locations were as much as 50 miles apart. Having all of the events at one location was a luxury they had never enjoyed. We agreed to find a mutually agreeable date for them to come visit me in California.

Now, I would have to make the correct connection within the L.A. Olympic Games venue selection committee. Luckily for me, there were other groups of Olympic officials in Colorado Springs at the same time as my meetings. One of these group meetings was for the members of the 1984 L.A. Olympic Games Organizing Committee who were exactly the group of people that I needed to find. With another stroke of luck, I was introduced to Mr. Richard (“Dick”) Sargent who had been tasked to select the venues for the events for the upcoming 1984 Games. Once again, I explained the uniqueness of Coto de Caza for the modern pentathlon and the enthusiasm that everyone involved shared to have the Games come to our home. Mr. Sargent explained that he would be pleased to visit and see if our location was as perfect as I had proclaimed. Then we would have to verify that all five events could, in fact, be conducted according to the rules of that sport. Since I was so confident that all five events could be performed at Coto de Caza, he agreed to come for a visit.

The day of the meeting, I was quite nervous. The butterflies in my stomach reminded me of the times before I had to throw the discus. When Mr. Sargent arrived with the modern pentathlon committee, I instantly felt myself enter a “competition mode”. I smiled and greeted everyone and introduced them to Mr. Richard (“Dick”) Boltinghouse who was the...
head of the real estate in Coto de Caza. His job was as big as mine since he would have to agree to any of the required changes at each venue.

The meeting proceeded smoothly. Initially, we drove them to each of the five event sites. At each location, there were discussions about what, if any, changes needed to be made. For example, there was an indoor horse riding ring with an open-sided, covered area. Coto would need to have a temporary floor installed so that the fencing event could take place there. For the equestrian event, we discussed the arrangement for each of the jumps as well as the spectator space. The day continued in this fashion and, at the end, we were informed that Coto de Caza most certainly would be selected as the Olympic site. Shortly after this meeting, Coto de Caza was officially designated the site for the Los Angeles 1984 Summer Olympic Games Modern Pentathlon.

Everyone involved was ecstatic about this development and eventually, the entire population of Coto residents was integrated into the event. Residents opened their homes to team members and coaches, the officials conducting the events, and even family members of participants. The 1984 Games were a real “love fest” reminiscent of the 1960s.

I was especially pleased since I had promised Mr. Palmieri that I would bring the Olympic Games to Coto. I had fulfilled my promise and also made Coto de Caza even bigger on the map. In addition to successfully creating Coto as an official 1984 Olympic Games venue, I also brought another Olympic sport to Coto. The team was the women’s Olympic volleyball team.

In 1977, before I had even been to Coto de Caza, I went to the Colorado Springs Training Center for a biomechanics meeting in the lab. During that time, I had the opportunity to meet Dr. Arie Selinger, a fellow Israeli, who was the head coach for the U.S. women’s volleyball team. At that time, neither women’s volleyball nor being their coach was a position of particular status. In 1977, the U.S. women’s team was ranked 45th in the world.

Arie was an impressive-looking man of medium height with chiseled features and striking blue eyes. He carried with him the vaguely reflective, slightly pained expression of a person who is walking around with far too many things on his mind. The more I learned about Arie, the more impressed I was with his history, accomplishments, focus, and obsession for volleyball.

At that time, the Colorado Springs Training Center was still under development. The team members were housed in a former military barrack with four girls in each room. The dining room supplied regular meals but they were not programmed for athletic performance nor, from the reports the girls gave me, were they particularly appetizing. Another disadvantage was the altitude of 7000 feet. Colorado Springs was an excellent location for training long distance running due to the altitude but was not conducive for volleyball training.

In spite of these difficulties, Arie was demonstrating remarkable improvement in the skills and gamesmanship of the team. They continued to play better, but they were not medal contenders by any stretch of the imagination.

Arie and I spent hours during my visit discussing his background and the history of U.S. women’s volleyball. He explained that the United States had never brought a national team together so early, and had never before had a national team been offered the training advantages customarily granted to its competitors throughout the world. Challengers in Japan, Korea, Cuba, Russia, and Hungary had lived and practiced together for decades. However, until now, the United States had been satisfied with doing no more than throwing strangers together at the last moment and then telling them to play.

The results of waiting until the last moment, throwing a group of individuals together, and hoping that raw talent would prevail had been disastrous. In 1964, the first time the game was an Olympic sport, the U.S. had finished fifth in a field of six. Four years later, they finished eighth in a field of eight. In 1972 and 1976 they failed even to qualify for the Games. Their status was so low that other countries refused to send their best squads to America compete.

But things were changing. “We have,” says Arie Selinger, “improved from nothing.” Although Arie was not bragging...
about himself, the reality of this remarkable improvement was due to one crucial element—a dedicated coach with his specialized, focused training regimen.

We talked for a long time, in Hebrew, as Israeli compatriots do. I learned about Arie's personal history. Arie was born in 1937 in the Jewish ghetto of Krakow, Poland. During World War II, he and his family successfully evaded the Nazis for two years but eventually were caught and shipped to the concentration camp called Bergen-Belsen. In 1945, he and his mother were stuffed into a boxcar, and headed towards an execution site. The train had been diverted to a side track at the bottom of a hill to allow another train to pass when a squad of American soldiers crested the hill. The American soldiers forced the Nazi guards to surrender and the prisoners were freed from their stifling boxcar prisons.

Arie and his mother were sent to a specialized hospital for recovering prisoners of war. Arie was younger and healthier and able to travel with his uncle to Palestine, as Israel was known at that time. He told me a funny story about his early days in Israel when he lived on a kibbutz with his uncle and other family members.

Every night, Arie would sneak to the farthest back section of the kibbutz. The entire kibbutz was surrounded by a fence to keep their animals in and prevent predators from coming in and wreaking havoc. Arie would cut a hole in the fence and run away. His uncle and the other members would spend hours every morning searching the area around the kibbutz and, each time, there was enormous relief when they found Arie. Finally, his uncle took Arie to the front gate and showed him how to open it. Arie was told that the gate was never locked and he could leave any time that he wanted. They begged him, however, to please stop cutting holes in the fences because their animals escaped, which took precious man hours to recover as well as the additional time needed to repair the fence. The concept of freedom of movement was a revelation to a very young man who had spent all of the life he could remember hiding in fear.

It took a while for him to adjust to the new and exciting life in Israel. Also, he had to learn that he lived in a country that was founded on the premise that Jews were home, safe, and treasured. After the years that he and his family had endured Nazi prosecution, this required another mental adjustment.

After his mother had recovered her health, she was able to join Arie in Israel. She too adjusted to the newfound freedoms, as had her son, and lived a long life. Arie credits her with saving both of them and for creating an environment for him that mimicked as normal a childhood as she could and sheltering him, as much as possible, from many of the real horrors of the camp.

The rest of Arie's background was similar to most Israeli children. After he had finished high school, he served in the military. Following his military service, he competed as a sprinter, long jumper, and volleyball player on Israel's national teams. Later he coached men's club teams and the national women's team before moving to the U.S. in 1969. He moved to Urbana-Champaign, Illinois, and enrolled at the University of Illinois. He earned a Ph.D. in the physiology of exercise. In 1975, he was named coach of the women's volleyball team in the U.S. When I met Arie, he was living with his wife and daughter in a military barracks across the path from the one that housed his players.

Arie explained to me how the sport of volleyball functions around the World. “Take the top teams in the world,” he said. “Korea, China, Cuba, Russia, Japan, and Peru all follow the same training regimen. They practice six hours every day for six or seven days a week. If we want to get to the top, we must compete against and beat those teams.

“How?” he asked rhetorically. “One of our advantages is that we have an edge in talent. This is due to the large population of American athletes from which to select. Since the U.S. is a country crazy about basketball, it is easy to find tall girls. However, height alone will not defeat these teams. We have to train in the same fashion and for the same number of hours as all of our competitors. Japanese teams are notori-
ous for the intensity of their training schedule. They train for eight hours a day, and they rarely get a day off. For the U.S. to successfully compete against Japan or any other world class volleyball team, we will have to train for at least seven hours a day. We either have to train as much as they do, or we will fail among the top teams.”

“Many people tell me that we don’t have to be like other countries. That’s true. But if the United States volleyball team is expected to compete successfully at the international level and win medals at the Olympics, they must be prepared. I also get the argument that we’re trying to develop sports monkeys or that the team members should be going
to school. I don't understand that line of thinking. Nearly everyone understands the necessity of practicing the violin eight hours a day. But the same person fails to see the logic of athletes practicing eight hours a day. The team and I must continually focus on training and try to improve our skills.

This conversation stayed with me as I played it around in my mind. I had personally seen how the East Germans trained their athletes and that had led to the establishment of the Colorado Springs Olympic training site. Despite a fantastic and dedicated coach and an excellent team of hardworking athletes, I was worried about their chance for success. At that altitude and under those living conditions, I could not believe that the women's team would persevere. I tried to think of a good solution but it continued to elude me.

However, miracles sometimes do happen. The Coto Research Center was that miracle. When Ann and I signed the contract in 1978, I realized that this would be a perfect solution for Coto and for the volleyball team. The real estate personnel could make much about an Olympic team living and training in Coto de Caza. For the volleyball athletes, life and training in California would be an improvement compared to the situation in Colorado Springs.

Arie and the volleyball team would have a dedicated gym for playing and training, they could live close to their "job" in private, normal apartments, and they could use the Wilson-Ariel computerized exercise machine for fitness. In addition, I could work closely with Arie on analyzing various skills with the motion analysis system. We could analyze his team members as well as players from other countries. We could see what and how his competitors were executing their techniques. This information could then be used to improve the U.S. team and determine the best strategy to defeat their opponents. It seemed to be a perfect solution for everyone.

Although the team was doing well and improving in every aspect of their game, I reiterated my thoughts to Arie. “You won't earn a medal in the Olympics from a training location at Colorado Springs.”

“I know,” Arie replied. “But it is all that I have available to us.

“Arie, what if I show you a place where you can prepare the girls for the gold medal? Come with me and I will show you an alternative for your consideration.”

We flew to Coto de Caza and, as I had expected, he could not believe what he saw. We walked the court that would be his for training. I showed him my computerized exercise machines and the motion analysis system in operation. I presented studies that we had done before on volleyball. Arie's eyes lit up. "It could happen here," he said, musing to himself. "The promised land for athletes.”

I smiled and knew in my heart that the deal was done. There would have to be a few details worked out but they would be resolved in short order.

“But now,” Arie said, "for the 64-million-dollar question, Gideon. Who will finance bringing my team here? And how? Obviously, the U.S. Olympic Committee will not allow me to move here with 14 players and then have to allocate funds to support them.”

I told him that if he wanted to live and train here, I would make the necessary arrangements at Coto de Caza. Arie's job, I told him, was to write a wish list for training for his team in a letter. I asked him to direct the letter to Dr. Dardik, the Chairman of the Sports Medicine Committee. Then, I assured him that I would find the money.

Arie's requirements were logical for a total team approach. He needed housing for the team members and the coaching staff, funds for food, equipment, and travel expenses for international tournament competitions. He wanted to be able to use our motion analysis program for his players and also to determine what other volleyball teams were doing. This was a “weapon” that no other team had and would give the Americans a slight edge in knowing how to play against them.

I took Arie's list to Dr. Dardik and reviewed the details. We decided on a united front to meet with Colonel Miller and explain how the team could be successful in Coto de Caza, as well as why they would fail if they remained in Colorado Springs. We also had some ideas regarding funding that would support this move. Fortunately, Colonel Miller was impressed with the improved training opportunities and was quite willing to approve the arrangement.

U.S. Women's Olympic volleyball coach
http://arielnet.com/ref/go/4024
Needless to say, my head was abuzz with ideas for funding. Coincidently, we were working with the Mizuno Corporation to analyze protection pads and shoes for various sports. We had completed a section of the project and I needed to present the results to them in Japan.

Arie also had to meet Mr. Mizuno in Japan because of his involvement with the women’s national volleyball team of Japan. Japan, after all, has been a perennial power in women’s volleyball since the early 1960s. The Japanese approach to building championship volleyball teams reflected no less devotion to detail than did their approach to manufacturing automobiles, cameras, and computers. They were focused on the tiniest detail and were willing to work hard for perfection.

The Japanese team was a formidable foe for us. Not only had the Japanese charted the strengths and weaknesses of every young woman currently playing on the U.S. national team, but they had also scouted the top collegiate talent and even evaluated a handful of talented juniors. To the Japanese, any young woman who had any chance of representing the U.S. in the 1980 Olympic Games was of interest to the Japanese. “One thing about the Japanese...” Arie used to say, less in anger than in bemusement and admiration, “when they’re committed to something, they don’t fool around.”

But I reminded Arie of another facet of the Japanese. “They also like to make money. What if you suggest to Mr. Mizuno the possibility that the U.S. women’s volleyball team would wear Mizuno shoes and clothes for all international tournaments and, if they qualify, during the Olympics?”

“Can’t hurt,” he replied. “I’ll discuss the potential when I meet with Mr. Mizuno in Japan.” During his trip to Japan, Arie was able to meet Mr. Mizuno and discuss the possibility of funding the U.S. Olympic volleyball team. Mr. Mizuno was quite willing to support the team and, in addition, would provide all of the shoes and clothing which would carry the manufacturer’s logo on them.
In my mind, it was quite an unusual arrangement that a foreign company was more willing to help the women’s team of another country. In professional sports, such as football, basketball, and baseball, teams and players earned huge amounts of money and every team had enormous support from sponsors. However, amateur players, including Olympic sports, had few corporate sponsors and little financial assistance from the Olympic bodies. Things may change in the future but, in 1979, we were only able to secure funds to support the team by successfully appealing to a foreign company and, luckily, with an excellent and profitable result.

The basic idea was that Mizuno would finance the move of the U.S. Women’s Volleyball team from Colorado Springs to Coto de Caza, and continue their support of the team while they were in residence. Also, Mizuno would finance the team for two Olympiads that would cover 1980 in Moscow through 1984 in Los Angeles. In return, the players would wear Mizuno clothing and shoes. Where possible, they would integrate the Mizuno logo on their Olympic uniforms in subtle innovations that did not violate the Olympic rules.

Mr. Mizuno, Arie, and I met in Japan and signed the contract. The week after the signing, Arie rented a bus and moved the whole team to Coto de Caza. This move provoked a tsunami-like shock wave, and I received criticism from people in Colorado Springs who were unhappy that the team was leaving. Fortunately, I had a solid defense. “Do you want a gold medal in women’s volleyball, or not? If you want to produce a medal-winning team, this is the only way to do it.” Eventually, tempers cooled, and I retained my position as Director of Biomechanics of the U.S. Olympic training site. More importantly, the women’s volleyball team was set to train in Coto for the next eight years.

The team averaged five months a year traveling throughout Europe, Asia, South America, and within the United States on barnstorming tours in which it was not unusual for them to play as many as 28 matches in 28 consecutive days. When they were not traveling, they trained eight hours a day, six days a week (okay, they only trained for half a day on Saturday) and they did so with relentless intensity.

Since the women were “amateurs,” they received no salaries. They were provided room, board, and a modest sum for expenses each month to cover such luxuries as personal clothing, suntan lotion, and long-distance phone calls to families and boyfriends. (A note to younger readers; this was the time before cell phones. Long distance calls cost real, serious money for each minute. Instant messaging and WhatsApp were far into the future, and no one dreamed of taking pictures of food to send to their friends.)

No one on the team, in other words, was playing for the money. I suppose it was no surprise that most Americans were unaware that there was a national Olympic women’s volleyball team, so the players were certainly not on the team for personal glory. Each player was on the team for one basic reason: to win an Olympic gold medal for the United States in women’s volleyball. If they could achieve this goal, they would be the first to accomplish the feat.

The team continued this intense training with their eyes on winning gold in Moscow. The shock and dismay that fol-
lowed the presidential announcement that the United States would boycott the Moscow games was a severe blow to all of the players and staff. Needless to say, Arie and all of the U.S. Women's national team were bitterly opposed to the boycott. They were convinced that they would have achieved their goal in Moscow. A victory would have been more than amazing since it had not been very long ago that the United States women's volleyball teams would not have qualified for the Olympics. Believing that they would actually win a gold medal was hubris of the highest level. But they believed in themselves and, after this setback, they were even more determined to win a gold medal at home in 1984.

All of the team trained on my computerized exercise equipment every day they were in Coto during those eight years. The average increase in vertical jump was 6 inches, although some of the girls improved their jumps by 8 inches. Each team member could operate the equipment and store their individual data in order to evaluate their performance. This also gave Arie a chance to build team profiles.

The girls not only operated the computerized exercise equipment, they also learned how to perform biomechanical analysis on themselves. They were able to digitize their motion and execute the software, resulting in performance evaluation for different specific skills, such as setting, digging the ball, or blocking techniques. Then we would have conferences to discuss the results with Arie, and determine what strategy to employ based on the skills of his players and the techniques of each opponent.

My biomechanical research team and I traveled with Arie around the world and collected data on every team. My staff and I would sit in strategically located seats around the arenas and film the games. We filmed teams in Russia, Cuba, Peru, Brazil, Japan, China and other countries that participated in the Volleyball World Championships. Then, we digitized the motion data and performed two types of analysis: 1) biomechanical analysis of individual players, and 2) team movements under various playing situations.

For the team strategies on the court, we divided the court into 36 squares with each square given its own number. The figures on page 385 show two examples:

Our software calculated what the opposing team would do under different conditions. In a game of volleyball, the players cannot wait for the ball to be spiked or hit before they react. They have to predict where the ball will come from, since the time from the ball being hit by the opponent until it reaches its target on their side of the net is only 0.2 seconds or so. We studied and calculated how each team moved and how they arranged themselves during actual game play. We analyzed hundreds of games and were able to build strategies to use against each team. Not only did we know whether a player was going to spike the ball or whether she was bluffing, but we also determined their team movements on the court as the figures on page 385 show:

Imagine playing poker against someone and having a mirror behind him to see his cards. That was our unique ability. We amassed a collection of game performances for four
years before the 1980 Olympics. Then our library of teams and players continued to grow during the next four years in anticipation of the 1984 Olympics. In this way, we could watch for any changes in personnel or techniques and plan our training and game execution precisely.

Also, we periodically created a “simulation” game on the training court in Coto de Caza. We hung a large, white bed sheet from the ceiling and projected video or films from actual games. Our players had to play against the silhouettes projected on the sheets. Arie would frequently adjust the speed of the projector so that the opponents played faster than they were able to do in reality. Then, at future competitions, when our girls then played against those teams, they would comment how slow the opponents were that day.

This was how the U.S. Olympic Women’s Volleyball team rose to be ranked among the top of world teams. In 1977, they had been rated 45th in the world. After four years of hard work, they were ready for the Moscow Games in 1980. When the U.S. boycotted those games, that setback inspired the team to redouble their efforts and bring gold home in the Los Angeles 1984 Olympic Games. By 1984, the team was in the top echelon of the volleyball group of competitors and was ready to prove to themselves and the rest of the world how good they were.
The rise to greatness resulted from the intensity, hard work, years of dedication every day and every month, and with computerized assistance. They were able to improve their volleyball skills, their muscles were strengthened with a computerized machine tailored to each player’s unique needs, and computerized libraries of calculated opponent strategies enhanced Aric’s ability to coach his players against every other team. These factors had helped the U.S. to win the bronze medal in the 1982 World Championship in Peru.

In the 1984 Olympic completion, the best team in the world was the Chinese. They had defeated Peru in the 1982 World Championships and had dominated all of their opponents in the intervening years. The 1984 Olympic Games venue was Long Beach, California and the U.S. and China were in the same competitive pool.

There were two pools, A and B. Pool A consisted of teams representing Japan, Peru, South Korea, and Canada. The other group, Pool B, included the United States, China, West Germany, and Brazil. Because of the boycott of the western countries against the Russians in 1980, the Soviet block of countries and their allies boycotted the 1984 Games. Thus, many of the other strong volleyball countries, such as Russia and Cuba, did not compete in the L.A. Games.

The U.S. had some limitations unlike the Chinese. For example, all of the Chinese players, except for their setter, were the same height. This was a big advantage since their setter could place the ball at the same height for everyone.
Our setter had to adjust the ball location specifically for each player. Not only did she have to have great skill to make this adjustment for each of the spikers, but it also signaled the opponents about who would be hitting the ball. We were able to overcome this disadvantage and other physical differences with our computerized team strategy.

Olympic volleyball teams play preliminary rounds in group or pool play. The top two teams of each group advance to the next rounds which are the elimination competitions. China was in the same group as the United States. Therefore, we had an early match against the Chinese. This early match in pool play ended with the U.S. women winning with a score of three sets to one. The U.S. girls played fantastically and were encouraged that they might even beat the mighty Chinese if they made it to the finals. Although they had to be cautious in their optimism about continuing to play well, it was hard to contain their bubbling excitement.

Both China and the U.S. continued to defeat their respective opponents until they both reached the final gold medal game. The winner would receive the gold medal, and the loser would receive the silver medal. Unfortunately, China had understood our secret team strategy. Therefore, in the final game, the Chinese coach rearranged his players within the court and used different game strategies for passing and spiking. They played differently than what the American team had expected and trained for, and China won by a score of 3-1. The U.S. received the silver medal which was an amazing feat. They might not have won the gold medal, but they had truly soared to greatness.

In addition to our work with the volleyball team, tennis players, and our Wilson Sporting Goods projects, we also had magazine articles and television coverage. We were dubbed as "A Laboratory for Jocks" (see page 373) because of the many innovative techniques that we employed to study athletes and their performances. As the pictures on page
In our studies at the Coto Research Center, we used EMG and a specially designed visual apparatus to analyze these tennis player's net volley techniques. Another article appeared in Science Digest in 1989 and described, “Building the Athlete of the Future” (see page 372). The theme of the article was a discussion of some of the techniques available to athletes to improve their performance levels in their chosen sport.

Another one of the magazines was Golf Magazine and it described the “perfect swing” as being unique for each individual (see page 391). There is not a single, cookie-cutter perfect swing that fits everyone. People are not identical in size and weight, and there is no reason to assume that there exists a “perfect swing” to fit all golfers. Individuals must identify their own swing of perfection.

One of our golf studies involved putting. We studied various techniques for putting and from these research projects we perfected a club called the “Magic Putter”.

The Magic Putter was designed to carefully calibrate the putter’s center of gravity so that when the golfer used it, the club functioned like an extension of his or her arms. The whole system (the entire arm from the shoulder down to and including the putter) moved like a single, unsegmented pendulum.

The game of golf relies on two distinctive skills for delivering the golf ball to its target. One is the swing from the tee which requires force, velocity, and power, as well as a level of accuracy. The other skill, which requires a higher degree of accuracy and precision, is putting the ball into a small hole on the green.

A high level of precision requires efficient neuromuscular control. The movement of the club depends on an efficient biomechanical technique allowing the neuromuscular system to execute the movement at a high level of accuracy. Optimum performance depends on the efficiency of control. It does not matter how strong the muscles are or how good
Mac Wilkins, Al Feuerbach & Dave Laut practice on 3 force plate system with the APAS System
http://arielnet.com/ref/go/2727

Ben Plucknet, world record holder
http://arielnet.com/ref/go/2728

Brian Oldfield, world record holder
http://arielnet.com/ref/go/2729
Chapter 16: The Coto Research Center

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The golfer's metabolism is, control is the most important factor. The brain must execute complex computing functions to generate and control extremely sophisticated behavior.

The fineness of control depends upon the number of motor nerve units per muscle fiber. The more neurons involved, the finer the ability to maneuver, as in the case of the muscles that control the eye. When there are fewer motor nerve units involved, the action becomes less refined as, for example, walking. The individual fibers, which cause a muscle to contract, function with elaborate synchronization. Synchronization of muscle firing is critical for optimizing a particular movement such as putting. In the power events, such as in the drive off of the tee, it is critical that the muscle action is simultaneously activated to optimize the force. This is done by the central nervous system sending signals to the individual muscle fibers. However, in the putting movement, control is of great importance.

What, then, are the elementary requirements of movement? The first element is muscle. The second component is a signaling system that makes the muscles contract in an orderly manner. Our movements are generated in different ways depending on the level of skill needed. When putting, golfers recruit their muscles at a different time in the move-

Dave Laut, Olympian
http://arielnet.com/ref/go/2730

Russ Hodges
http://arielnet.com/ref/go/2732

Yuriy Sedykh, hammer throw & Natalya Lisovskaya, shot put
http://arielnet.com/ref/go/2731
ment, depending on the level of skill that they have achieved. The motor program is constantly changing in order to produce efficient movement. Different instructions to the muscles must come from the nervous system. Since there are numerous combinations of muscles which produce a similar putting action, the internal programming movement model will vary as situations change. Thus, the neuromuscular program sent by the brain will activate a selective set of muscles as the situation dictates.

For some sporting activities, the participant can repeatedly practice the action enough times that the skill becomes nearly automatic. For example, the shot, hammer, or the discus throws are nearly the same every time. Therefore, these athletes can train their neural patterns to be constantly recruited in the same pattern. This is not the case with golf. Every shot requires adjustment to the ball location, soil conditions, the wind, and distance to the hole, among other things. Somewhere within the nervous system, a model of movement is formulated which is structured for the demands of muscle coordination for a golf swing. But the optimal motor control of the skilled movements, such as with putting, is generated by a higher motor program involving our central nervous system and conscious adaptation to conditions.

Based on our studies, we decided to test the hypothesis of whether minimizing the number of body segments involved in the putting movement would enhance the accuracy of the putt. We helped to design a special putter whereby the golfer would hold the club in a way that the swing was a pendulum action of one arm from the shoulder. To properly use the putter, the golfer needed to stand in the proper position facing the hole. The putter was held with one arm while the other arm supported the club in a stabilizing position. The movement of the putter was like a pendulum initially going backward and then swinging forward. The golfer used only the arm while trying to eliminate or, at least, stabilize movements of the trunk and hips.

Another significant advantage with this club movement was that the golfer faced the hole directly. That is, the golfer

*The Olympians at our Coto Research Center*
looked directly at the target rather than standing and looking sideways in the more traditional putting stance. This allowed the golfer to putt using normal binocular vision facing the target. The sideways style of putting requires a constant turning of the head from facing down towards the ball and twisting back to see the hole. Not only is this an abnormal biological disadvantage but it also requires constant movement of the head. The Magic Putter eliminated this visual disadvantage.

This invention, the Magic Putter, has been used by many golfers. Like any new tool, it requires practice to feel comfortable using it. But the positive response from those golfers who adapted to the unusual stance was only praise and successful putting results.

After the project with the “Magic Putter,” we were not idle for even a moment. Our life was fun but hectic during that time. Not only did we have projects with Wilson Sporting Goods, working with the women’s volleyball team, bringing the modern pentathlon to Coto, on-going testing and improving the Computerized Exercise Machine, but I was approached to be on several television shows.

One of the first was by David Letterman, the comedian, which surprised me initially. Mr. Letterman told me that he loved the game of paddle ball, and wanted to know if I could analyze his game. He wanted to know how Hilary Hilton, one of the game’s champions, was able to beat him every time. He explained to me that he was much faster and stronger than she was, but Hilary was able to win using smaller movements and with weaker shots. How could this happen?

I said, “We will take our biomechanical equipment to the paddle ball court and film you playing against Hilary. Then we will analyze the shots and the positions on the court. With these quantitative findings, we should be able to answer your questions.

Ann and I traveled to New York City with our cameras and other necessary equipment. We set the cameras and collected data for two days as Dave and Hilary played many games. As David had predicted, Hilary was able to defeat him in every game.

We collected the film data which we could process according to our normal analytic procedures. Following this filming session in New York City, we returned to our laboratory and began the long process of analyzing the data. Ann had to digitize for many hours because there were two camera views for every shot. We selected several backhand and forehand shots by each player which required many hours to complete the process. After the digitized film data was available, we processed it with our normal biomechanical quantification procedures. These steps generated the kinematic parameters of positions, velocities, and acceleration for the different limb segments.

The results revealed that, although David was faster and stronger in his ability to hit the ball, Hillary was quicker in anticipating where the ball would go as soon as David hit it. On the other hand, David waited for the ball to hit the wall before making his move. What this meant for David was there was a time delay in his reaction to the ball. He wait-
ed until the ball hit the wall before he moved into a position where he could hit it. Hilary’s technique involved rapid prediction regarding where the ball would hit the wall and where she should intercept it for the return volley. She moved into position before the ball hit the wall and had ample time to deliver a return volley. This anticipation was presumably based on her experience, although it could be a natural talent upon which she was able to capitalize. Hillary was able to interpret her opponent’s body movements and began to react early enough to be in the correct position when the ball hit the wall. Because she was able to anticipate where the ball was going to hit the wall, Hillary was ready at the proper location in time to make her return shot. David always had to wait for the ball to hit the wall or the ground and this defensive strategy was too slow to defeat Hillary.

After we had completed our research, we contacted David Letterman’s staff to let them know that we were ready with the results. Shortly after that, I was scheduled to appear on “The David Letterman Show” with Hilary and Dave.

I was able to explain that our evaluation demonstrated how a player who is physically smaller and weaker can overpower an opponent who possesses superior levels of force and speed. Implementation of the correct strategy allows a player to overcome weaker physical characteristics by utilizing skillful techniques. In this way, Hilary demonstrated anticipation of ball movement that allowed her to make more efficient return shots. David was more powerful in speed and strength but hindered by having to wait to make shot decisions.

Some of the films of the data collection were shown with the two players engaged in the game. We illustrated with the different biomechanical results how Hilary was more efficient in her game strategy and how Dave was more powerful with his strokes. The recommendations were that David focus on his strategy to significantly improve his game. However, this
would require hours of practice. Hilary, as a professional, could continue utilizing her athletic talent and would always find new and more effective ways to improve her game. Any changes that Hilary would need to make would probably be small and subtle.

After the work with David Letterman and Hilary Hilton, we had the privilege of providing thousands of analysis for athletes at our Coto Research Center. We were involved with many Olympic activities in this rich sporting environment.

Then, we were approached by WGBH, a PBS television station in Boston, to do a series on different athletes and their sports. The show was called Future Sport and consisted of thirteen episodes. Vic Braden and I were the hosts and interviewed the athletes and described the biomechanical analysis of their sports.

Fencing, sprinting, archery, and Rolf Benirschke, kicker for the San Diego Chargers

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of their individual sports. A list of some of the athletes who appeared in these episodes were:

- Frank Shorter, 1972 Olympic gold medalist in the marathon
- Kate Schmidt, 1972 and 1976 Olympic bronze medalist in the javelin
- Al Oerter, 1956, 1960, 1964, and 1968 Olympic gold medalist in the discus throw
- Hal Connolly, 1956 Olympic gold medalist in the hammer throw
Athletes at the Coto Research Center

- Edwin Moses, 1976 and 1984 Olympic gold medalist in the 400-meter hurdles
- Scott Tinley, triathlete and 1982 and 1985 Ironman gold medalist
- Bob Seagren, 1968 Olympic gold medalist in the pole vault
- Franco Colombo, 1976 and 1981 Mr. Olympia
- Sharon Shapiro, 1970s eight-time National title holder on U.S. national gymnastics team
- Ken Norton, 1977 and 1978 world heavyweight boxing champion

Making this Future Sport series was one of the most exciting and fun things that I have done in my career. I interacted with many of my childhood idols, some of the greatest
The Discus Thrower and his Dream Factory

Gideon Ariel & M. Ann Penny Ariel

athletes of the era, and individuals who possessed unbelievable athletic talent. It was a truly enjoyable and stimulating time.

It has been many years since we filmed this program during which I have traveled around the world presenting at conferences and visiting universities. Not infrequently, I would be walking down a hallway and hear the Future Sport theme music. Every time I heard this unique musical introduction, when I looked into the classroom or auditorium, on the screen would be one of the episodes of “Future Sport.” I am always honored and humbled by its universality.

My next television appearance began in Seoul, South Korea in 1988. I was in Seoul to present research findings at the International Olympic Scientific Congress. I was accompanied by a close and dear friend, Mr. George Dales. Mr. Dales and I were also preparing to film as many of the track and field competitions as we could arrange at the Seoul Olympics.

During this time in Seoul, I was delighted to see a familiar face from our days in Amherst, Mr. Tom Brokaw of NBC. Mr. Brokaw and I chatted for a time, and he described a topic of a new NBC Special that he was hosting called “Black Athletes: Fact & Fiction.” We discussed this issue as well as the enormous sensitivity that the topic provoked in America. Tom wanted the program to be factual, objective, and as scientifically based as possible. He was determined to present facts rather than myths or biased opinions and was convinced that this would be an interesting and valuable program.

Tom and I met several times to discuss how I could conduct objective, scientific tests to compare athletes within the population that NBC would provide. One of our planning sessions was in my hotel room where I was able to update Tom with examples of our biomechanical technique and some suggestions of what test parameters would most appropriately answer his questions. Tom was familiar with the biomechanical analysis since we had analyzed him and Bill Rodgers in 1976 and presented the results on the “Today” show that he hosted. Here in Seoul, some twelve years later, I was able to demonstrate our newer, more sophisticated pro-
grams. I was also able to demonstrate a three-dimensional “stick figure” that we could rotate on the screen, including integrated performance analyses.

I explained to Tom that the entire discussion, or lack thereof, in America regarding black and white athletes was incomprehensible to me. Since I had been born and raised in Israel, this issue of race was nonexistent in my country or culture. Israel had been a land of immigrants long before I was born in 1939. There were Jews from every corner of the world living in Israel. The country was a blend of languages, skin tones, and Jewish heritages that every immigrant brought with them. This mixture of Jews from around the world was especially prevalent in my school, Hadassim, where I spent so many years. My roommates, for example, were from Argentina, Romania, and Iraq. Another classmate was the fastest runner in Hadassim named Miriam Sidranski. She had been brought by her father from the Belgian Congo after the death of her mother so that she could grow up and learn in a Jewish-Israeli environment.

Miriam Sidranski was an Olympic sprinter with me at the 1964 Olympic Games in Tokyo. There she competed in two track events for Israel. In the 100-meter sprint, she finished sixth in her preliminary heat with a time of 12.1 seconds but did not advance because only the top five finishers from each heat ran in the next round. Unfortunately, Miriam missed advancing by 0.1 seconds. She then ran in the 200-meter sprint, finishing in 24.68 seconds but did not advance past the preliminaries. Officially, she finished in 21st place.

Coach Johnson (left) argued the results with Tom Brokaw (right)
http://arielnet.com/ref/go/1240
Outside her Olympic experiences, Miriam was one of Israel’s best female sprinters in the 1960s. In the Tokyo Games, she had broken the Israeli record (24.68 seconds) in the 200-meter event. As of June 2001, it was still the eighth best individual result in Israeli history. Miriam was also very successful in the 100 meters, breaking the national record with a time of 11.7 seconds (hand-timed) in September 1964.

Miriam and I have been friends for more than 50 years and the issue of skin color or country of origin has never been an issue. I believe that this is the prevailing attitude among Israelis in general. I had no experience with racial prejudice until I arrived in the United States. This bias and controversy have baffled me since I arrived in America in 1963 and there seems to be no resolution to the situation.

Tom planned to interview scientists from different areas, including sociology, physiology, and psychology, regarding this issue. My strength was biomechanics and, as I explained to Tom, how the athlete moves depends on physics. The mechanics of the movement may be affected by psychology or physiology or sociology, but the movement itself depends on the athlete’s physics. Any athlete with good psychology and bad physics results in a happy loser. An athlete with bad psychology and good physics can still win. Human physics is quantified using biomechanics.

All movement is produced by contraction of muscle fibers. Muscle can function in only one direction, that is, they contract. When skeletal muscles contract, they pull bones towards each other. For example, bending your arm at the elbow...
bow is caused by muscular contractions that move the bones of the forearm towards the bone in the upper arm. All athletic events, running, jumping, swimming, etc., depend on the movement of bones that result from forces generated by the muscles.

Each muscle is composed of fibers that contract at various speeds to generate the forces. There are different types of muscle fibers, known primarily as “red” and “white”, or “fast twitch” and “slow twitch”. Each of these fiber types possess unique actions and produce responses consistent with the numbers of each fiber type within each muscle. NBC had worked with a specialist in muscle fiber types to describe this aspect of the movement.

With regard to the biomechanical quantification, NBC arranged for a population of accomplished athletes consisting of ten black and ten white basketball players. This is a very small sample size and could in no way represent all members of groups which number in the millions. However, we concentrated our efforts so that the results of the study, using first-class technology, would be scientifically objective for the athletes involved.

The basketball team from the University of California at Irvine, located in Irvine, California, were filmed executing several activities, including jumping from a height onto a force platform, jumping up from a force plate, and utilizing the computerized exercise machine to measure forces and velocities at various resistances.

We performed an extensive study on this sample of athletes of ten black and ten white men. Of course, this is a very limited study of the scope of the population since the number is so small. However, the technology to conduct this study was uniquely new and specialized.

Mr. Brokaw wanted the study to be as objective as possible. Therefore, we devised a strategy, which is known in the scientific community as a “double-blind study”. This means that when the data was collected, only an unbiased observer nominated by NBC marked the data with a code indicating whether the athlete was black or white. That individual was the only person who could identify the coded data stored on the computer.

A few days after the data was collected, Tom and the NBC staff put me in the computer room to analyze each data set belonging to each participating athlete. My task was to examine the forces and other measurements and, based on the data, label the file as “B” for black or “W” for white. The force platform data for some of the athletes repeatedly revealed a distinctive pattern of rapid and explosive forces followed by a gradual decline of the force. Alternatively, for the other group of athletes, the force platform results showed a slower, more gradual force generation but without the rapid...
The NBC staff member who maintained the data identification code was able to group the findings. For all twenty cases, the data showed that the group labeled by me as “B” was associated with the fast, explosive force patterns and the group labeled as “W” consisted of the slower more gradual force development. In other words, there was an obvious difference between the two groups with regard to the pattern of force development.

We then examined the different exercise results performed on the computerized exercise machine. In general, the results were consistent with the force platform findings. The individuals who demonstrated an ability to rapidly extend their legs were found to be in the “B” group and the ones who were less quick were in the “W” group. There was some overlap in the actual strength measurements with a number of athletes labeled as “W” demonstrating force production equivalent to those coded as “B”. But in general, there were clear differentiations between the two groups of athletes.

These results convinced NBC that biomechanical analysis was significantly objective from a scientific standpoint, and it was decided to present them in the program. The results would be presented alongside the findings of other scientists on this subject. In general, the black athletes demonstrated better responses in producing vertical forces on the plate, as well as faster recruitment times on the computerized exercise machines. These biomechanical findings clearly demonstrated that the black athletes were athletically superior to their white compatriots.

Needless to say, this television program generated criticism. Unfortunately, in America, a discussion of this nature is politically incorrect. Rather than allowing an unbiased examination of the facts and permitting scientific inquiry to answer the questions, any examination that involves race is perceived to be tainted and discriminatory. For example, Dr. Brook Johnson, the head coach of Stanford University track team, dismissed the results and attributed them to social issues and coaching only.

As a non-native American, I feel disappointed and frustrated in my adopted country when it comes to science and race. I am well aware of the long and unfortunate history of bias and discrimination against black people here. However, I believe that a fresh examination from a scientific point of view would be helpful in moving this bias into a healthier perspective. If anyone had told me that an Israeli could run faster or throw the discus farther than another group of athletes, I would have been ecstatic, even though I certainly come from a population which has also suffered cruel and painful discrimination.

During the NBC program, I participated in the open discussion following the filmed presentation of the various scientific inquiries. Jon Entine, author of the book “Taboo: Why Black Athletes Dominate Sports and Why We’re Afraid to Talk About It” included one of my answers from the open discussion.

“'I know that the American system is very sensitive to statements of Black and White. But you cannot defy science. You cannot just say that day is night and night is day. These are facts. And I think it's to the advantage of the black athletes to be proud that God was on their side.'”

Gideon Ariel

Biomechanist, former Israeli Olympic Athlete

Breaking the taboo on race in sports
it has been my great fortune to have had the opportunity to spend time with him.

Amidst the research projects, television shows, and continued work on the Computerized Exercise Machine, we were lucky to receive a surprising new burst of enthusiasm from an unexpected source. Because we were adjacent to the Vic Braden Tennis College, we frequently were asked by Vic to give demonstrations of our motion analysis system to his class members. Ann and I normally followed the same format. I would be the narrator and described what we filmed and how the results were generated on our computer. Ann followed my lead and demonstrated the digitizing and showed the three-dimensional stick figures. Our two-man team operated smoothly because Ann could anticipate what I would describe in our step-by-step demonstration.

One day following our presentation, one of the guests at the tennis college asked what computer system we used. I explained how we had converted our original software from the room-sized Honeywell computer to the Data General minicomputers that we were currently using. The gentleman asked whether we thought it would be possible to operate our analysis on an IBM computer. He expressed greater interest and asked more sophisticated computer questions than did most of the tennis college participants. I, being naturally effervescent about our motion analysis program, was happy to discuss the system and answered his questions. In response to the question about IBM, I told him that I did not know but could think of no reason why we could not. Since we did not have an IBM system to try, I could not say more.

At this point in the discussion, the tennis college participant explained that he was Don Estridge and that he was an IBM vice president of manufacturing. More importantly, one of his pet projects and brainchild was the personal computer or PC as it became more commonly called.

Philip Donald Estridge (June 23, 1937 – August 2, 1985), known as “Don,” led the development of the original IBM personal computer (PC) and, thus, is known as “father of the IBM PC.” His decisions dramatically changed the computer industry resulting in a vast increase in the number of personal computers sold and creating an entire industry of hardware manufacturers of IBM-compatible PCs.

Don’s education was a bachelor’s degree in electrical engineering at the University of Florida. He worked in the Army, designing a radar system using computers and at NASA’s Goddard Space Flight Center until he moved to Boca Raton, Florida in 1969.

His efforts to develop the IBM PC began when he took control of the IBM Entry Level Systems in 1980 with the goal of developing a low-cost personal computer to compete with increasingly popular offerings from the likes of Apple Computer, Commodore International, and other perceived IBM competitors. To create a cost-effective alternative to those companies’ products, Estridge realized that it would be necessary to rely on third-party hardware and software. This was a marked departure from previous IBM strategy which centered on the in-house vertical development of complicated mainframe systems and their requisite access terminals.

Don Estridge - IBM PC executive
Estridge also published the specifications of the IBM PC allowing a booming third-party after-market hardware business to take advantage of the machine's expansion card slots.

The competitive cost and expandability options of the first model IBM PC, model 5150, as well as IBM's reputation, led to strong sales to both enterprise and home customers. Estridge was rapidly promoted and, by 1984, was IBM's Vice President of Manufacturing, supervising all manufacturing worldwide. Steve Jobs, renowned for his empire at Apple, offered Estridge a multi-million-dollar job as president of Apple Computer. Estridge turned him down.

For my company and me, this fortuitous meeting had an enormous impact on our motion analysis business. From the beginning of our company, we had developed our software to operate on many computers. We had grown from the massive Honeywell at Dartmouth College to the Control Data computer at the University of Massachusetts. Each of the changes meant new programming languages and translations of our software.

The next major transition was to the smaller, more compact Data General minicomputer that exposed yet another programming interface. Now, if we were able to run our system on an IBM personal computer, this would take our software and company to a whole new level. If we could rewrite our software to operate on this smaller, more compact PC, we would be able to sell the hardware with our software licensed on it directly to our customers. This would allow the customers to perform their biomechanical analysis from the filming at the beginning to the data transformation at the end. We would be out of the processing loop completely.

By selling our biomechanical analysis system directly to the customer, we would have more time to develop new features for the software. For the customer, this would provide complete control of their data, which was particularly important to corporations that were uncomfortable having their secrets outside of their walls. Universities could provide students more time and flexibility to pursue projects. For IBM, despite our obvious smallness in consumer sales numbers, we were precisely the kind of affiliate they were attempting to attract. We could be an outside third party software developer and they could use our uniqueness in their marketing.

During our subsequent meetings with Mr. Estridge, he asked whether we could have our software programs operational on the PC in time for the Los Angeles 1984 Olympic Games. We assured that we would be able to meet that deadline. I knew that we would have to work deep into the night to accomplish the task, but this would not be the first time that we had to produce under pressure.

IBM sent us ten new PC prototype computers for our work on the project. One of our initial challenges was the lack of a hard disk in the computer to store the program or the data produced. Instead, those original computers utilized floppy diskettes. We had experience with floppy diskettes previously with the Radio Shack computer, so we plunged into the project.

The project was for $100,000 with a bonus if we could successfully demonstrate our motion analysis system on the PC before the 1984 Olympics. The bonus was double the price of the project. We were so excited to be working on this project with IBM that Ann and I confessed to each other that we would have probably had done it for free. The money would be nice but, at that time, IBM was bigger and more realistic than OZ. For us, IBM was the top of the mountain and we were thrilled to be working with Mr. Estridge.

Our programmers, Jeremy and Alan, were assigned 100 percent of their time to achieve our target completion date. The programs and implementation were finished in 1983, ahead of schedule.

Because we had finished with time to spare, IBM decided to launch our biomechanical application on their personal computer during a special marketing meeting at their home site in Boca Raton, Florida. The idea was to have the women's volleyball team play "matches" for the sales staff while intro-
ducing an application that would run on their new “darling”, the PC. They flew the entire volleyball team as well as my staff and me to Boca Raton for this company meeting to present the APAS system on the IBM PC.

The volleyball competition was held in a large gym with hundreds of marketing team members divided into four color-coded groups. The volleyball team engaged in an exhibition tournament exchanging uniform colors so that each group could cheer for their “team”. What an amazing experience to watch the cream of the IBM marketing team as well as some of their executives cheering exuberantly for their “team”. The entire two days in Florida was an incredible experience and a lot of fun. I have thought about this meeting periodically and wondered if those men and women followed the U.S. women’s team as they won the silver medal in 1984.

Sadly, Don Estridge died in a plane crash, along with his wife, Mary Ann, on August 2, 1985. He was only 48 years old. At the time of his death, IBM ESD (which included the development and manufacturing of the IBM PC, PC DOS, PC LAN and TopView) had nearly 10,000 employees and had sold over a million PCs. IBM’s president and chief executive officer John F. Akers said at the time: “Don Estridge was a man of vision whose skill and leadership helped guide IBM’s personal computer business to success. He had a very bright future in our business. He and Mary Ann will be greatly missed by all their friends and colleagues.”

We converted all our software operation and research projects onto the IBM personal computer. This conversion changed our life at the Coto Research Center. We could perform the same complicated analysis that we used to do on the expensive Data General equipment in our office or home. Companies did not need to pay us to do the job. A company could buy an IBM PC, use our software, and do their analysis in-house which they liked much better for security and development reasons. Several photographs showing our PC system, at the time, are shown on the page on the left.

We continued both software and hardware improvements on our Computerized Exercise Machine, advanced our software capabilities, and expanded our technologies to fit the times. By 1987, we reached a point of new challenges and changes for our company.