Chapter 7: Love and Work

The doctoral program curriculum was similar to the one I had pursued for the master's degree. There were academic requirements within and outside the focus of the individual's interest and there was a mandatory research project. I registered for fall classes in statistics and for several new courses which sounded intriguing. One was cellular physiology, with a new professor, Dr. Eddington, and the course description suggested how students would become proficient with the electron microscope. I was surprised to learn that in the one year I had been away, the university had acquired such a sophisticated tool for the study of human movement. Another new course which set my heart ablaze was biomechanics of performance, to be taught by Dr. Stanley Plagenhoef. He was a new professor and the class had a promising title. I eagerly anticipated the biomechanics class since it sounded more promising to my way of thinking than even kinesiology had. I had my fingers crossed when I went to the first class.

When I stepped into the classroom for the first day, I was in for another surprise. There was my nemesis from before. The tough pretty girl, who had stood up to me after statistics and slammed the door in my face outside of Dr. Kroll's lab, was sitting in the front row. I considered my options. Then, selecting bravery over cowardice, I sat down next to her.

We had a few minutes to chat before the professor arrived to begin the class so I reminded her that we had been previously introduced by Jim Salidas. She told me her name was Ann Penny. She explained that she was half way through the master's program and then would continue towards the doctorate. Following graduation from the University of North Carolina, she had taught physical education in a private school in Princeton, New Jersey, for two years. Suddenly, the lights flashed in my brain! Now I understood why I had not met her during my master's program. As we chatted, I learned of her disinclination to teach children in elementary or high school. Apparently, it had taken less than one full day of teaching for her to realize that she had made a huge mistake in her college career path. Now she was in graduate school at the University of Massachusetts with the goal of following a more scientific program of study.

Jim Salitas, a friend I had first met during my master's program, soon joined us. It transpired that Jim and Ann had become very close friends during the previous year. They had studied together in several classes and shared many discussions over coffee. At that time, there were few women in this field of study, so, as it turned out, Ann was the only girl in class. She was intelligent, direct, and capable. Jim sat down and we began discussing our class schedules, what we had done during the summer, and people that at least two of us happened to know. It was one of those conversations where everyone was talking at the same time but somehow all was understood.

We also caught up on the details of our private lives. Jim was originally from New Hampshire and was married with two children. His wife was a wonderful person who supported Jim completely in his academic quest. But they struggled financially since she could only work as a babysitter and his assistantship was too small to support a family of four.

I reminded Jim of how he had helped me during my master's program to overcome my all-thumbs approach to loading the movie projector. We remembered how I tried to thread the film through the maze of pressure plates and make the loops form properly and eventually laughed until tears poured because of my ineptitude. Now we could share those hilarious moments again. Once again, my old characteristic of persistence and effort had rescued me. I never give up when I undertake a task. Sometimes it takes extra time and effort, but I never quit and eventually I could operate the projector. Jim agreed with my description of the times and my personality assessment.

Dr. Plagenhoef entered into the classroom and commenced to amaze us with the abilities to quantify motion using biomechanical analyses. The biomechanics class was an eye-opener for all three of us. We left the class bubbling with ideas and went directly to the closest coffee shop to expand on what we had learned. Everything that the new professor, Dr. Plagenhoef, had discussed was especially exciting to me

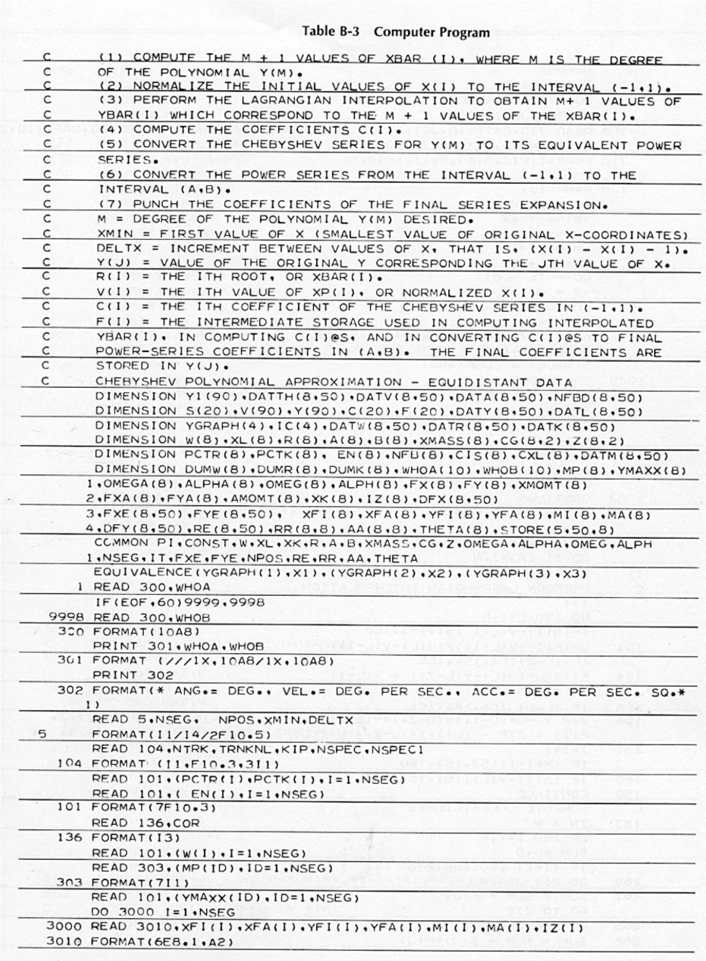

Table B-3 Computer Program

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

Section of one of the first ever programs for biomechanics

since I saw an academic path towards understanding movement from a mechanical point of view which had been my quest for decades.

Over endless cups of coffee, Jim and I learned more about Ann. She was born in Raleigh, North Carolina, but spent most of her childhood in Chapel Hill, North Carolina. "Go Heels" was a phrase we heard often. To an Israeli, this made no sense and to a New England Yankee like Jim, this was nearly a declaration of war. We were further informed that the sky was Carolina blue because G_d was a Tarheel.

Despite this seeming craziness, it turned out that Ann was also obsessed with understanding the anatomy and the mechanisms of controlling the human body. I was more intrigued by the mechanical aspects while Ann was more interested in the nervous system's impact on the functions of movement. Jim was interested in both aspects and hoped to find a career path perhaps in physical education or coaching. Jim's financial stresses pushed his plans to find a teaching position in a college in New England since this was close to home for both Jim and his wife.

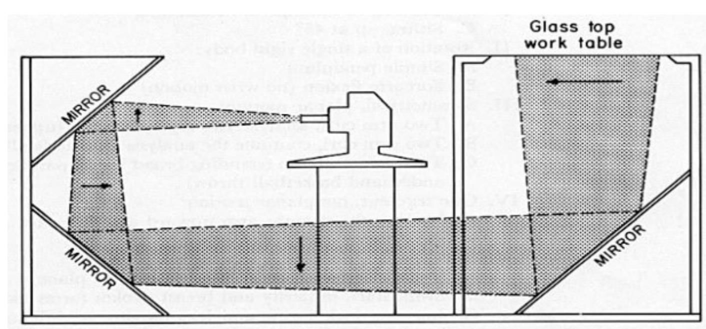
Our friendship flourished, and soon we were the "Three Musketeers". Jim, Ann and I would meet in class, in the laboratories, and over coffee. Frequently, we drove to the local ice cream shop, where Jim and I would consume enormous hamburgers and milkshakes, followed by four-scoop banana splits. Ann would drink her coffee and shake her head at the amount of food two men could eat and remain trim. Our shared common interests seemed endless and we were lucky to be able to help each other with difficult class work. If one of us could not solve a problem, eventually we would collectively discover the answer.

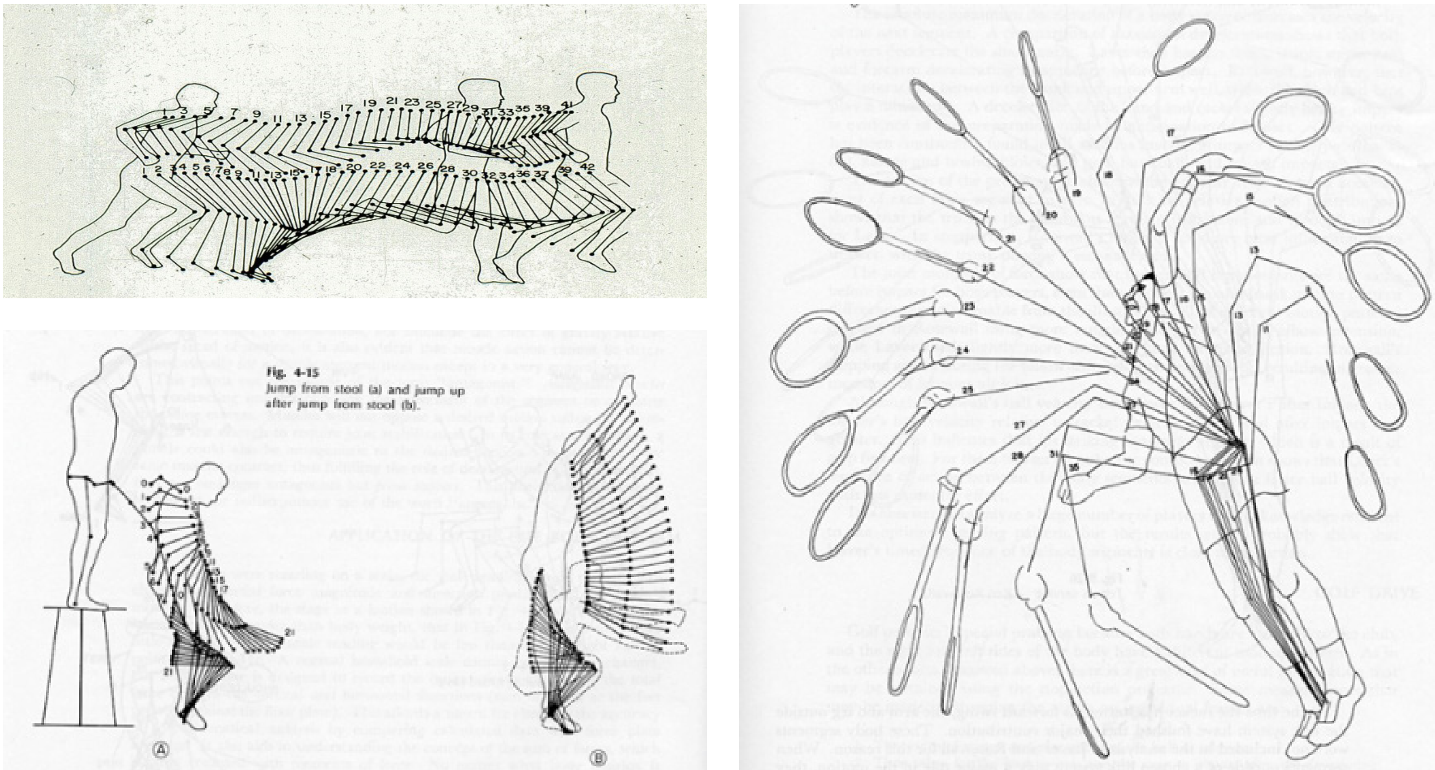
As the semester progressed, I became convinced that biomechanics provided the way for me to understand and produce answers to my many questions about movements and activities. Clearly, biomechanics was my field and gave me a focus to achieve the answers I sought. But there were new aspects, which intrigued me continually. Early in his career, Dr. Plagenhoef had developed a biomechanical program written in one of the early computer languages called FORTRAN.

Unfortunately, the process required to perform a biomechanical analysis was excessively tedious. The sequence began with filming the subject at a right angle to the motion. After the film was developed, the next step was to project the 16mm film of the movement one frame at a time. The film sequence was projected through a series of angled mirrors onto a glass-topped table. As each frame appeared, the location of the body's joints was traced by marking points on a large piece of paper which had been taped onto the glass top. This process was known as "digitizing".

The next step required measuring the various angles and distances on the large paper with a ruler and protractor carefully recording them in a table. The data in the numerical table had to be hand-punched into computer cards necessitating sitting for hours in the computer center to complete this task. These punched cards were then submitted to the com-

Projection system for tracing films frame by frame





Composite tracing

puter center for processing by the biomechanical program. If all the point information had been correctly transmitted to the computer punch cards, a long, thick stack of paper was the happy result. But if even one card was wrong, upside down, or missing, there was only a thin computer printout of failure as the result. There were many times, after hours of waiting, the result was a disappointment. However, if all went according to plan, the program could correctly calculate the kinematic characteristic of moving bodies.

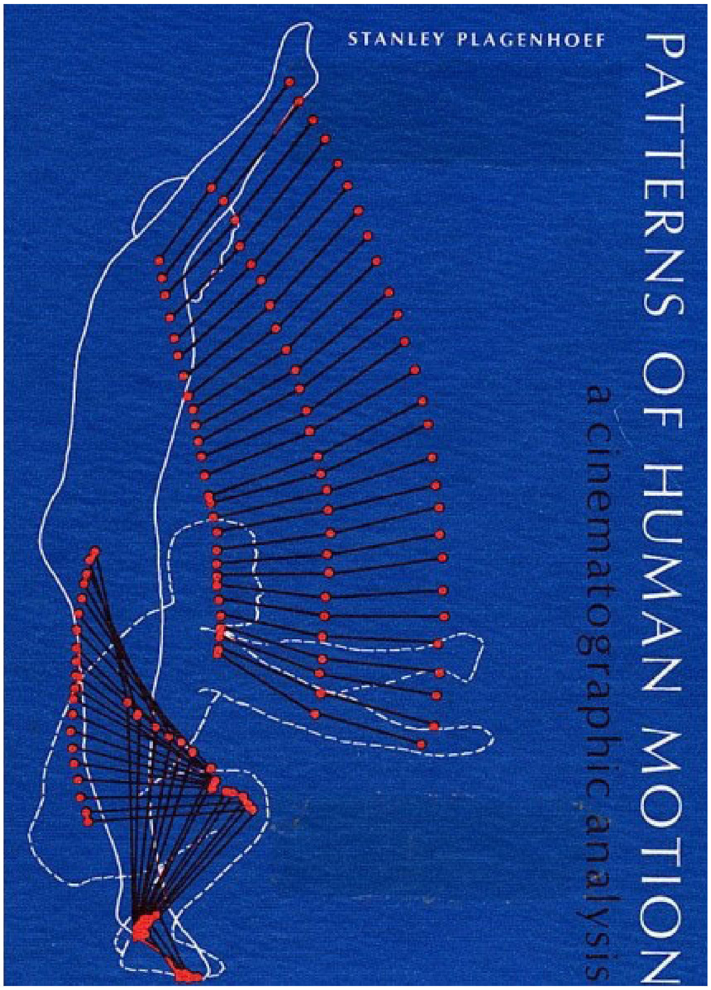
The program produced kinematic parameters which included the positions, velocities and accelerations of each of the selected joints. The information for any one of these joints and for any of the selected kinematic parameters could be plotted on paper. The plotted data yielded diagrams from activities such as stepping from a plateau, jumping into the air, and hitting a tennis serve.

During the semesters that Dr. Plagenhoef taught our class, he was in the process of writing a book, titled "Pattern of Human Motion". All of the biomechanics class members, including Ann and me, contributed most of the figures to his book. The tables and diagrams were ours, although no royalties resulted from our work. We were typical graduate school slaves, but the learning and experience more than made up for any financial rewards or lack thereof. After all, the students were there to learn, not to earn a living.

That was my first introduction to using a computer to measure or quantify human movement. I became obsessed with using this tracing procedure and Dr. Plagenhoef's biomechanical program. I wanted to analyze as many track and field events as possible with this technique.

Fortunately, at that time, I was the assistant track coach and shared an office with the head coach, Ken O'Brien. He was the same coach who had invited me to work with the field events during the year that I pursued my master's degree. He had enthusiastically welcomed me back after my stint in Indiana and Ohio, and gave me the job of working with the field athletes as I had previously.

Soon after the semester began, I made a fantastic discovery. During the previous year, Ken had acquired loop films for each track and field event. Each event was individually presented for one full cycle of that specific activity on 16mm movie film. The event cycled continuously in a repetitive loop. In other words, the activity would continue to repeat over and over as many times as desired. The first event I examined showed a javelin thrower running down the runway, employing the complicated cross-step running approach pattern, planting the front leg, and throwing the javelin. Coach O'Brien had loop films for the discus throw, shot put, hurdles, and the other track and field events.



***Patterns of Human Motion* by Dr. Stanley Plagenhoef**

The most important part of the technique for throwing the javelin was from the moment of foot plant until the javelin was released. Therefore, I cut that section out of the loop since the only section of the throw that I needed for my biomechanical analysis was from the moment of the foot plant until the release of the javelin. After I had cut that section out, I connected the remaining film into a loop. After I had connected the remaining film, anyone watching the film of the javelin throw would see the athlete run down the runway with the complicated crossover footwork followed by the javelin flying in the air. Everything in between the run and the javelin flight was missing.

This was the era of films rather than the digital technology currently available. During the first century of photography and movie-making, everything was recorded on film. Film was a celluloid material whose light-sensitive surface could record lasting images. At that time, film was the only option for recording. Film could be easily cut and spliced so I could remove the parts I needed and connect the rest of the film into a loop.

Using this splicing technique, I removed the most important segment of each event, such as the takeoff in the high jump, the release of the discus, the step and stretch over the hurdle, and all of the other films that Ken had purchased to teach track and field events. I carefully returned the abbreviated films, neatly connected, to their original containers and replaced them in the film drawer in coach O'Brien's office. I planned to return those sections to their proper places in the loop, but before that happened, the loss was discovered.

A day or two after I had altered the loop films with surgical precision, Ann was working on her studies at my desk in the office I shared with coach O'Brien. Suddenly, Ken burst into the office. He slammed his books down on his desk and began pulling open each of the drawers in his two metal file cabinets all the while shouting about films. He would yank out a metal drawer, rummaged about in the files, throw things up into the air, and then slam the drawer back into place. The entire time of opening and slamming drawers, he maintained a thunderous monologue about missing films and shouted about Gideon cutting the movies. Ann silently observed this cacophonous and loud racket generated by the metal file drawers as they were pulled open and slammed shut. The tumultuous file drawer sounds were amplified with Coach O'Brien's shouts accompanying the pandemonium. Ann described this tumult to me later when the proverbial dust settled.

This berserk behavior was so completely out of character for the normally mild and gentle Ken O'Brien that Ann slowly and silently oozed under the desk in hopes that she would go unnoticed. After a few minutes of this tirade, Ken breathlessly sat down in his office chair and noticed Ann who by then was peeking warily from beneath the desk. Despite his enormous frustration, Ken smiled sheepishly and suggested that she warn me of my fate if the films were not repaired quickly to their proper sequences. Imagine a slapstick comedy act with drawers flying and the ravings of a madman

Head Coach Ken O'Brien

Janis Lusis breaking the world record
http://arielnet.com/ref/go/1080

Janis Lusis, Klaus Wolfermann & Bill Schmidt

while an innocent bystander hides watching in fear. This is a glimpse of what that day looked like. Needless to say, I returned the missing film sections as quickly as possible.

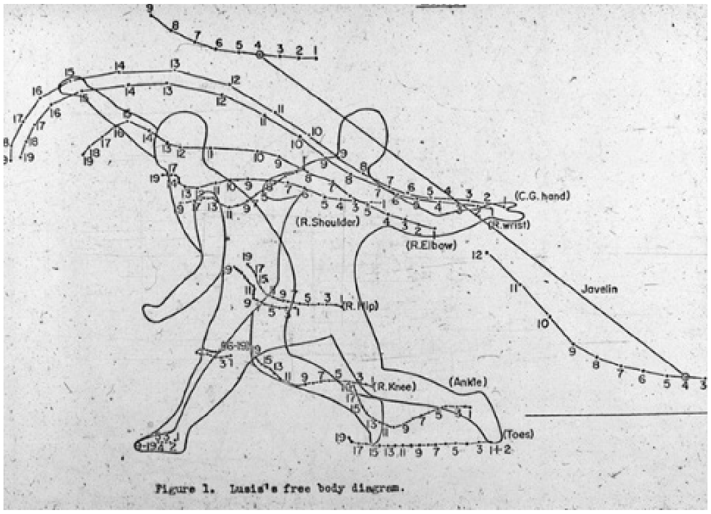
In my defense, I spent long hours analyzing these athletic movement sequences which had been temporarily removed from the films. One of my first studies was to examine the style and technique of the then world record holder in the javelin throw. The athlete was Janis Lusis, a Latvian and Soviet athlete, who won a bronze medal at the Tokyo 1964 Olympic Games, a gold medal in 1968 in Mexico City, and a silver medal in Munich in 1972. His performances were amazing, and he demonstrated a tremendous accomplishment to perform at such an elevated level across three Olympiads.

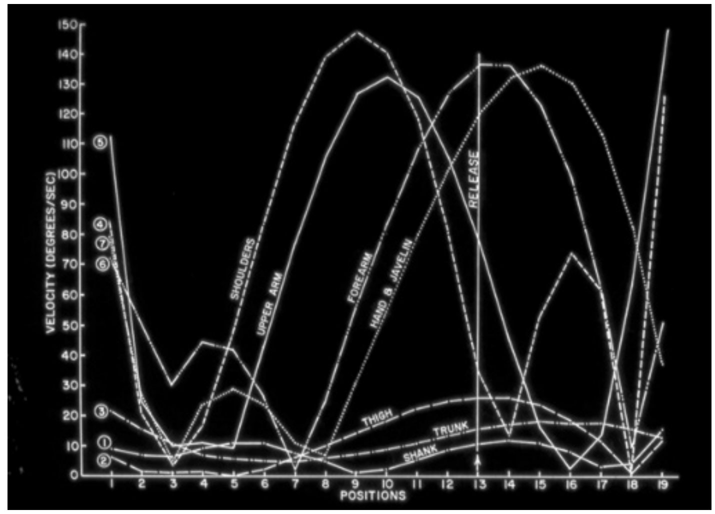
My goal was to understand his technique from a quantifiable rather than merely visual perspective. I traced the film, frame by frame, measured the coordinates, punched the computer cards, and ran the biomechanical program on the university's mainframe computer. The results were fascinating and I immediately began work on a presentation to the athletes and coaches at the Olympic Training Camp in Dartmouth College and for the International Track and Field Coaches Convention to be held in Eugene, Oregon. I also planned for the article to be published in the Track and Field Quarterly Review.

In both my presentations and the publication about Lusis' javelin throw, there were diagrams of the movement path followed by each joint. In addition, I demonstrated how the athlete was able to coordinate the acceleration and deceleration of the various segments. I explained quantitatively that the lower, heavier parts of the body, such as the legs and torso, had to rapidly slow down close to the release of the javelin, thus transferring the momentum to the arms and javelin. The analogy I employed was a speeding car crashing into a wall and sending the driver flying through the windshield. My speech and this article described many details about how Lusis performed, and how his style could be utilized by other athletes.

I was very optimistic about the usefulness of biomechanics in understanding the activities in which many people had spent their entire working careers. My experiences, until then, were that some coaches were as stubborn as donkeys and resistant to change. Their attitudes were if it had not been done before, there was no reason to do it now. Because I was aware of this ingrained resistance, I was somewhat apprehensive before my presentation and the response that it might receive. I took a deep breath and decided to try my best to explain the beauty and usefulness of biomechanical analysis to these coaches. Then, let the chips fall where they may, as the saying goes.

I was pleased and felt justified after my talk when many of the coaches attending my presentations were enthusiastic about this new biomechanical information. Anything that could help their athletes perform better and make them better coaches was welcome. This was a refreshing attitude and one I hoped to spread throughout the coaching community.





Lusis tracing & velocities output
http://arielnet.com/ref/go/4004

The editor of the Track and Field Quarterly Review, George Dales, was extremely enthusiastic about the potential of biomechanical analysis for athletes. It was at the Eugene convention when I met George in person for the first time. Previously, we had communicated only by mail. George was the head coach at the University of Western Michigan in Kalamazoo, Michigan, and was obsessed with track and field from both the athlete's and coach's perspective. He wanted to help this population in meaningful ways, and sought to publish articles that would accomplish this goal. George enthusiastically embraced my method of performance analysis and published many of my research papers throughout the nearly 50 years since that first article. He has been a great supporter and friend of mine and Ann and both of us cherish this long and enduring friendship.

I returned to Amherst after the Oregon convention, elated by the response which the presented material had received. Now, it was back to work on publications, academic class studies, teaching, and coaching.

While I was engaged in these daily tasks, however, I pondered about a good Ph.D. dissertation topic. The thinking process was similar to the dilemma about a suitable topic for my master's thesis. How could I combine the mechanical aspect of the movement with the physiological aspect? I knew that Dr. Ricci, my dissertation advisor, would want me to concentrate on the physiological part but that had less appeal to me. I needed a subject that would interest both of us. I reflected on my discus and shot putting background from the perspective of the new Olympic attitudes concerning supplements and performance enhancing substances. I had attended a few conferences dealing with the Olympians and had chatted with athletes throughout the Yankee Conference, during track meets, and when I coached field events. It became increasingly apparent that pharmaceuticals were becoming as much a part of sports as training and equipment were. Nearly all of the college athletes I met were convinced that "the other guy" was taking drugs, such as anabolic steroids, to enhance their performances.

In addition to the assumption that "the other guy" was taking steroids, there was a growing controversy on whether anabolic steroids produced enhanced musculature and, therefore, improved performance, or whether there was only a placebo effect. I had heard from my Israeli friends that the undercurrent murmured in the competitive locker rooms in Europe and Asia was that the Russians and East Germans were consuming a variety of drugs. This belief fueled the gossip mill among athletes from college age through the Olympic ranks. Since I had coached Olympic athletes previously and was currently working with the college team members, I thought that this would be an excellent opportunity to determine the precise effects of anabolic steroids on strength and performance. I could evaluate both mechanical and neuromuscular factors and determine what, if any, effects the anabolic steroids had.

Another important consideration was that all dissertation research had to be unique. It was well known in the scientific medical literature that physicians routinely prescribed anabolic steroids to hospital patients. However, the patients were frequently elderly and/or had been bedridden for extended periods of time, and their muscles had begun to atrophy. However, no one knew the effects of anabolic steroids on healthy, well-trained athletes since that group had never been studied. I was convinced that this research topic would be both timely and unique and should be suitable as a dissertation topic. I discussed the idea with Professor Ricci and he agreed that the idea had merit.

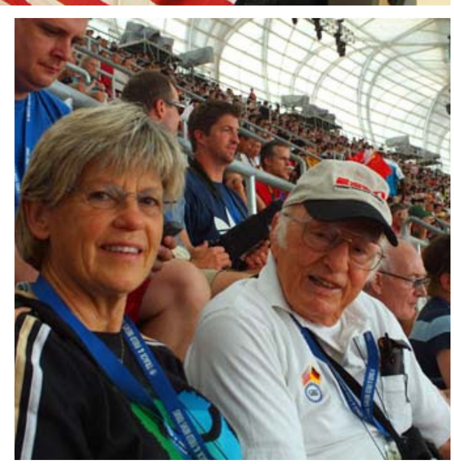
The next task was to devise a scientific strategy to determine if anabolic steroids had any effects and, if so, to quantify them. Since I taught weight training classes and coached track and field athletes, I optimistically placed a “Volunteers Wanted” sign-up sheet on the wall next to the weight room door. When I went to class the next afternoon, I was shocked to discover that the page overflowed with names. The list of volunteers was more numerous than the 30 subjects that the study needed.

After careful screening, thirty men were chosen and divided into three normal and homogeneously representative sample groups. Each potential subject was sent to the infirmary for thorough physical exams by the doctors to ensure that the subject was healthy and physically able to participate in the research proposed. After being medically cleared, the doctors assigned each of them to one of three groups. The subjects were unaware that there were any differences among the groups. The infirmary physicians placed one-third of the men in a placebo group, a second third were in the anabolic steroid group, and the remaining men were in the control group. Then, the roster of participants was sent to me.

The three groups participated in identical training and testing events. The only differences among the groups was whether they received the steroid. The control group followed the same exercise protocol as the other groups but were given “dummy” pills. Their performance on the exercises constituted the extent of their participation in the study. The individuals in the other groups were given pills that looked like everyone else’s.

Each week, the other subjects would report to the infirmary for an assessment of their health and then they would be given a container with that week’s “prescription”. At the midpoint of the experiment, the infirmary reversed the ingredients in the pills. The group which had initially received the placebo would be administered the anabolic steroid and vice versa. The pills for all groups looked identical, including the control group which continued to receive only “dummy” ones. This information was not shared with the subjects who

George Dales, fifty years of professional relationship & personal friendship
http://arielnet.com/ref/go/1082



all thought they were receiving anabolic steroids throughout the study.

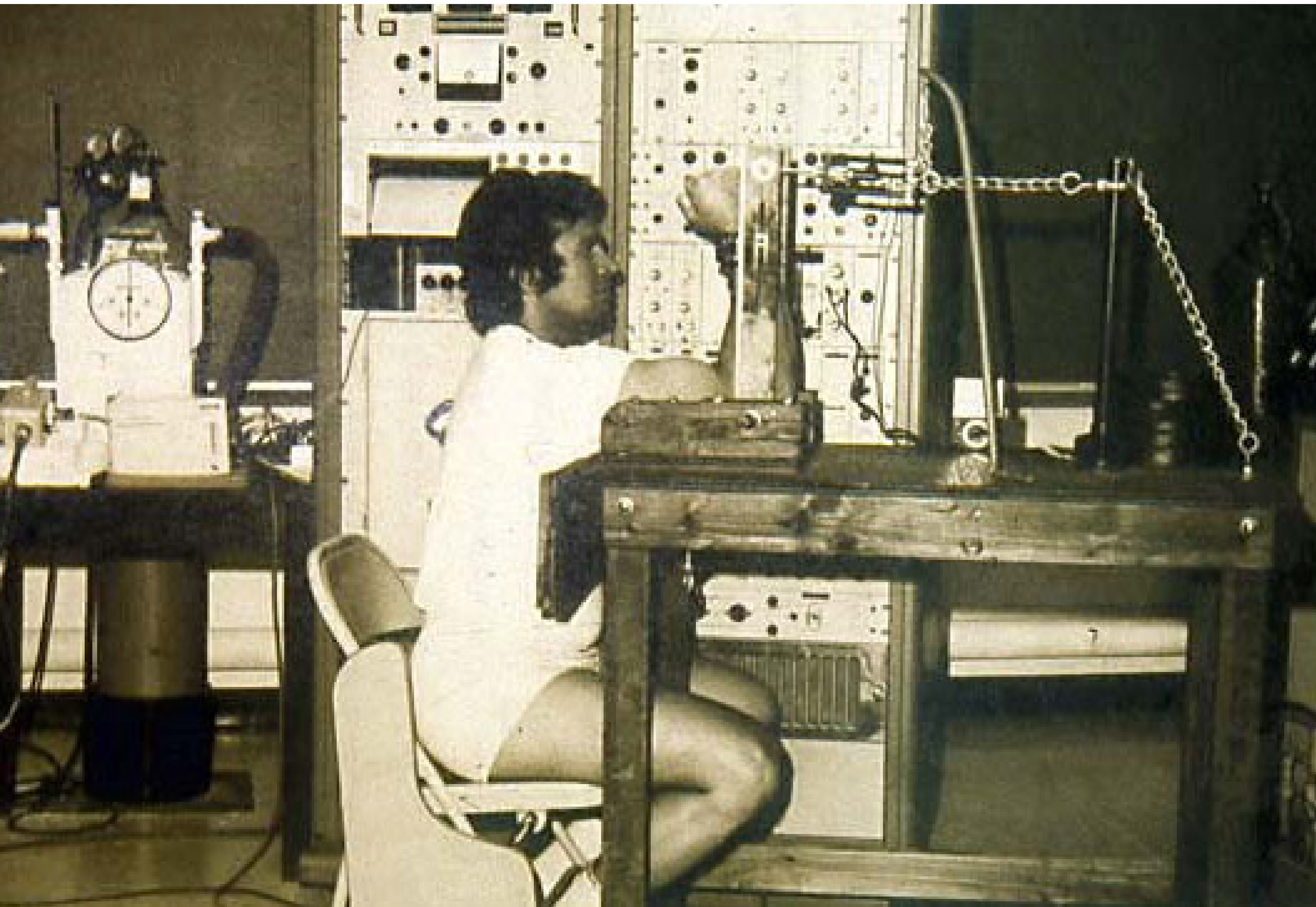
Every participant reported weekly to the testing laboratory for specialized strength evaluations which I conducted. I measured their strength with a device which I had designed for testing isometric strength. The apparatus was constructed to obtain accurate and consistent isometric strength measurements for all subjects. Isometric strength is defined as the maximum force the muscle can produce in a fixed position. The test position was for a seated subject with the upper right arm supported on a table, the elbow fixed at a right angle, and a cuff around the wrist. The subject was instructed to pull the wrist cuff as forcefully as possible and the strength was recorded on the computer. The apparatus with a test subject is shown in the photograph on page 108

Another weekly test was to measure the patella tendon reflex. A "reflex" is a response to a stimulus without conscious thought and involves the reactions of nerves, ligaments, tendons, and muscles. Simply put, the patella tendon reflex is what the leg does when the doctor hits the knee with that little hammer. For my dissertation study, a special procedure involved placing electrodes on the right leg so that, in addition to the reflex itself, I could evaluate some of the neurological components.

The third aspect of the study was a prescribed weight lifting program. Every day, all the men had to follow a specialized training program and record the amount of weight they lifted each day for each exercise. I collected these results every day for processing.

The experimental subjects reported to the infirmary every Monday morning for their battery of physical tests and then received their weekly dose of pills. The study progressed nicely for about three weeks and I was amazed to watch the progress of the people on the various tests. At that point, it was merely my personal observation but all of them seemed to be increasing in strength. I was excited about the study and convinced that it would yield fascinating results and garner worldwide interest especially among coaches and athletes.

Isometric strength apparatus



On Monday of the fourth week, I was working with some of the subjects in my one o'clock weight training class when Dr. Ricci rushed into the weight room. His hair was disheveled and windblown, his face red, and he was gasping to catch his breath. Between gasps, he told me that we had to hurry to the infirmary because the chief physician had called for an urgent meeting with both of us.

Once we were out of earshot of the test subjects and rushing across the campus to the infirmary, Dr. Ricci explained the urgency. There was a medical problem with one of the students. One of the weekly medical tests for that subject had revealed a potentially disastrous problem which the doctor would explain once we were privately secluded in his office. My heart sank as I feared not only the terrible news that I might have to present to my subjects, who were my friends, but also having to redo the vast amount of work already invested in this dissertation study. I would have to start from scratch with a new idea. I felt gloomier and more worried with each step we took towards the infirmary.

As I sat facing the head physician across his desk, his expression said it all. My research project was doomed and I would have to begin again. The doctor explained that prior to my study, there was no scientific literature about the effects of anabolic steroids on healthy human males. Therefore, his medical staff had included, as one of the batteries of tests for each subject, a test for sperm count. Unfortunately, he explained, subject JP's test that morning showed a sperm count of zero. They wanted me to find him immediately and have him come to the infirmary for a retest. Hopefully, it was merely a lab error.

I jumped up and ran from the room. Since this was long before cell phones, I had to depend on my friends to know where I might find JP. Soon, he was located, and we ran as fast as possible to see the doctor. Once again, as JP and I sat across the table from the chief of the infirmary, the doctor explained the reason we were there. As he listened, JP became flushed and stared sheepishly at the doctor.

"I know the rules included sexual abstinence for the duration of the study," he stammered. "But Saturday night my friends and I were eating pizza and drinking beers at one of the local student hangouts. Two of the most beautiful girls were there, sitting on my lap, kissing me, and they insisted that I go with them to their room. I knew that this was against the study rules but I couldn't resist. I couldn't believe this was actually happening to me and it was impossible to say 'No' to them. They were so beautiful and insatiable. I am so sorry. I hope I haven't ruined your study, Gideon" he said greatly chagrined.

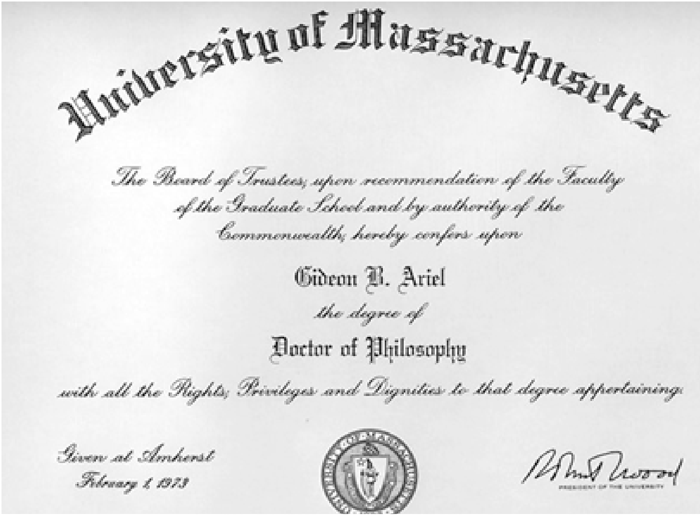
The doctor and I looked at each other and burst into laughter. What a relief to hear this tale of fun and college behavior. With our collective fingers crossed, we hoped this would be the explanation for the zero-test count. The doctor told JP that he would have to drop out of the study and report to the infirmary for follow-up tests until they were confident that he was completely healthy. Then, shifting his gaze towards me, the doctor told me to continue the study following the protocol in place. Without a doubt, I floated, rather than walked out of his office.

The data collection was completed in 16 weeks. I statistically processed the results and discovered several interesting results. One finding indicated a significant improvement in force and other neuromuscular patterns due to the use of anabolic steroids. Another result indicated that the increase in strength was not due only to training or psychological factors. In studies previously reported in the scientific literature, test subjects consisted of weak or untrained subjects. In those studies, strength increases could be explained by their lifting weights for the first time, rather than by any steroid use. The subjects in my study were already strong and athletic prior to the study. In other words, they were already skilled in the activities themselves and improvement in strength at their level of achievement was quite difficult to obtain merely by lifting weights.

For this reason, I had three groups in my study. The control group had received only "dummy" pills and the other two groups had received either placebo or anabolic steroid pills. I had included administration of the placebo to detect whether merely ingesting a pill was a contributing factor to the resulting responses. The administration of the placebos and the anabolic steroids were reversed at the halfway point in the study. This meant that the subjects in two of the groups received both placebo and anabolic steroids but in different segments of the study. The results revealed that athletes given the placebo during the first half showed little strength gain until they were switched to the anabolic steroids in the second portion. Those subjects who began with the anabolic steroids had sharp strength gains in the first half and demonstrated little change during the second half when they were administered the placebo. The control group which had received nothing demonstrated little or no improvement in their overall strength levels. These responses were consistent with expectation.

After processing and analyzing the data, I had to write the dissertation according to the rigidly prescribed format that everyone was required to follow. Ann was enormously helpful since her English was superior to mine. Although I had been living in America for nearly ten years, I maintained a noticeable accent when I talked, and my writing skills apparently had some kind of "accent" as well. She and I worked for many long hours until the document was finally finished.

Every doctoral student had to present their research to a committee and, if successfully received, would be awarded



Doctor of Philosophy from the University of Massachusetts, 1973
http://arielnet.com/ref/go/1083

the degree. My committee was extremely pleased with my work, especially because of the sophisticated statistical tools which I had used to evaluate the results. I passed with flying colors and submitted the final, printed version to the university. My Ph.D. was officially awarded in 1972.

After completing my dissertation and receiving my Ph.D., I began to prepare the information for publication. In those days, as now, the need to publish or perish was a necessity especially if a student planned for a university position following graduation. At that point in my career, I was unsure of what avenue I would take but I knew that publications would be essential on my resume.

I persuaded another graduate student to help me with the articles in exchange for including his name on the publication. I would provide the data and interpretations and he would write the article in the exquisite English that he possessed. My friend readily agreed and we spent many hours writing and rewriting the material. We prepared and mailed different manuscripts to four journals in anticipation of their being accepted for publication.

Unfortunately, we were less precise about the details regarding which journal received which article. We mailed different articles to several publications since each article, as well as the journals themselves, targeted a variety of subject matters. As luck and lack of attention would have it, we sent the same article to two different journals. That would not have been so terrible except that each journal accepted the publication. Even as we rejoiced over the acceptance letters, we paid no attention to one small detail. Each letter referred to the same title but we failed to notice that the letters were from different journals. We cheerfully congratulated ourselves on two articles in two journals.

Imagine the dismay and consternation we experienced the day our mailboxes contained two separate journals, but with the identical article in each publication. The good news was that each of the organizations which had accepted our publication was at the top of the academic ladder. They were the Journal of Applied Physiology, and Medicine and Science in Sports. The bad news was that we had committed the ultimate sin in academia: we had double-published!

The scandal soared into the stratosphere of condemnation and blame. Eventually when the academic dust settled, we had to write letters of apology to each organization explaining our oversight. We threw ourselves on the mercy of the editors and asked for understanding. The letters were published in the next publication cycle in the Letter-to-Editor section, complete with the editors' chastising condemnations. Students and professors scolded us as well. Eventually we were forgiven and have continued to enjoy successful careers.

During the time I was working on my dissertation activities, I continued to take classes and was involved with the track and field team. The teamwork included daily sessions in the weight lifting room, coaching the field events, and traveling with the athletes to competitions. The competitions were held indoors during the winter session, and outdoors during the spring period. One day in 1971, returning to Amherst from a track meet with one of the javelin throwers, Rocco Petitto, we noticed a beautiful, quiet lake along the left side of the road. The lake with the surrounding trees looked tranquil and welcoming.

"Hey, let's go look at that lake," I said to Rocco. I had always loved nature and especially water. The lake appeared even more serene and beautiful as we drove closer. Eventually we found a placard with the name identifying the lake as Metacomet Lake. Shortly thereafter was another road, Poole St., which appeared to border the lake as we turned onto it. We drove along this small road and enjoyed the beauty as it curled around one side of the lake under a canopy of tall oak, pine, and maple trees. I saw a "For Sale by Owner" sign in front of a small, reddish-colored waterfront house with a phone number printed at the bottom. I copied the phone number onto a small slip of paper and put it in the car's glove compartment. The next day I called the owner, who told me the asking price for the house was $15,000.

At that time, I was separated from Yael and lived in a small apartment in Northampton. The town of Northampton is about ten miles west of Amherst across the Connecticut River, and is the home of Smith College, which is one of the

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Effect of anabolic steroids on reflex components

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

methandrostenolone; latencies; motor times; total reflex times

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

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

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

METHODS

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

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

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

The subject was seated on a specially constructed knee reflex apparatus. A movable backrest was adjusted until

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My house on Metacomet Lake in Belchertown, Massachusetts
http://arielnet.com/ref/go/1085

sister colleges of the Ivy League schools. My small apartment was adequate for my needs, but there was no lake for my soul.

"How could I get $15,000?" bounced around in my head. I discussed it with Ann, who had become a close, trusted, good friend in addition to a collaborator in our shared academic classes. Her suggestion was to see what terms I could negotiate at the local bank. Neither one of us had ever borrowed money nor applied for a mortgage from a bank, so this was a completely new experience and a little unnerving.

Under a cloak of apprehension, which each of us felt but valiantly covered, we were escorted into the bank manager's office. The banker was surprising friendly, even as he asked questions from a huge list on his loan application questionnaire. The questions were straightforward, and I could easily answer them. Because I was teaching at the university, had some cash in their bank, and was beginning to generate money from biomechanical projects, he offered me a loan at a 3.0 percent interest rate.

University of Massachusetts
http://arielnet.com/ref/go/4006

Ken Weinbel & Carl Wyland at the training camp in Dartmouth College

I called the seller, received the bank loan, and became the proud owner of that cute red house on Metacomet Lake. I was so happy to have a home of my own and on a lake as well. I knew that, in addition to using it as my home, I could use it for my scientific and business activities.

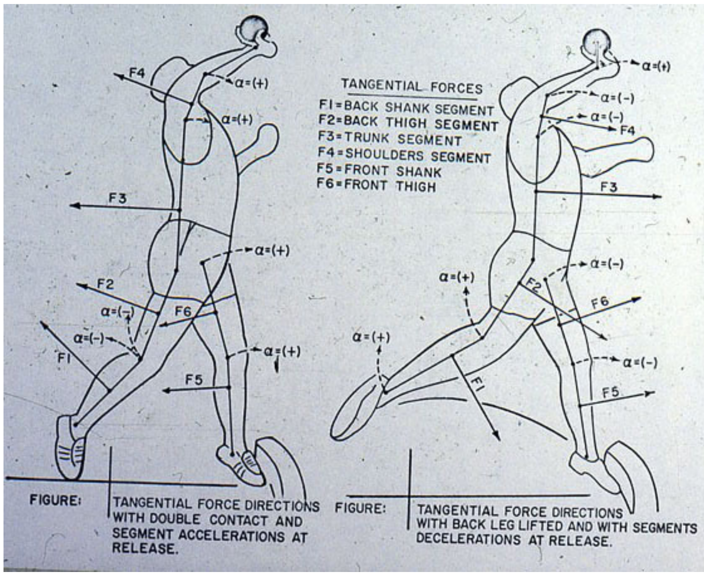
In the mean time, while all classes and my dissertation data collection were proceeding, I was also traveling nearly every weekend to track meets throughout the Yankee Conference. There were competitions in Boston, Providence, New London, and Hanover. I met coaches from the schools and shared information. It was at one of the meets that my head coach, Ken O'Brien, introduced me to the coaches from Dartmouth College. Its head coach was Ken Weinbel, and his assistant was Carl Wyland. It transpired that Dartmouth College would be hosting a special Olympic throwers camp during the summer, and coach Weinbel asked me if I would be interested in participating as one of the coaches in this camp. He was especially interested in the biomechanical analysis that Ken O'Brien had described. I was very excited by this opportunity and enthusiastically agreed to join the coaching staff for the camp.

When the summer arrived, I had many decisions to make. The first one was what to do about money? I had to find a summer job which would not conflict with the time needed to attend the Olympic throwing camp at Dartmouth College in Hanover, New Hampshire. Luckily, the director of the university's intramural program would be traveling most of the summer, and needed someone to fill his position for that time. I applied and got the job, with the understanding that I would have to travel to Hanover periodically.

The next task was to find someone to assist me in the data collection and processing at the Olympic camp. Although Ann would have been invaluable, she was quite busy with classes so she could only help in a limited capacity. Luckily, one of my student athletes, Rocco, needed to raise his grade point average with high extra credit grades during the summer class period. We made a deal that he would be my biomechanics assistant in exchange for "A" grades in three special-credit classes from me. Since Rocco was a javelin thrower for the school, he was familiar with the biomechanical work I had been performing for the team members. In addition, he was an undergraduate physics major so he brought his own knowledge to this new and developing area of biomechanics.

The throwing camp was three long and intense weeks. Rocco and I would drive the four hours from Amherst to Hanover, work with the throwers, and film the various performances. After a few days of filming, we would drive the four hours back to Amherst to process the data. Rocco did most of the tracing of the films and transfer of the numbers onto the computer punch cards. I had to execute the biomechanical programs and interpret the resulting outputs. These processes were arduous and time-consuming. Rocco, Ann, and I discussed at length about finding or creating better techniques for data collection and processing.

Ann was involved in much of the work we brought back from New Hampshire. She used my office for much of the summer, since it was convenient for her classes, my intramural job, and for the biomechanical analysis we were doing for the throwing camp athletes. Summers in Amherst were relatively quiet and tranquil. There were few academic classes available in the summer, so most students and faculty left town. The campus population consisted mostly of university employees or graduate students working on projects. Our dear friend, Jim Salidas, had taken his family to a well-paying summer job which left Ann, Rocco, and I to work and study together.



Analyzing one of the shot putters at the camp

While I was working with the Olympic athletes in Hanover I took some courses in the computer science department at Dartmouth College. Coach Weinbel had helped to arrange this unique experience for me. Dartmouth College had a faster, newer computer than we had at the University of Massachusetts and, in addition, there was around-the-clock access. We could send our data over an acoustic coupler to the mainframe, and pick up the printouts even at 2:30 a.m. in the morning. This was a marvelous advantage over the Massachusetts system, so I tried to capitalize on it as much as possible.

One of the computer courses fascinated me, since the two professors, John G. Kemeny and Thomas E. Kurtz, had invented a new language called BASIC (Beginners' All Purpose Symbolic Instruction Code). It was a simpler, more straightforward computer language than FORTRAN, and it allowed the user to communicate with the computer via time-sharing. This meant that a user could directly connect to the computer through an acoustic coupler and share the computer's processing time with other users. It was also possible to work at a remote site rather than having to be directly connected via hard wires to the computer. The main-frame computers were larger and could perform faster than any individual human and, therefore, a computer system could host many users working simultaneously. Even with many simultaneous users, the computer had more capacity that went untapped. In today's world, most people own a mobile phone or a computer and connect through some kind of wireless or wired Internet service provider. In 1971, nothing like that existed; Bill Gates and Steve Jobs had not yet worked their magic.

In one of the coaching sessions with the Olympic throwers, I explained the step-by-step procedure, starting from the throwing performance, filming and collecting data, processing the data collected, the computer calculations, and finally explaining the results to the athlete. Biomechanical analysis was a fantastic solution for quantifying sports performance, despite the drawback that it was a slow and tedious process.

Following the coaching session, I was explaining to coach Weinbel that an improved tracing system would accelerate the process by many hours and should be less labor intensive. In fact, an automated digitizer would enable the films to be more easily and quickly processed. Since I had become familiar with the ability to time-share with the computer, I recognized that this would be a perfect marriage of technologies. I began to envision an automated tracing system linked directly to the main computer system through the telephone couplers we utilized at Dartmouth. Ken Weinbel listened to me with the same skepticism that the kids at Hadassim had when I told them about going to the Olympics.

Since I never gave up on solving a problem, I continued to ponder a solution to this laborious bottleneck. One sunny day in Hanover, shortly after that biomechanics discussion with coach Weinbel, he suggested that I go to a specific laboratory in the Medical School to see some of the equipment they used. He had heard about a medical application using lasers and though there might be a potential application for my biomechanics need.

I hurried over to the Dartmouth College Medical School and located the lab he had mentioned. I discovered a surgical center employing equipment to outline brain tumors on X-rays using a specialized pen. The patient would have four to six X-rays taken of the tumor, each from different angles and orientations. The technician employed a type of specialized light pen to trace the outline of the tumor on each X-ray. Then the exact location of the tumor in the brain in three dimensions would be determined using a program that the physicians and researchers had developed. The location had to be determined very precisely since the tumor in the patient's brain was to be annihilated by intersecting laser beams. Any error in the exact location of the tumor would result in damaging healthy tissue.

I wondered whether I could use something like this for the film sequence of a movement. Perhaps a pen could touch each joint center and a sound could replace the light used to outline the tumor. The biomechanical technique needed to determine the "*x*" and "*y*" coordinates for each joint center for each frame of the film. I asked the researchers at the tumor laser lab if their system was accurate. Their response was that it was life or death for the patient so the system had better be accurate. Next I asked for the name of the manufacturer which they readily provided.

The light tracing equipment was manufactured in Connecticut, in a small town not too far from Amherst. Shortly after I saw the equipment in the Dartmouth College Medical School, Ann and I drove to the factory. We explained our needs and I asked whether they could build a prototype using sound. I had an idea that the bottom and side of a frame would have built-in microphones. A "pen" or "stylus" would create a sound that would be detected by the microphones. The pen would create a spark with a certain frequency which would propagate the instant that the glass surface was touched. The first microphone that detected the arrival of the sound would be the one located at the shortest distance from the pen in both the horizontal and vertical directions. These perpendicular microphone locations represented the *x* and *y* coordinates.

The "tracing" or "digitizing" equipment would transmit the *x* and *y* values to be punched onto a paper tape. After the film had been "digitized" for the entire motion, the paper tape could be submitted manually to the computer. An acoustic coupler could also be connected so that the data could be sent directly to the computer. In this fashion, there would be a computer connection and a backup paper punched tape. After the *x* and *y* coordinate data was saved in a computer file, the biomechanical analysis program could be executed.

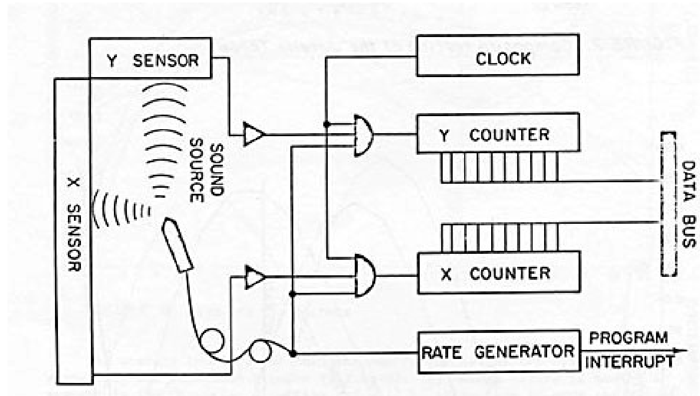
By inventing the Sonar Digitizer, I had developed a unique device which would significantly accelerate the digitizing process. Increasing the identification and stored information of the body's joint locations would greatly enhance the biomechanical quantification process. The company enthusiastically embraced the sound modification, and said they would let me know as soon as it was available for us to see. As we drove back to Amherst, Ann and I could not stop talking about this fantastic device, and we already imagined using it before it actually existed.

In one of our biomechanics classes in the previous spring semester with Dr. Plagenhoef, Ann had leaned over and whispered that this would be a great technique for analyzing racehorses. After class, we continued the conversation and amplified the possibilities that could be used with horses. It could be employed to predict the best horse to win a specific race, detect an injury, or even play a part in which yearlings showed the most promise.

I told her, "Let's start a company."

She responded, "Okay. Let's do it."

Now, several months later, we were driving through Connecticut towards Amherst and she reminded me about that earlier discussion. Since neither of us had ever started a company, we did not know how or where, nor how much money was needed for such an idea. As I was returning to Hanover the next day, we decided the next step would be to see if anyone at the throwing camp could give us any suggestions.



The Sonar Digitizer

The next day, between training sessions, I told coach Ken Weinbel about our idea to form a company and asked if he had any suggestions about creating one. He said one of his friends worked in the Business School and he would ask him.

The following day Ken had the information. The professor said that it was very inexpensive to establish a corporation in New Hampshire, costing a mere five hundred dollars. The fee in Massachusetts for forming a corporation was five thousand dollars, and the yearly filing fees were higher as well. I was astonished that states sharing a border could have such disparate costs. America could be a baffling place.

In addition to finding the information I had requested, coach Weinbel expressed an interest in being an investor in our company if we decided to proceed. I told him that I would discuss it with Ann and let him know when I came back to camp in a few days.

Ann and I discussed the situation and decided it would be an advantage to have someone with known credit and a professor at a prestigious school as a member of our company. Therefore, Ken Weinbel invested the money we needed to incorporate in NH and to cover some of the initial costs for running the business. For example, we needed an office and the new Sonic Digitizer which was being developed in Connecticut. In exchange for this cash investment, he would receive 50% of the company while Ann and I would own the other 50%. The company was named Computerized Biomechanical Analysis, Inc. (CBA). It was the world's first research company established for analyzing motion, regardless of whether it was human, animal, or fish. Our motto was, "If it moves, we can measure it". CBA Inc. still exists and continues to do well.

Our new partner, Ken, found a large, spacious, second-floor office for the company. It was located above the fire

Location of CBA office in 316 College Street, Amherst, Massachusetts

department and next door to the most delicious ice cream store in town. We had room for desks, the new digitizer, and started work on the remaining film from the throwing camp.

It was during this long summer, filled with work but with less pressure than during the normal schoolwork and classes, that things began to change. Ann and I studied in the same office and worked on the biomechanical projects for the throwers. When we were in Amherst, she invited me to her apartment for steak and salad dinners so that we could continue working. Somehow, without either of us noticing, we developed a unique and special relationship. As Ann tells it, one day she blinked her eyes wide open with the realization that she loved me! I am certain, to this day, she was more shocked than I was. All our time together had been filled with shared ideas, interests, and dreams, but without holding hands, kissing, or anything else. Our friendship had grown, strengthened, and now blossomed into love. Each of us was surprised at this discovered love, but happy with the realization.

School began again in the fall with a flood of students and faculty returning to Amherst. Life was busy now, with many things occurring at the same time. Ann and I had full academic course loads to occupy our minds, and now we had to run a company as well. In addition, I had classes to teach and a team to coach, while Ann continued with her research assistantship, collecting data for her professor. I lived in my new house by the lake, while Ann continued to live in her apartment. We cautiously tiptoed into our newly enchanted life.

We quickly realized that for our company to succeed, we needed to let the world know that it existed and what it could do. Communication about this innovative service seemed obvious to two graduate student researchers. We assumed this information could be provided through scientific presentations and publications—especially international ones. Needless to say, we were incredibly naive at that time about the world of business and commerce.

For several months, we worked on an article, which described the system in a step-by-step fashion so that academicians and lay people could understand it. I chose the journal Mechanics and Sports, in the hope that they would publish the article which included my digitizing innovation. The article was titled "Computerized Biomechanical Analysis of Human Performance" and I was overjoyed when it was accepted for publication.

Immediately after the article's publication, Dr. Plagenhoef called me to his office. I had been very busy during the summer and Dr. Plagenhoef had been in Maine for vacation. Since I had completed his classes the previous year, I was a little surprised to receive this summons from him. I was completely unprepared for his aggressive tone once I was in his office.

"Why would you publish an article in biomechanics without consulting me?" he asked.

I told him that during the summer while he was away, I had started a company dedicated to biomechanics.

"You started a company?" he shouted.

"Yes, sir," I answered him.

He was clearly upset, and I was confused and stunned about his furious reaction. I had understood that one of the most important achievements for academicians was to publish their work. I had no idea what had provoked the angry response about starting a company. Dr. Plagenhoef continued his tirade and then I was dismissed.

I left his office with a sense that my relation with him might make things a little awkward around the department. Despite Dr. Plagenhoef negative reaction, I kept busy preparing publications, working on projects within the company, studying, managing the weight room at the university, and working with coach O'Brien and the track and field team. As assistant coach, my responsibilities were to coach the shot put, hammer, discus and javelin events.

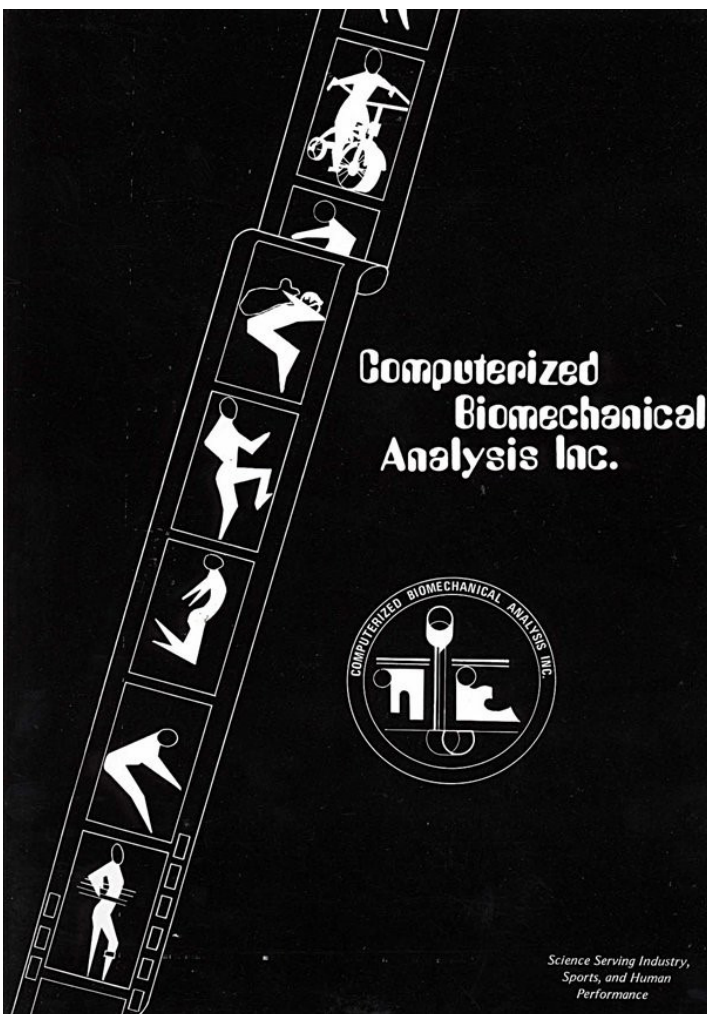
My expectation was that both amateur and professional athletes would come to CBA for help. Our analyses of the way they ran, swung a bat, or kicked a ball, would assist them to perform better or to avoid injury. Now all we needed were paying customers. Since I had begun to attend academic conferences and present my research, these venues seemed like potential sources. One downside to this idea was the jealousy that academicians have when someone else is more successful than they are. The other problem is that people attending these kinds of conferences are usually seeking sponsors for their own research rather than hiring other people. Since I continued to travel with the track and field athletes to competitions during the indoor season, we considered the possibility that there might be people who wanted our services among that population.

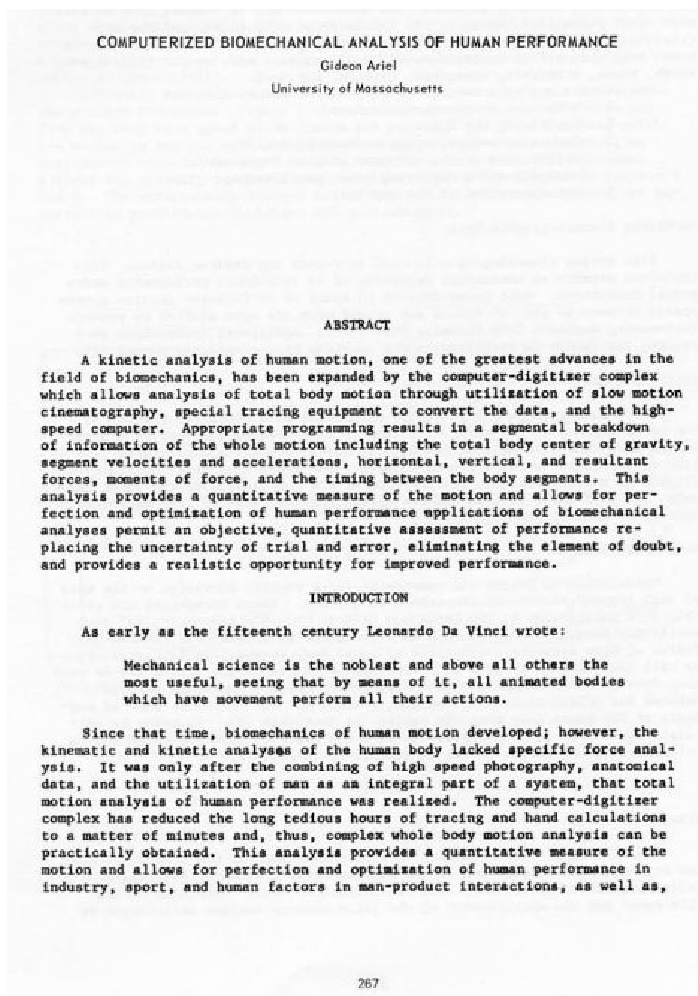
Word of my system spread around the world. One day I received a phone call from Gerald Astor, one of the editors of Esquire Magazine. He had heard about our system and asked me if I could determine the ultimate performances in different track and field events. I told him that I would try and, after one year of work, this resulted in the article: "How to Know A Perfect Performance When You See One". The publication came out just before the Montreal 1976 Olympic Games. It made our system famous around the world!

In fact, this book was started with Gerald Astor after the Montreal 1976 Olympic Games.

Traveling to track meets and trying to spread the word about CBA's services had not brought us new projects as expected. The article I had written about analyzing human performance had created interest among academicians, but no jobs yet. Ken, Ann and I decided that CBA needed a brochure to advertise our services. We would be able to hand them to prospective companies, or mail them if requested. We designed a brochure with a creative design on the front and slots inside which allowed us to insert letters or publications.

A publication describing the services of C.B.A. Inc., published in "Mechanics and Sports", 1972
http://arielnet.com/ref/go/1086





COMPUTERIZED BIOMECHANICAL ANALYSIS OF HUMAN PERFORMANCE

Gideon Ariel

University of Massachusetts

ABSTRACT

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

INTRODUCTION

As early as the fifteenth century Leonardo Da Vinci wrote:

> Mechanical science is the noblest and above all others the most useful, seeing that by means of it, all animated bodies which have movement perform all their actions.

Since that time, biomechanics of human motion developed; however, the kinematic and kinetic analyses of the human body lacked specific force analysis. It was only after the combining of high speed photography, anatomical data, and the utilization of man as an integral part of a system, that total motion analysis of human performance was realized. The computer-digitizer complex has reduced the long tedious hours of tracing and hand calculations to a matter of minutes and, thus, complex whole body motion analysis can be practically obtained. This analysis provides a quantitative measure of the motion and allows for perfection and optimization of human performance in industry, sport, and human factors in man-product interactions, as well as,

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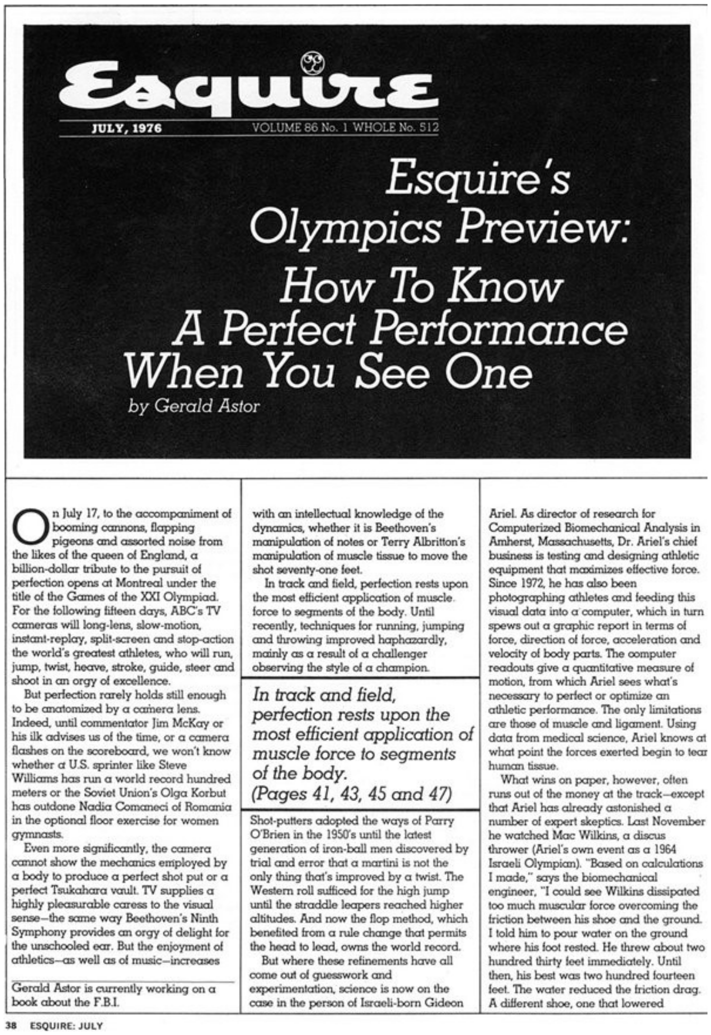

Esquire

JULY, 1976 VOLUME 86 No. 1 WHOLE No. 512

Esquire's Olympics Preview: How To Know A Perfect Performance When You See One

by Gerald Astor

On July 17, to the accompaniment of booming cannons, flapping pigeons and assorted noise from the likes of the queen of England, a billion-dollar tribute to the pursuit of perfection opens at Montreal under the title of the Games of the XXI Olympiad. For the following fifteen days, ABC's TV cameras will long-lens, slow-motion, instant-replay, split-screen and stop-action the world's greatest athletes, who will run, jump, twist, heave, stroke, guide, steer and shoot in an orgy of excellence.

But perfection rarely holds still enough to be anatomized by a camera lens. Indeed, until commentator Jim McKay or his ilk advises us of the time, or a camera flashes on the scoreboard, we won't know whether a U.S. sprinter like Steve Williams has run a world record hundred meters or the Soviet Union's Olga Korbut has outdone Nadia Comaneci of Romania in the optional floor exercise for women gymnasts.

Even more significantly, the camera cannot show the mechanics employed by a body to produce a perfect shot put or a perfect Tsukahara vault. TV supplies a highly pleasurable caress to the visual sense—the same way Beethoven's Ninth Symphony provides an orgy of delight for the unschooled ear. But the enjoyment of athletics—as well as of music—increases with an intellectual knowledge of the dynamics, whether it is Beethoven's manipulation of notes or Terry Albritton's manipulation of muscle tissue to move the shot seventy-one feet.

In track and field, perfection rests upon the most efficient application of muscle force to segments of the body. Until recently, techniques for running, jumping and throwing improved haphazardly, mainly as a result of a challenger observing the style of a champion.

In track and field, perfection rests upon the most efficient application of muscle force to segments of the body. (Pages 41, 43, 45 and 47)

Shot-putters adopted the ways of Parry O'Brien in the 1950's until the latest generation of iron-ball men discovered by trial and error that a martini is not the only thing that's improved by a twist. The Western roll sufficed for the high jump until the straddle leapers reached higher altitudes. And now the flop method, which benefited from a rule change that permits the head to lead, owns the world record.

But where these refinements have all come out of guesswork and experimentation, science is now on the case in the person of Israeli-born Gideon Ariel. As director of research for Computerized Biomechanical Analysis in Amherst, Massachusetts, Dr. Ariel's chief business is testing and designing athletic equipment that maximizes effective force. Since 1972, he has also been photographing athletes and feeding this visual data into a computer, which in turn spews out a graphic report in terms of force, direction of force, acceleration and velocity of body parts. The computer readouts give a quantitative measure of motion, from which Ariel sees what's necessary to perfect or optimize an athletic performance. The only limitations are those of muscle and ligament. Using data from medical science, Ariel knows at what point the forces exerted begin to tear human tissue.

What wins on paper, however, often runs out of the money at the track—except that Ariel has already astonished a number of expert skeptics. Last November he watched Mac Wilkins, a discus thrower (Ariel's own event as a 1964 Israeli Olympian). "Based on calculations I made," says the biomechanical engineer, "I could see Wilkins dissipated too much muscular force overcoming the friction between his shoe and the ground. I told him to pour water on the ground where his foot rested. He threw about two hundred thirty feet immediately. Until then, his best was two hundred fourteen feet. The water reduced the friction drag. A different shoe, one that lowered

Gerald Astor is currently working on a book about the F.B.I.

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Publication in Esquire magazine
http://arielnet.com/ref/go/1088

Our new endeavor was born long before the era of e-mail, websites, or even fax machines. We had a prototype fax machine which was connected to our land-line phone system as it was the only way to connect to the telephone at that time. In addition, the machine needed about 2 hours to send one short letter because the technology was so slow and the recipient had to have the same slow device to receive the fax. Needless to say, these early fax machines were not going to be of much help for our fledgling business.

Early in 1973 we determined that we needed a company car for us to use for travel between Amherst and Hanover since we had cameras, tripods, and other biomechanical paraphernalia to transport. We purchased a hearse from a local funeral home in Hanover which served our needs well. It was a perfect vehicle for us at that time, and it provoked many smiles of disbelief among our colleagues.

Unfortunately, an oil crisis began in October 1973, when the members of the Organization of the Petroleum Exporting Countries (OPEC) proclaimed an oil embargo. By the end of the embargo in March 1974, the price of oil had risen from \$3 per barrel to nearly \$12 globally. Prices in the US were significantly higher.

Our problems by October were twofold: (1) the hearse was a gas-guzzler, consuming 7 miles per gallon and (2) gas stations were restricted on the number of gallons they were permitted to sell to each customer. Since we normally departed our Hanover office after midnight for the drive back to Amherst, we were frequently alone on the road for most of the 100-mile trip. We would have to stop at least 3 or 4 times to buy the limited amount of gas permitted at each station. It took much longer than necessary to make the trip, and the weather was becoming bitterly cold, creating a risk of getting stranded on the highway.

Ann and I discussed the idea of creating a biomechanical laboratory in my new lake house in Belchertown. Although CBA had a wonderful office in Hanover, it was still a long drive back and forth to Amherst. During the summer months, our schedules had been less hectic. Now with all of us working full time and the problem with gas, Ken, Ann, and I felt the need to re-evaluate the situation.

I invited Ken to my new home and convinced him that with the time-sharing connections, we could eliminate the expenses in the Hanover office and move the headquarters to Belchertown. He agreed since it saved both time and money.

In no time, the laboratory was working perfectly in the lake house. We projected the film onto the newly invented digitizer which was mounted in the division between the living room and the kitchen. The digitizer was connected to a Teletype for recording the coordinates on paper tape, and directly to the mainframe computer through the acoustic coupler. This arrangement allowed the data to be transmitted directly to the computer, eliminating hours of work previously needed for punching cards. In addition, the paper tape provided backup in case anything happened during the direct transmission.

It was fortunate that we had developed a backup system. As every scientist and engineer knows, things can go wrong, and soon after we moved the laboratory to Belchertown, it happened to us. During a digitizing session, the computer connection began transmitting scrambled data. This was a monumental disaster since we depended on flawless interaction with the computer. It was a dreadful discovery that the data transmission was garbled, but of greater importance was to determine what could have caused things to go wrong? What could be the source of the noisy interaction?

Each connection between equipment was checked. We restarted the projector and the digitizer but nothing corrected the noise problem. Finally, I lifted the phone from the acoustic coupler and listened. There was a strange buzzing noise which I had never heard before. I shouted into the phone to see what would happen. After about two minutes of shouting, someone answered me.

"Who are you?" I inquired.

"Who are you?" a man replied.

After several minutes of discussion, we discovered we were neighbors across the street from each other. This was during a bygone era when people had to share phone lines on what were known as "party lines". There could be two, three, or more homes connected to the same phone line and you had to share it with each other. What had transpired was that, every time our neighbor had tried to use his phone, he heard the screeching sound the coupler made. Since he had no idea what the noise was, and the noise seemed to always be there, he was never able to use his phone. Finally, in desperation, he put his electric razor next to the phone and just let it run. Here, then, were two families baffled by crazy phone noises.

We needed to convince the phone company to give each of us a single-family phone line although the homes around the lake were more rural and remote than in a big city. At that time, there was only one phone company, and this monopoly was notoriously stubborn and insensitive when dealing with individual clients. Imagine having two or three people sharing the same cellular phone in 2017. Imagine if Androids or iPhones were not stand-alone devices, but rather were shared by several people at the same time. Imagine having to wait to take pictures or read text messages until another person sharing the phone had completed their own task. That was our situation. I guess the uniqueness of our problem must

Instant replays and electronic wizardry, CBS Morning News, 1976
http://arielnet.com/ref/go/1089

have played into the decision since we were given a direct, unshared line to our kitchen laboratory.

Shortly after the phone situation, we expanded our staff. During one of my trips to Dartmouth, I was chatting with Ken Weinbel's assistant coach, Carl Wyland. Carl was a good shot putter who had thrown the shot more than 60 feet. He showed me his dog and her six puppies. The mother was a pedigree Siberian husky but the father was the Newfoundland "milkman" who had sneaked into the backyard. Carl gave me one of the furry little guys whom I named "Ringo" after one of the Beatles, the English rock band. Ringo became CBA's first employee.

Our second employee arrived shortly thereafter. On a chilly September evening after a late dinner, we returned to the office to work a few more hours. Somehow, crickets always found a way into our office and then had to be relocated outside by Ann since she would not allow them to be killed. That evening, when she was providing a new home for a wayward cricket, there was a loud meow. When she looked down, a large gray cat was rubbing against her leg. The cat followed her into the office, enjoyed a hearty meal, and drank quite a lot of water. Apparently, he had wandered away from his home and found us. This was at the beginning of the school year when the town of Amherst was inundated with new students, graduate students, and faculty members returning home. We tried for several days to locate its owner, but to no avail. The cat had lived in the office without creating any problems. After a week, we decided to hire him as our second employee. We named our new staff member "Melich" which means "king" in Hebrew.

We took Melich with us to Belchertown to meet Ringo. The first few minutes after Ringo and Melich were formally introduced to each other, there was a little tension. However, I explained to them that now they were our family members and employees and, therefore, had to be friends. I guess they understood my accent because they lived happily together for the next twelve years.

Ann digitizing on our home biomechanical system
http://arielnet.com/ref/go/1090

Now that school was back in session for the regular school year, I had to drive from Belchertown to my office at the university in Amherst every day. Regular classes, dissertation work, and coaching responsibilities were back in the forefront of my workday.

My track and field athletes trained four hours each day, including weekends. This was the commitment I insisted on if they wanted to be on the team. Without this devotion to their personal fitness, they would be wasting my time and theirs. The strength and fitness program in the weight room, thus, became well known on campus, and new athletes continued to join the training sessions.

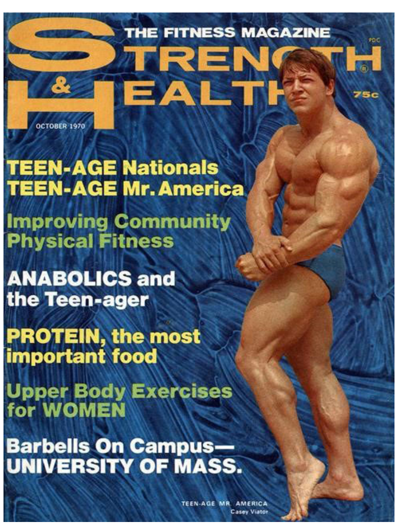
Unexpectedly, I received a call from one of the editors of the Strength and Health magazine. Mr. Bob Hoffman was the founder of the magazine as well as of the York Barbell Company. Mr. Hoffman was instrumental in arranging for Arnold Schwarzenegger to come to the United States from Austria. Bob Hoffman's picture, taken during his body building days, had graced my wall when I just a young boy in Hadassim.

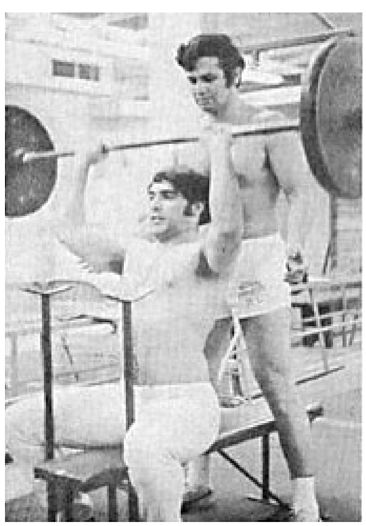
Ringo & Melich
http://arielnet.com/ref/go/1091

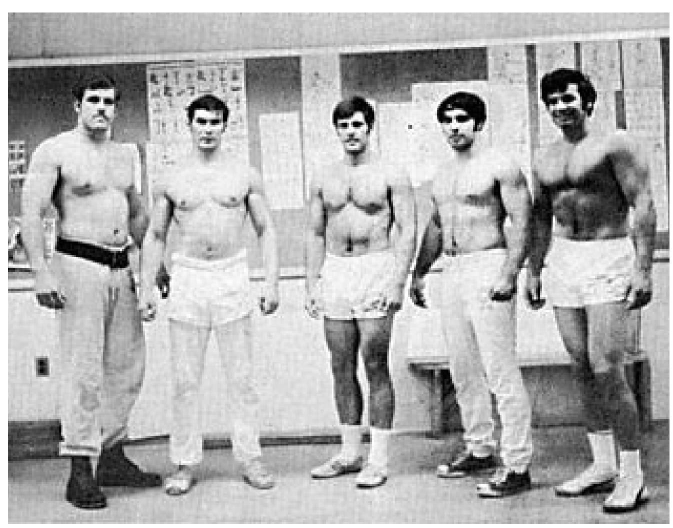
It was a pleasant surprise to learn that the editor of this magazine wanted to do a story on the training methods I used. I had no illusion that some of the professors, including Dr. Plagenhoef, would be annoyed with me when they learned about this development. I continued to experience a nascent, but growing, impression that these kinds of opportunities were going to have a negative effect on me in the future. Students were encouraged to publish and achieve success but independent publications, private companies, publicity, and other types of success were not supposed to happen to graduate students. I was the first and only graduate student in the department of exercise science who had inventions and had begun a private company. There were no official rules or pronouncements that commercial independence was not allowed, but I continued to sense an undercurrent of displeasure and negativity.

During this same time frame, Ann continued to pursue her doctoral programs in the exercise science department. Ann's interest was in Motor Integration, which belonged to the field of Neurosciences, while I concentrated on the field of Biomechanics and began to focus on post-doctoral studies particularly in computer science and computational neurosciences.

Publication in "Strength and Health"—I am on the right wearing shorts
http://arielnet.com/ref/go/1092







Publication in The Olympian
http://arielnet.com/ref/go/1093

My publications advanced my reputation in the field, and I began presenting various studies at national and international meetings around the world. One of my presentations was given to the American College of Sports Medicine in Baltimore. The title of my presentation was the same as my publication in the Mechanics and Sports Journal, "Computerized Biomechanical Analysis of Human Performance". For my presentation, I utilized the typical format employed at that time. This meant that I projected 35mm slides onto a screen, and discussed what each slide represented. The ability to connect your own PC and use PowerPoint or animated graphics were far into the future. However, at this conference, I presented my computer programs and demonstrated how it was now possible to biomechanically analyze human performance.

After my presentation, many of the scientists and attendees chatted with me about the subject matter. One of them was Ed Burke, the American hammer throwing record holder. Ed asked me whether my system could analyze people performing an exercise skill such as the bench press. I assured him that it was quite possible to measure such a performance. We had a lengthy discussion over dinner about his hammer throwing, my discus background, the recent article in Strength and Health, and the exercise machine company where he worked.

Ed told me about his boss, Harold Zinkin, who lived in Fresno, California. Harold had developed a line of exercise machines which were marketed under the brand name of Universal Gym. Ed worked for Harold traveling around the country promoting Universal Gym.

Ed shared some interesting facts about his boss, Harold. When he was young, Harold Zinkin had been Mr. California. One of Harold's best friends was Jack LaLane, who was possibly the most famous fitness guru in the 1950's and later. For years, these two friends had worked out on the sunny beaches of Venice, California. Venice was called "Muscle Beach" because of the large number of devoted weightlifters who trained and flexed their muscles for the public to admire.

There were also many competitive challenges among these weight lifters and body builders. However, there was one stunt that none had successfully accomplished, despite repeated efforts. The stunt, nicknamed "the pyramid", was to have the first person arch his back into a back-bend or wrestler's bridge. The second man could stand upright on the stomach of the first person. Then in a stacked formation, the third and fourth men stood on each other's shoulders balanced on the shoulders of the second man. In other words, three men stood on each other's shoulders, while the man at the bottom of the pyramid supported them in a back arch position. Success was only achieved if they could maintain the configuration for three seconds. Everyone struggled to achieve this feat, but only Harold Zinkin, Jack LaLane, and their two friends, "Moe" DeForest and Gene Miller, were ever able to successfully create and hold this human structure.

I was pleased and hopeful that Harold might provide an opportunity for me to meet Jack LaLane. They were both fascinating men who loved life and were willing to share their joy with others.

At some point during the dinner, Ed asked if I could fly to Fresno to talk with Harold. I readily agreed and we discussed some potential dates. After I had returned to Amherst, Ed and I communicated and found a date that did not conflict with my very full schedule. Although I was stretched in many directions at that time, Universal Gym seemed like a natural potential customer for CBA. So I flew to California.

Ed introduced us in Harold's office. What I noticed immediately about Harold was his incredibly muscular build despite his age. I was in my 30s and trained every day, but Harold, twenty years older than I, was still a powerful, muscular man. He came around his desk and shook my hand. His grip was firm and his smile was infectious.

Harold gave me a tour of the amazing pictures on his wall which included photos of famous people he knew. Prominently placed was the infamous pyramid of him, Jack LaLane and their friends. There were also some marvelous oil paintings that his wife, Betty, had painted.

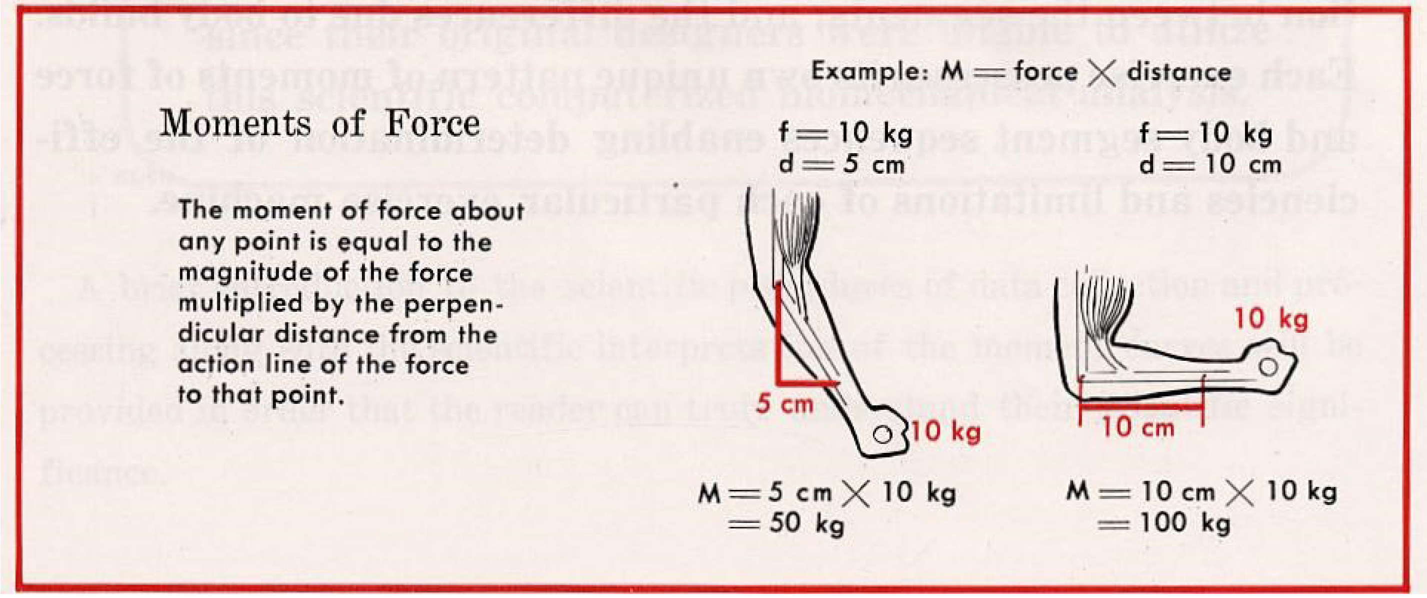
When we sat down, he said, "I heard that, in one of your presentations, you called dumbbells and exercise machines dumb. You said there is a need to develop an intelligent machine. Okay. How would you do it?"

I explained that the human body is made of levers and muscles in configurations such that, when you lift a weight, there is a mismatch between the resistance and the position of the limb at that point.

"And?" he asked.

"A better design would be to vary the resistance based on the limb angles and levers." I thought for a moment. "What is needed is a mechanism on the equipment that can vary the resistance. In other words, it is necessary to devise a machine

Ed Burke
http://arielnet.com/ref/go/1095



Moments of force
http://arielnet.com/ref/go/3020

or mechanism that can compensate for the changing lever systems of the human," I explained.

"How would you do that?" he asked.

I told him that most exercise machines are designed merely from personal observations and ideas. They lack scientific data about individual athletes or specific performances. That is to say, a device might purport to exercise a specific muscle or group of muscles, but without proper mechanical calculations and testing, it is impossible to know whether the claims were correct. Whether or not someone exercises efficiently cannot be determined merely with visual observations. Leonardo da Vinci studied birds, but none of his brilliant designs, impressive though they were, allowed men to fly. It is possible to have a good concept, but the idea must be quantitatively tested, and a machine with exact specifications must be created, before the desired results can be produced.

"An exercise machine needs to be built," I explained, "that takes into consideration the natural changes that occur in the human lever system while performing any movements that necessitate different levels of muscular involvement. With traditional weight training equipment, much of the effort is wasted because the muscle-leverage system changes throughout the movement."

I saw a stack of weights in the corner of Harold's office. I told him "Pick up this twenty-pound weight and hold it at your side. Then lift it slowly upward, keeping your elbow

Harold Zinkin (bottom), Muscle Beach, Santa Monica, California, 1934
http://arielnet.com/ref/go/1097

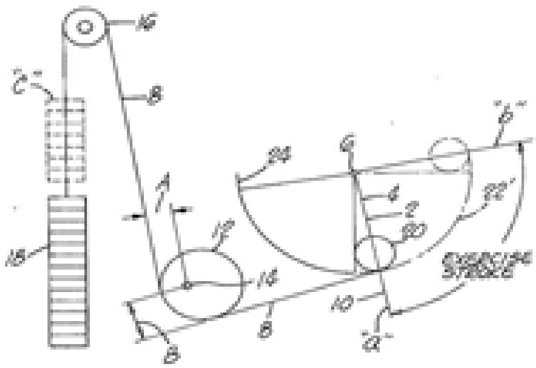
locked, until your arm is straight out at shoulder level. You can feel how much more your muscle must work as you lift the weight. Now try the same movement with this 100-pound weight. Most people would not be able to lift the 100-pound weight very far. What this means is that all weight lifting with barbells and dumbbells is restricted to the amount you can lift at your weakest point."

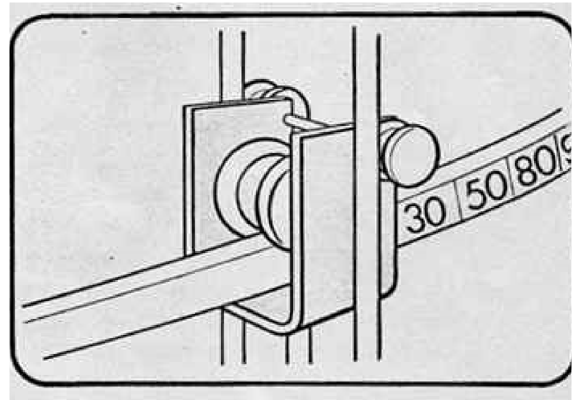
"Imagine performing that same lifting exercise again. Begin by holding a heavy weight, but, as you raise it, a magic genie removes some of the weight as the exercise becomes more and more difficult. In other words, the weight varies as you raise your arm. You start with a heavier weight, and, as the movement progresses, the amount of the weight changes automatically. We need to find a mechanical solution to provide the magic genie in my example," I concluded.

He nodded as he replaced the weights in the rack at the back of his office. Then he sat in his desk chair. Although Harold remained silent, he was obviously concentrating.

I continued, "To develop maximum conditioning effectiveness, we need to accurately vary the resistance. The variations in resistance should occur only when there are biomechanical advantages or disadvantages which decrease or increase the required muscular efforts. By varying the resistance accurately, it is possible to maintain the same degree of muscular involvement or effort throughout the entire range of movement."

"Give me an example of how you would do that," Harold replied.





Mechanism to vary the resistance on the Universal machines bars
http://arielnet.com/ref/go/1098

"Each exercise is different," I replied. "For example, when you execute a biceps curl, your arm is strong at the beginning, weak when the elbow reaches the 90-degree angle, and strong again when your hand reaches the shoulder area. However, there is an entirely different force profile for the leg extension, and yet a third force profile for the bench press. The only way to accurately determine what the force profile should be for each exercise is to perform a biomechanical analysis of them," I continued.

Harold said, "Gideon, do you think that you could redesign our existing equipment using your biomechanical evaluation? If you think that it is possible, I want you to proceed immediately and send me the bill. By the way, I want the results as soon as possible." He smiled broadly at the last comment.

Publication related to Universal Gym
http://arielnet.com/ref/go/4007

BIOMECHANICAL CONSIDERATION IN THE DESIGN AND CONSTRUCTION OF RESISTANCE EXERCISE EQUIPMENT

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INTRODUCTION

In order to accurately assess man's biomechanical system, it is necessary to resort to scientific methods of research which are capable of accurately determining the various human mechanical changes. This requires a systematic application of the laws of mechanics and biological concepts, both anatomical, physiological and biomechanical, to the problems of human motion.

In order to understand some of these complexities, consider the following illustration. A man performs a squat exercise using the same weight but assuming two different trunk positions. The traditional kinesiological approach utilizing conventional methods of determination of origins and insertions of various muscles may conclude that the knee extensors are the dominant muscles. However, by utilizing competerized biomechanical analysis to assess the intricate relationships among the body's link system, it was determined that with an erect trunk the knee extensors are the dominant muscular force, but when leaning forward the knee flexors are dominant.

I told him that I would need to have some of the machines he currently manufactured to begin data collection on them. Since I had a large basement in my house, he could ship the machines to me and I could make the measurements there.

I soon realized how serious Harold was about wanting the information quickly because three days later, a large truck arrived at my house with some Universal Gym equipment. The main unit was a large square with 16 different exercises that could be performed on it. In addition to the equipment, Harold arranged for one of his mechanical engineers, Ken, to spend time with us to collect and process the data. Ann, Ken, and I filmed the equipment and traced the movements using our new sonic digitizer. Then Ken calculated some of the mechanical changes based on the quantified results that would have to be made to have the resistance vary for each different exercise.

Eventually, our calculations and biomechanical analysis led us to devise a cam and lever system. The cam system we developed was the first one ever used for modern exercise equipment. We could use a cam directly for most of the single joint movements, such as the biceps curl. For the multi-joint exercises, we had to develop a modified system.

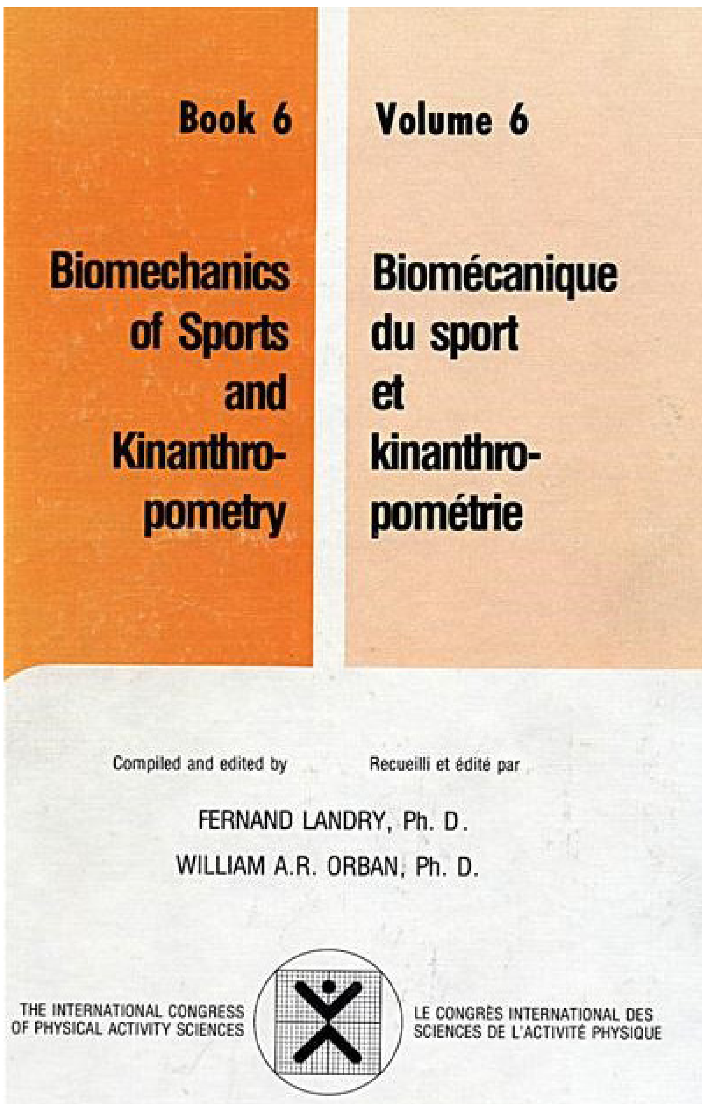
The biceps curl station on the equipment was modified to utilize a carefully calculated cam which provided resistance throughout the entire movement. The biceps curl station cable went around the specially designed cam and attached to the weight stack. Thus, when the person pulled on the cable, the cam provided changes to the moment arm on the cable. The cam caused the weight to vary appropriately as the individual flexed the arm.

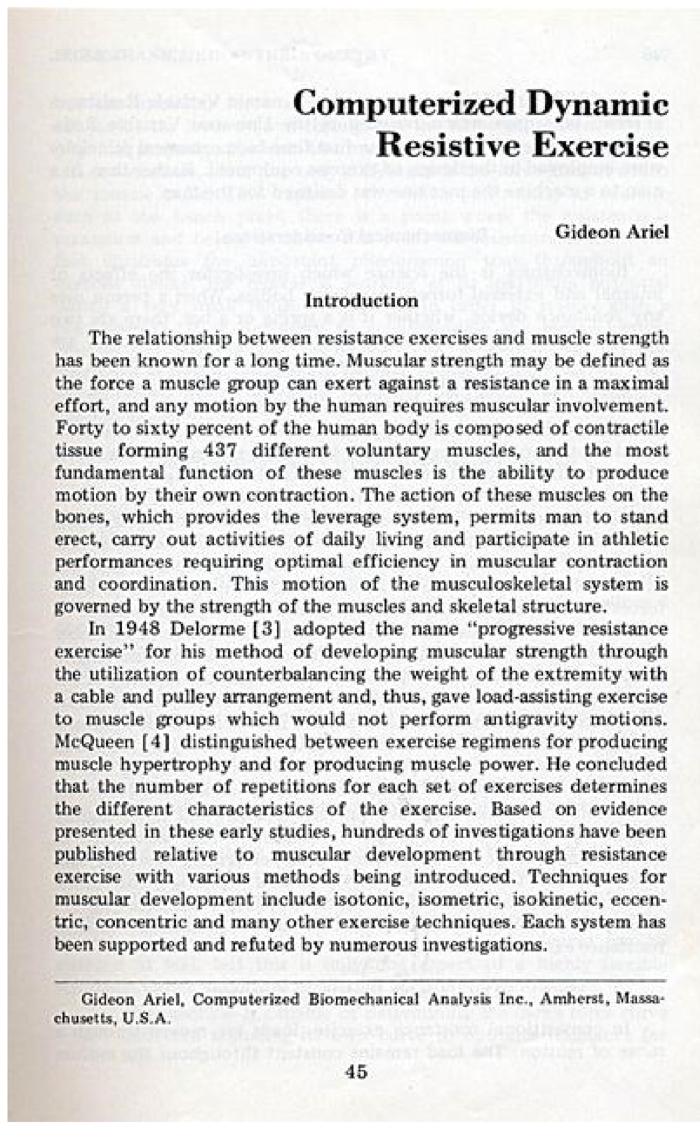
For the multi-joint exercises, such as the bench press, we had to devise a modified cam to accomplish the task. This device consisted of a sleeve which rolled on the bar. The bar was attached to a section of the frame opposite to the weight stack with the handles at the exercise station. A specially designed sleeve was connected to the weight stack, which rolled as the bar moved up and down. When the person pushed up on the handles, the bar moved up. The sleeve rolled on the bar as it was pushed up. As the bar moved up, the selected weight moved with it, so that the moment arm changed throughout the range of the movement. In other words, the rolling or sliding sleeve on the bar altered the amount of resistance the person had to lift. This change in the location of the weight on the bar relative to the person exercising provided the variable resistance.

Computerized Dynamic Resistive Exercise
http://arielnet.com/ref/go/1099

Ken took the calculations with him and returned to Fresno. Shortly thereafter, I flew to California to check the prototypes that Harold had built based on our calculations. For several months, we performed additional biomechanical analysis and finally perfected the variable resistance mechanism for each of the 16 stations.

Harold appointed me as the head of research for Universal Gym. We named the new exercise machine line the "Dynamic Variable Resistance" mechanism, or DVR. All Universal Gym machines incorporated these mechanisms of cams or levers that adjusted the resistance to the movement of the person who trained on the machine. This new concept machine was an immediate success among schools and athletic teams. The introduction and growth in sales of the





Computerized Dynamic Resistive Exercise

Gideon Ariel

Introduction

The relationship between resistance exercises and muscle strength has been known for a long time. Muscular strength may be defined as the force a muscle group can exert against a resistance in a maximal effort, and any motion by the human requires muscular involvement. Forty to sixty percent of the human body is composed of contractile tissue forming 437 different voluntary muscles, and the most fundamental function of these muscles is the ability to produce motion by their own contraction. The action of these muscles on the bones, which provides the leverage system, permits man to stand erect, carry out activities of daily living and participate in athletic performances requiring optimal efficiency in muscular contraction and coordination. This motion of the musculoskeletal system is governed by the strength of the muscles and skeletal structure.

In 1948 Delorme [3] adopted the name "progressive resistance exercise" for his method of developing muscular strength through the utilization of counterbalancing the weight of the extremity with a cable and pulley arrangement and, thus, gave load-assisting exercise to muscle groups which would not perform antigravity motions. McQueen [4] distinguished between exercise regimens for producing muscle hypertrophy and for producing muscle power. He concluded that the number of repetitions for each set of exercises determines the different characteristics of the exercise. Based on evidence presented in these early studies, hundreds of investigations have been published relative to muscular development through resistance exercise with various methods being introduced. Techniques for muscular development include isotonic, isometric, isokinetic, eccentric, concentric and many other exercise techniques. Each system has been supported and refuted by numerous investigations.

Gideon Ariel, Computerized Biomechanical Analysis Inc., Amherst, Massachusetts, U.S.A.

45

Computerized Biomechanical Analysis

Human movement analyzed with total precision. The first unveiling of man's precise resistive needs as required in true dynamic movement.

Isolated Camera Shots of each joint segment of movement

Special Tracing Equipm digitizes each joint moven for computer programmi

ANALYSIS PROCEDURE

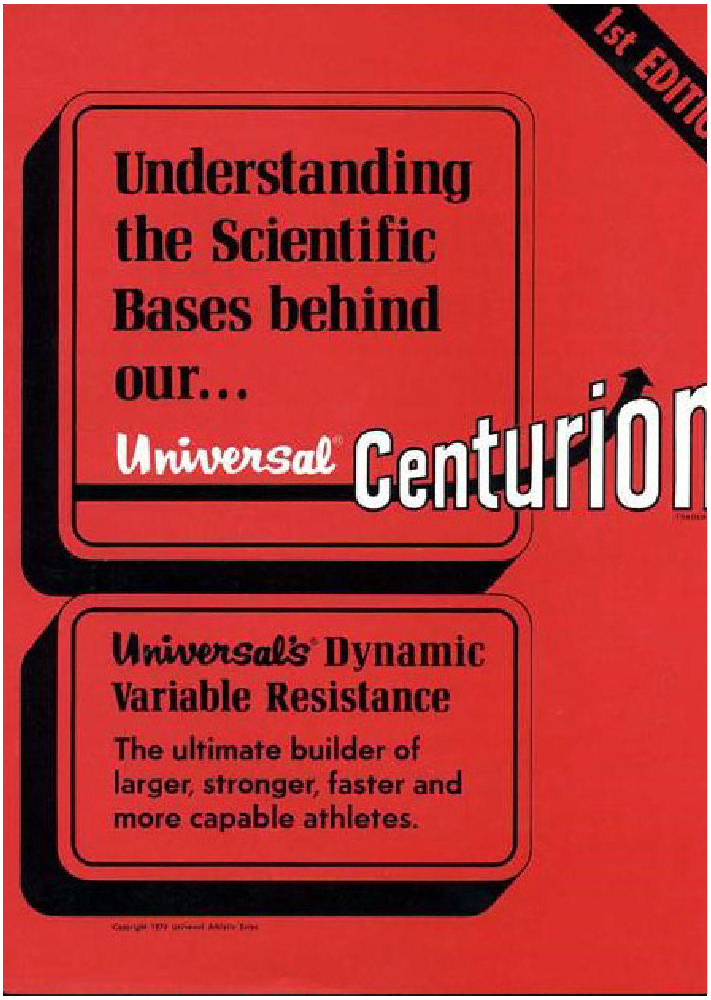
Sophisticated slow motion cinematography is used to capture highly complicated body movements. A camera with speeds ranging up to thousands of frames per second, becomes a recording observer of each single motor segment movement. Through careful use of this film, research scientists are able to get a full perspective on the complete movement cycle.

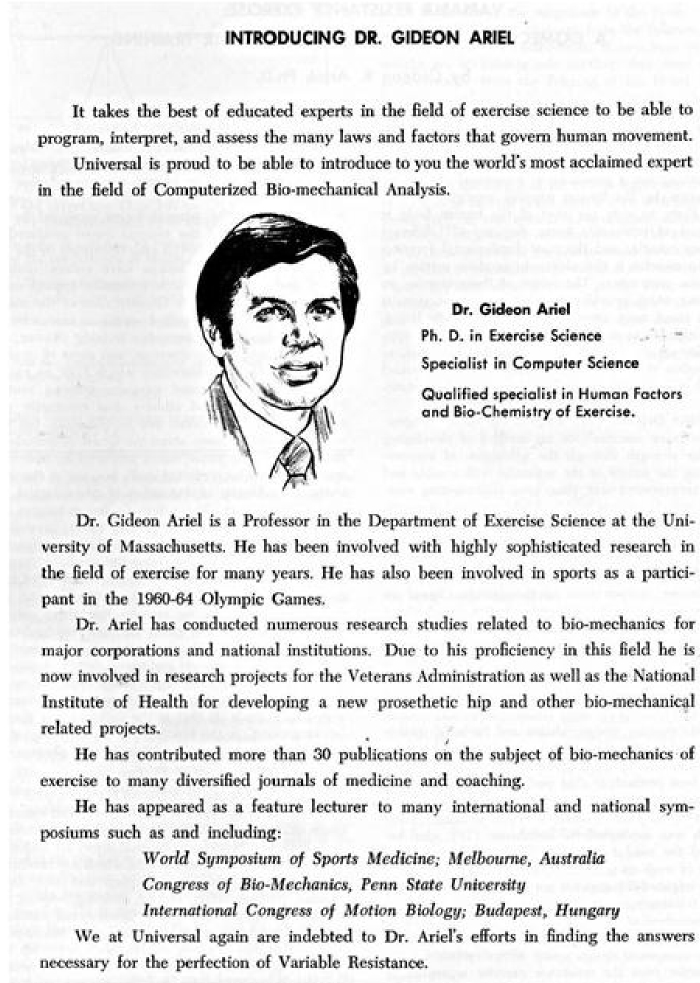
Complex tracing equipment is then used to digitize each segment movement and organize the data with all varying details. This digitized data is processed directly into a high speed computer.

As film has aided the human power of observation, increasing the amount of available facts, computers are required to remember and collate the facts. These modern technological "wonders" are fed vast amounts of film-bred information which they instantaneously decipher and edit into a usable form.

The computers are progra calculate the forces of ea body segment and their c tions to the whole movem

Independent modern computer center used by Universal.





INTRODUCING DR. GIDEON ARIEL

It takes the best of educated experts in the field of exercise science to be able to program, interpret, and assess the many laws and factors that govern human movement. Universal is proud to be able to introduce to you the world's most acclaimed expert in the field of Computerized Bio-mechanical Analysis.

Dr. Gideon Ariel
Ph. D. in Exercise Science
Specialist in Computer Science
Qualified specialist in Human Factors and Bio-Chemistry of Exercise.

Dr. Gideon Ariel is a Professor in the Department of Exercise Science at the University of Massachusetts. He has been involved with highly sophisticated research in the field of exercise for many years. He has also been involved in sports as a participant in the 1960-64 Olympic Games.

Dr. Ariel has conducted numerous research studies related to bio-mechanics for major corporations and national institutions. Due to his proficiency in this field he is now involved in research projects for the Veterans Administration as well as the National Institute of Health for developing a new prosethetic hip and other bio-mechanical related projects.

He has contributed more than 30 publications on the subject of bio-mechanics of exercise to many diversified journals of medicine and coaching.

He has appeared as a feature lecturer to many international and national symposiums such as and including:

World Symposium of Sports Medicine; Melbourne, Australia
Congress of Bio-Mechanics, Penn State University
International Congress of Motion Biology; Budapest, Hungary

We at Universal again are indebted to Dr. Ariel's efforts in finding the answers necessary for the perfection of Variable Resistance.

Brochure describing the Dynamic Variable Resistance mechanism
http://arielnet.com/ref/go/1101

DVR helped the company expand and their revenues grew exponentially.

Universal created a new brochure which introduced the variable resistance concept as well as me personally. I was proud that I was so prominently included in their advertising brochure. For CBA, this was a fantastic development since we received publicity as well as payment for the scientific analysis.

Our relationship with Universal progressed nicely as well. Both Ann and Ken Weinbel were pleased with the success we had with this project and with the continuing involvement with Universal. It was also helpful that I was asked to attend many of the fitness trade shows to describe the DVR concept. This publicity helped CBA since the more well-known I was, the greater the chances that we would attract projects from other companies.

The Universal Gym project
http://arielnet.com/ref/go/1102

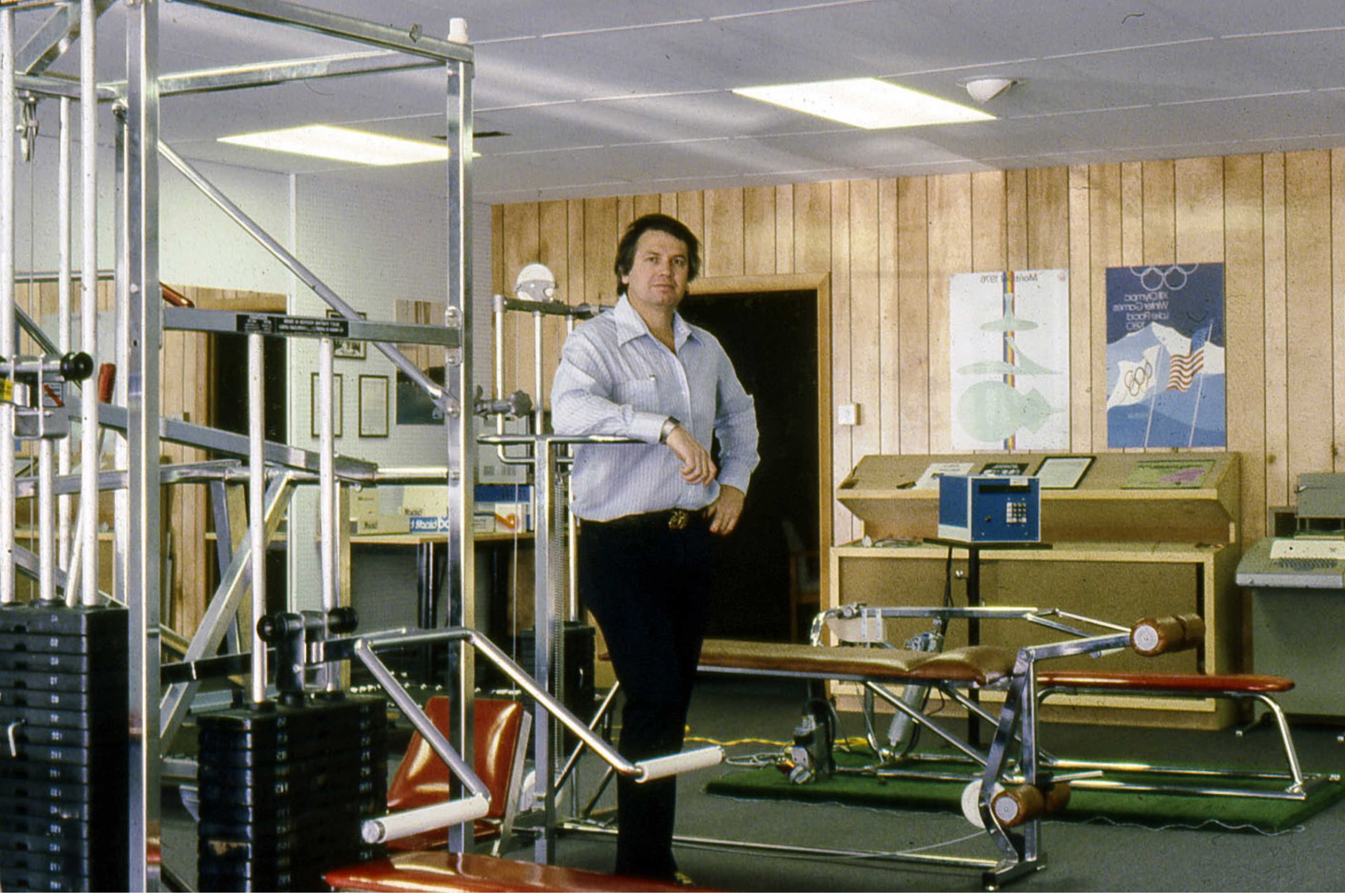
In one of my trips to Fresno, Harold said, "Gideon, we would like to pay you royalties for each machine we sell. How much do you think would be fair?"

I told him that I had no experience with this situation. Since he had been fair with us in all the projects to date, I told him that I trusted him to decide on a fair amount.

"How about $350 per machine?" he asked.

"That sounds great," I replied. After that meeting, we received royalties on each machine that Universal sold. At one point, they sold more than five thousand machines per year so the effort which we had previously expended was nicely compensated.

Not long after my meeting with Harold and the initiation of the royalty payments, Ann accompanied me to Fresno to work on the current project. Harold called us into his office



The Universal Gym equipment with DVR (Dynamic Variable Resistance)

and his first question was, "Gideon, what do you do with the royalty checks we send you?"

I shrugged and said that I put them into the bank. Harold asked whether I kept a bankbook with deposits and withdrawals. I told him that normally I had a general idea in my head as to how much money was in the bank account. Nodding his head, Harold called for his secretary to come into his office.

"How many checks have we sent to Gideon, and how many has he cashed?" he asked her.

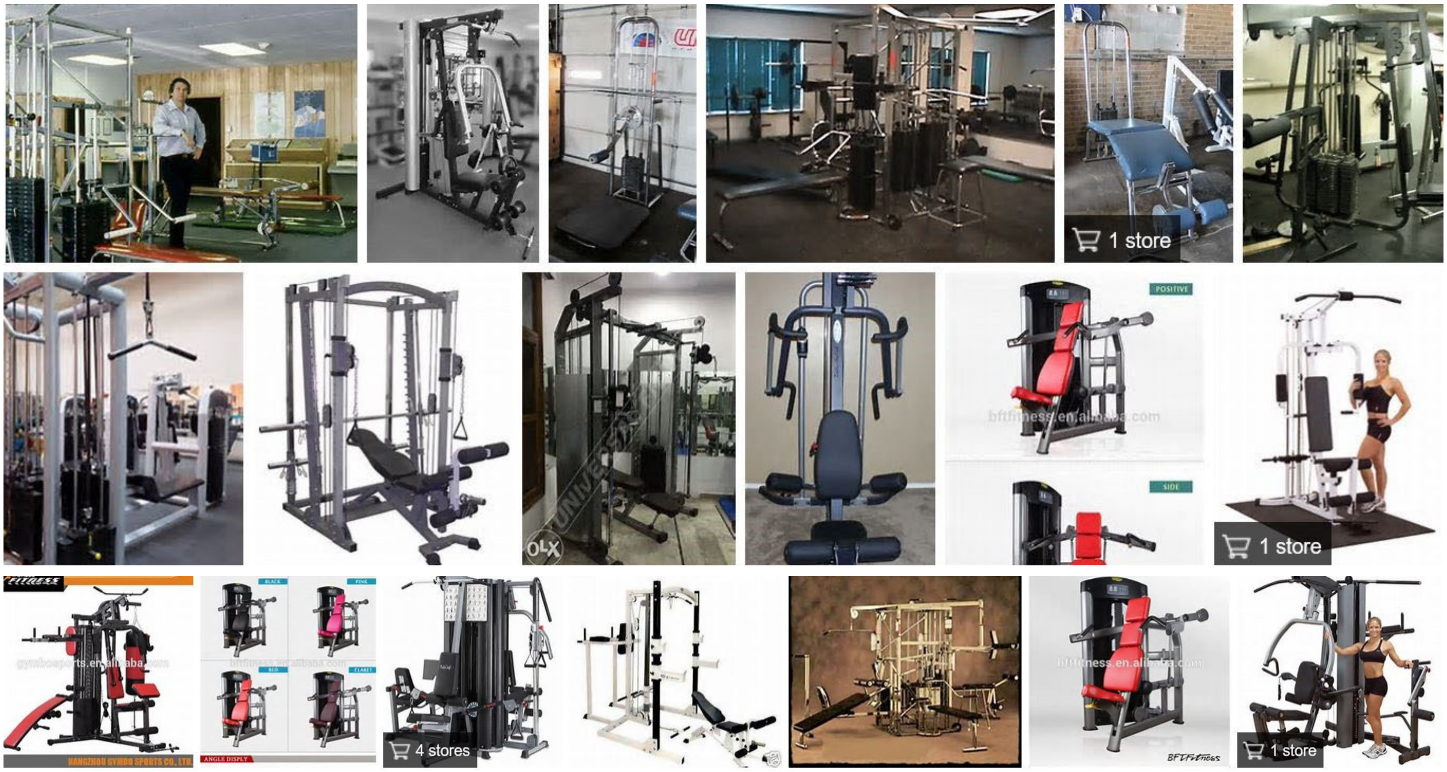
"We have sent twenty checks, and he has cashed fourteen of them," was her answer.

At this point, Harold turned to Ann and inquired whether he could hire her, with Gideon's agreement, to act as his accountant regarding the deposits of the checks from Universal and maintenance of his bank account. I laughed, and readily agreed that Ann would be perfect for this task. Ann agreed as well and was shocked when Harold said he would pay her fifty dollars a month to perform this task. At that time, fifty dollars went much farther than it does in today's world, so she was more than thrilled to accept this job.

Harold also told me that I should apply for a patent for the DVR, since I had invented the system. He said that Universal would do the paperwork and legal processes at their expense. However, the patent had to be issued to a person, not a company. Subsequently, the patent was issued and, for the first time, a cam or a mechanism to vary the resistance based on anatomical and biomechanical conditions was incorporated into exercise machines. Today, any gym utilizing a cam-based machine is a copy or an application of my idea and this patent. This method of varying resistance revolutionized resistive training methods for many exercise machine companies, and many publications resulted from it.

It is needless to say that those patents generated millions of dollars of income for us.

As luck and hard work would have it, we now had an office with equipment, a computer connection, and some money from Universal Gym. We had real biomechanical power

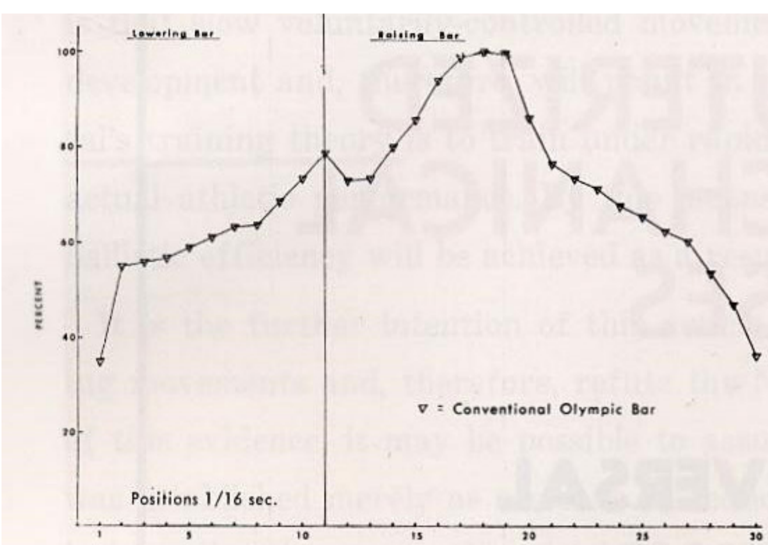


Most exercise equipment is a derivative of my patents

and hoped that soon there would be additional moneymaking projects.

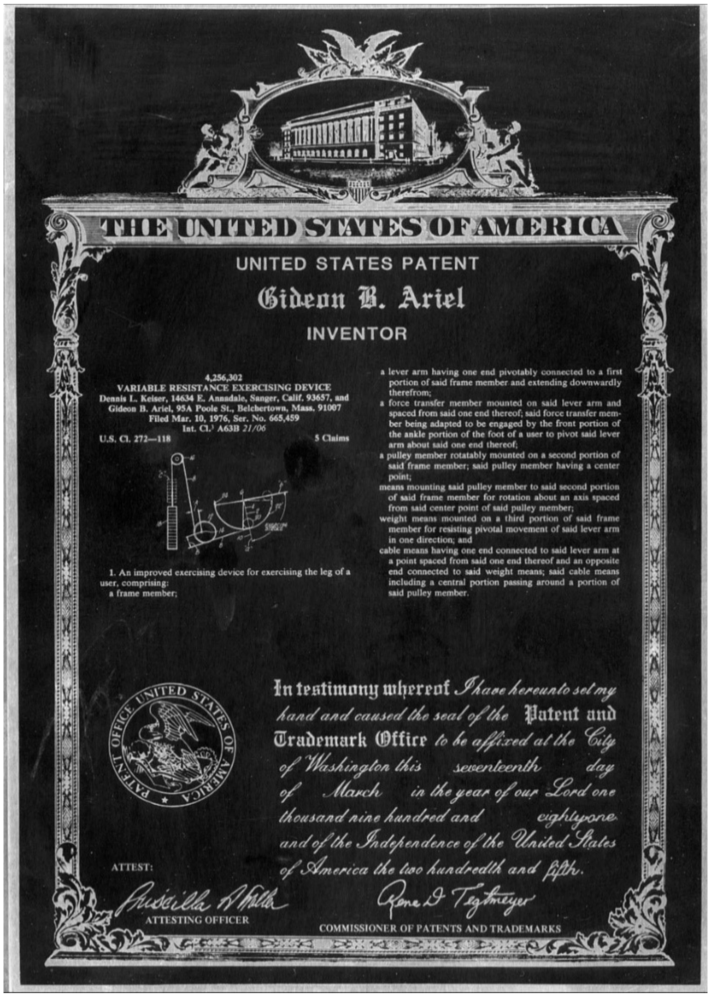
One day someone from the Spalding Corporation called. He introduced himself on the phone as Egon Romacker, and said that he was the director of research at Spalding Sporting Goods in Chicopee, Massachusetts. Mr. Romacker had read my article in Mechanics and Sports, and wondered if we could meet to discuss some ideas that he had. We arranged a time and date for lunch at a restaurant in Holyoke called the Yankee Peddler. I dared not invite him to our laborato-

Calculated force curve



EXAMPLE OF COMPUTER OUTPUT FORCE DATA
AT THE ELBOW FOR AN OLYMPIC BENCH PRESS
(In Kilograms)

Pos.	Elbow Angle (Deg.)	Moment (KG-M)	Horiz. Force (KG)	Vert. Force (KG)	Muscle Force (KG)	Shear Force (KG)	Comp. Force (KG)
1	177.6	9.196	— 71.23	—252.49	209.00	—26.27	261.03
2	153.6	8.029	—113.17	—204.78	182.48	49.95	228.58
3	134.6	5.714	—102.65	—145.37	129.86	68.46	164.86
4	120.1	4.034	— 81.79	—110.85	91.68	62.37	122.83
5	109.4	2.619	— 56.70	— 91.25	59.52	44.82	97.64
6	101.9	1.729	— 38.92	— 82.57	39.30	30.98	85.86
7	97.1	1.191	— 27.48	— 78.84	27.07	21.64	80.64
8	94.5	.861	— 20.12	— 77.29	19.57	15.50	78.35
9	93.5	.732	— 17.13	— 76.49	16.64	13.24	77.26
10	94.1	.717	— 16.64	— 76.24	16.30	13.03	76.93
11	95.7	.765	— 17.54	— 76.40	17.39	13.92	77.14
12	98.1	.806	— 20.28	— 77.10	20.36	16.37	78.02
13	102.2	1.065	— 23.89	— 78.27	24.20	19.35	79.52
14	104.7	1.195	— 26.53	— 79.85	27.16	21.17	81.43
15	108.5	1.347	— 29.53	— 82.01	30.61	23.15	84.03
16	112.6	1.604	— 34.65	— 85.36	36.45	26.77	88.15
17	116.9	1.792	— 37.94	— 88.89	40.73	25.88	92.42
18	121.6	2.239	— 46.26	— 95.46	50.89	33.93	100.51
19	126.6	2.683	— 53.65	—103.21	60.98	37.83	110.01
20	132.2	3.169	— 60.77	—112.82	78.08	40.04	121.73
21	138.5	3.951	— 71.76	—127.96	89.87	43.59	140.09
22	145.7	4.748	— 80.17	—145.80	107.91	41.67	161.09
23	154.4	5.891	— 89.73	—179.33	133.80	34.76	181.15
24	164.7	7.811	— 94.43	—215.04	163.80	15.53	206.18
25	177.1	8.638	— 88.49	—245.61	186.28	—23.14	260.14



THE UNITED STATES OF AMERICA

UNITED STATES PATENT

Gideon B. Ariel

INVENTOR

4,256,302
VARIABLE RESISTANCE EXERCISING DEVICE
Dennis L. Keiser, 14634 E. Annadale, Sanger, Calif. 93657, and Gideon B. Ariel, 95A Poole St., Belchertown, Mass. 91007
Filed Mar. 10, 1976, Ser. No. 665,459
Int. Cl.[3] A63B 21/06
U.S. Cl. 272—118 5 Claims

1. An improved exercising device for exercising the leg of a user, comprising:
a frame member;
a lever arm having one end pivotably connected to a first portion of said frame member and extending downwardly therefrom;
a force transfer member mounted on said lever arm and spaced from said one end thereof; said force transfer member being adapted to be engaged by the front portion of the ankle portion of the foot of a user to pivot said lever arm about said one end thereof;
a pulley member rotatably mounted on a second portion of said frame member; said pulley member having a center point;
means mounting said pulley member to said second portion of said frame member for rotation about an axis spaced from said center point of said pulley member;
weight means mounted on a third portion of said frame member for resisting pivotal movement of said lever arm in one direction; and
cable means having one end connected to said lever arm at a point spaced from said one end thereof and an opposite end connected to said weight means; said cable means including a central portion passing around a portion of said pulley member.

PATENT OFFICE UNITED STATES OF AMERICA

In testimony whereof I have hereunto set my hand and caused the seal of the Patent and Trademark Office to be affixed at the City of Washington this seventeenth day of March in the year of our Lord one thousand nine hundred and eighty-one and of the Independence of the United States of America the two hundredth and fifth.

ATTEST:

ATTESTING OFFICER

COMMISSIONER OF PATENTS AND TRADEMARKS

Patent for cam-based exercise machines
http://arielnet.com/ref/go/1103

ry in my kitchen. Ann and I dressed nicely for the meeting. "Nicely" for us meant we changed out of the blue jeans and T-shirts, which were our normal attire, into "dress up clothes" and drove the 20 miles for the meeting.

At the restaurant and, following the round robin of introductions, Mr. Romacker told us how impressed he was with our technique of analyzing athletes. His questions involved whether we could also trace and analyze other objects. I asked him what objects, and he answered, "The flight of a basketball."

"Of course," I replied without hesitation, although I had no idea whether we could do it or not. However, to secure our first real project, I confidently claimed we could analyze anything. Egon explained that Spalding was the leading basketball manufacturer in the world. However, some of their competitors claimed that Spalding basketballs wobbled in the air. In other words, they had been accused of producing basketballs like the crazy distorted ones that the Harlem Globetrotters, the comedic basketball team, used. The Globetrotters included giving their opponent, in one of their less-than-serious routines, a ball that wobbled and swayed all over the court, following unpredictable and irregular paths. This accusation against Spalding's basketball production could have serious repercussions in their market and, thus, negatively affect their profitability.

Mr. Romancer asked whether we could ascertain the actual flight of their basketballs, and, if there was a problem, if we could provide a solution to solve it. The question was "did their basketballs follow a parabolic flight, as dictated by gravity, or did they wobble during flight?"

Obviously, the ball would have to be perfectly balanced as it revolved around its center of mass. If one part of the ball were heavier or lighter than the other parts, it would wobble. Throughout the lunch, we discussed the various factors associated with ball flight, and created a draft testing protocol. We would have to determine whether the center of mass was located at the center of the ball. Egon agreed with my assessment, but told me that they had measured it numerous times with engineering firms, and had spent hundreds of thousands of dollars to show that the center of mass was exactly in the center of the ball.

"Well," I suggested to him, "we should set up the test area in a location in a gym where we can launch the ball from a machine. With a machine to launch the balls, there would be no human interactions which might contaminate the movements. The test could be repeated with the same motion for as many trials as necessary. The test results would be completely objective. Also, it would be a dynamic test, rather than a static test that most engineering firms would perform. We are the only company that can evaluate dynamic as well as static conditions. We will utilize our high-speed cameras, film the flight of the ball, and calculate both the center of gravity and the center of the ball. These films and calculations will determine whether the balls follow a parabolic path or not."

Mr. Romacker asked me how much the project would cost. I told him that I would let him know the next day. Spalding would provide the ball-throwing machine and find a local gymnasium for testing that would be conveniently close for both of our organizations. We would provide the biomechanical equipment. He told us to call him with a proposal as soon as we were ready.

When we drove back to Amherst, Ann and I were very excited about having our first project. I called Ken Weinbel and shouted, "Ken, we have a project!"

Ken was excited, too. He asked, "How much are you going to charge for this project?"

I asked him how much money he had spent on the company so far. He told me that it was about $12,000, including the corporation registration with the State of New Hampshire, and purchasing the digitizer, the two projectors and the two Kodak Special 64 frames-per-second spring-loaded cameras. I said that I would call him the next day after we spoke with Spalding.

Now Ann and I began our calculations. The project would require a full day of travel for filming the basketball flights and then there would be at least a week to complete the digitizing. We would have to perform paperwork calculations and report printing. When we considered the overhead expenses accrued to date we had quite a list. We included the $15,000 for the cost of the house, $12,000 for Ken's expenses, and $2,000 out-of-pocket costs for paper, gas, and meals. In addition, we needed another Teletype, which would cost $1,500. We concluded that $50,000 would sufficiently cover our expenses, and whatever was left over would be used for future expenditures. Since this was our first project, we wanted to make sure we would cover our costs and execute the job so well that perhaps we would, hopefully, generate some repeat business.

I called Ken and explained how we had calculated the cost for the project.

"You're crazy," he said.

"They have already spent more than a hundred thousand dollars and found nothing," I replied.

"Go ahead," he replied. "But I think you have priced us out of the competition and we will lose this opportunity."

The following day we arranged to meet Mr. Romacker at the Yankee Peddler for lunch where we would explain our proposed experimental protocol. We described the procedure of measuring at least 50 ball flights using different speeds and angles of trajectories. We would then digitize four points on the edge of the ball. The intersection of these points would be the location of the center of the ball. Then I would write a computer program to calculate the flight path of this calculated center and determine whether it followed a parabolic pattern. I described the equipment we would need, the biomechanical processing of the films, and the computations which would be required.

"So what is the cost of the project you are proposing?" he asked.

"I estimate the cost at 50,000 dollars," was my confident reply.

"Is that for the entire project?" he asked.

"Yes," I answered, with my fingers crossed under the table for good luck. Ann sat beside me and I knew she was as nervous as I was. We collectively held our breaths as we watched Egon thinking quietly to himself.

"Gideon," he said after a few moments and he extended his hand. "I accept your proposal and want you to start immediately."

We were elated on the drive back to our home where our laboratory was set up in the kitchen. I asked Ann, "What will happen if Mr. Romacker wants to see our laboratory?" and we both exploded with laughter. She answered that we had better produce an excellent report based on credible findings. If we did a good job on this project, perhaps there would be other ones to follow. Then we could consider a more proper laboratory setting in the future. First, we had to do our job and do it well.

The ball-throwing machine was delivered to the test location at a local school gymnasium. We met Mr. Romacker early one morning with our photographic equipment and prepared to film the basketball flight paths. It took nearly the entire day to film all the balls that Egon brought to the test session.

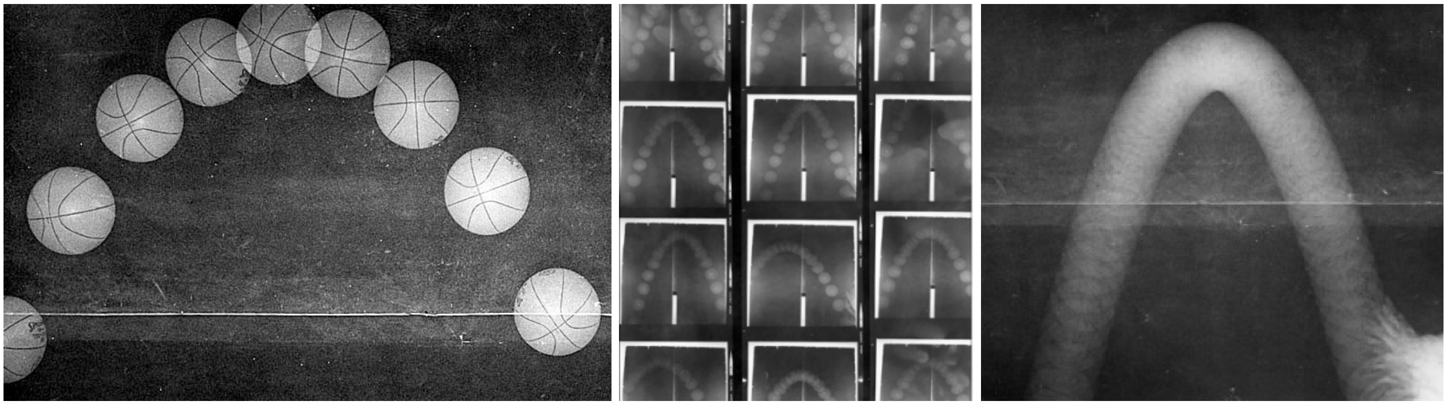
The next day we delivered the film to the local camera store so they could send it to a lab for processing. At that time, cameras only used film, and development usually required two days for processing. This was long before the advent of digital technology which can store the pictures on the disk and then immediately access them.

Once we received the developed film, digitizing of the balls commenced using our digitizer screen. The data was transmitted to the computer at Dartmouth through the phone line. Ann did the digitizing which took nearly two weeks to complete despite the long hours Ann devoted to the job. While she did the tracing work, I wrote a simple BASIC program to calculate the center of the ball and trace this point throughout its flight.

After we had processed the data, we began to examine the results. For every ball that we tested, we calculated that the center of the ball followed a perfect parabolic pattern. There were no distortions in any of the flights.

There were a few differences, however. We had requested that Spalding prepare three special balls for the test. One had a heavier weighted panel on the same side of the ball as the valve. Another ball had smaller seams and the third ball was a solid color without the usual black seams.

I called Egon to let him know that we had one additional test to perform before we presented our findings. We returned to the gymnasium where we had collected the original data. This time, we collected additional data using a strobe light rather than the normal gymnasium lighting system. We had rented a light strobe generator from one of the photographic stores. The light at the gym was turned off and Ann activated the ball-throwing equipment. Then we filmed the ball flights using only the strobe light to illuminate the throws.



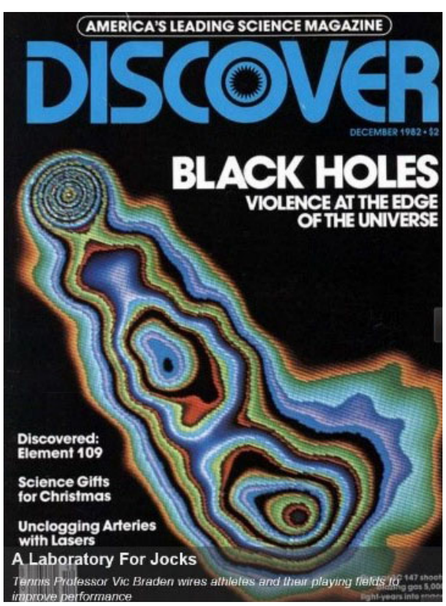
Analysis of basketball looping flights

We processed this film and analyzed our results following the same testing protocols. What we discovered was that, once again, the balls demonstrated no wobbling at all when biomechanically evaluated. However, when reviewing the film taken under the strobe condition, the ball appeared to be wobbling to the naked eye. Clearly, the brain's interpretation of the information provided by the visual centers indicated that the balls were wobbling. The brain was being deceived because of the nature of the visual input. Although the scientific data decisively calculated perfect parabolic flight paths, the brain thought that something else was happening. Now, we had to explain these apparently inconsistent findings to Mr. Romacker. We would have to explain what happens when people watch actions under strobe light conditions.

We met Mr. Romacker to present our results. We showed that the normal Spalding basketballs were perfect in their parabolic flight patterns. The special balls that we had asked Spalding to construct for us showed some variations. As expected, the weighted balls showed definite looping patterns. There was no difference in the smaller seamed and the solid colored balls.

After this portion of the results, we described our second data collection session using the strobe equipment. A strobe light flashing off and on produces the same effect as fluorescent lights do. A fluorescent light is a strobe light that flashes on and off at a fixed 60 cycles per second. However, anyone who has seen the apparently jerky movements of dancers in a nightclub that uses overhead strobe lights, knows that the movements do not seem to flow in the normal manner that we have come to expect from human activities. Dancing beneath a strobe light produces crazy exaggerated movements. The actions are distorted and almost seem to be disconnected.

Thus, the wobbling attributed to the Spalding balls was due to the same optical illusion as found in a strobe-lighted disco. Their normal production run basketball had very dark



Biomechanics - how computers extend athletic performance to the body's far limits
Now man and machine join on the sports field to boost phsyical output

Biomechanics
–how computers extend athletic performance to the body's far limits

Now man and machine join on the sports field to boost physical ouput

By DANIEL RUBY

TRABUCO CANYON, CALIF.

"Explode."

The heavyset man yelled in my ear as I strained to jolt the bar upward. But it was much heavier near the top of its travel than it had been at first. I lost momentum.

"Try again," he said disapprovingly. But my second bench press—and third—proved just as feeble.

A color graph appeared on the screen, displaying a shortage of foot-pounds where I'd need them most for heaving an iron ball. "You'll never make it as a shot-putter, my friend," said Gideon Ariel, a one-time Olympic shot-putter himself and inventor of the computerized weight machine that had just defeated me.

digitizing pens and hardware, high-speed cameras, force plates, and infrared detectors are the instruments that turn an already first-class sports complex (tennis courts, running track, gym, swimming pools, equestrian grounds) into the world's premier laboratory for the study of biomechanics—the science that relates the physics of motion to human anatomy.

The basis for Ariel's work is that old con man's truth: The hand is quicker than the eye. So are the feet, head, and every other part of an athlete's body. Only by slowing down the motion on film or videotape can anyone really tell what happens when a racket hits a ball or a foot meets a track.

Thigh bone's connected . . .

Of course, the use of film alone is nothing new to sport. What is new—and is becoming a powerful tool in recognizing talent, training athletes, treating their injuries, and designing their equipement—is the use of comput-

velocity and a certain angle. So we work backward. For the discus to have that velocity, then the hand must have that velocity. For that to happen, the forearm must be moving so, then the upper arm, the torso, and so on down to the feet. We created a computer model of the optimum throw and then tried to teach the athlete to do that."

At age 43, after working with Ariel, Oerter threw 27 feet farther than his best gold-medal performance. Now he is training for a comeback at the 1984 Olympics.

The interdependence of body parts is true of all sports. Ariel's co-researcher at Coto, psychologist and tennis guru Vic Braden, uses the analogy of a whip. "Power supply comes from efficiently transferring shock from one body segment to another and finally into the implement or ball." Or as Ariel likes to say: "You can't shoot a cannon from a canoe."

Biomechanics - how computers extend athletic performance to the body's far limits
Now man and machine join on the sports field to boost phsyical

Many projects at CBA Inc.
http://arielnet.com/ref/go/2007

seams and appeared to move up and down during flight with the same jerky appearing movements as the disco dancers. The interaction of the dark seams and the strobing fluorescent light produced an illusion of wobbling. Anyone watching the balls in the normal gymnasium setting under florescent lights, could be visually tricked by this strobe effect. The basketball, which we had asked Egon to prepare with no seams, had not introduced this illusion. Likewise, the balls with the smaller seams seemed to wobble less than the normal wide-seam ones.

We demonstrated this strobing effect with both the strobe and the florescent lights in the gym. Our analysis had determined the source of their problem and now they could design their basketballs to prevent this situation.

Egon was very pleased and excited to be able to explain the source of their problem to his boss. Now, they could brainstorm within the manufacturing department to solve the seam problem. The following week, we received the balance due, and a thank you note from Spalding for a job well done.

Ann and I continued to maintain an incredible work pace. We had more than enough work with our class loads, but now we had compounded it with the development and growth of CBA. In addition, we had our other commitments at the university, so we were very busy indeed. Fortunately, we had many common interests and complementary talents. I would conceive of wild, creative ideas and she would work out the details to bring them into proportions that were more realistic. Our life was good together and we seemed to be working towards a productive future.