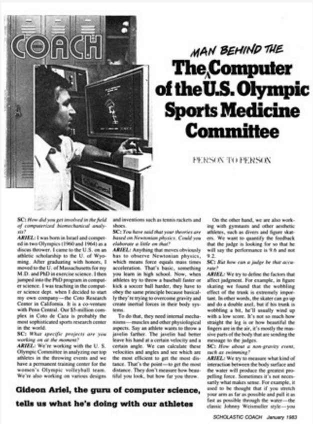
# The Man Behind The Computer of the U.S. Olympic Sports Medicine Committee

## Person To Person


COACH

MAN BEHIND THE The Computer of the U.S. Olympic Sports Medicine Committee

PERSON TO PERSON

**Gideon Ariel, the guru of computer science, tells us what he's doing with our athletes**

SCHOLASTIC COACH January 1983

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|---|---|
| **Code** | **adi-pub-01043** |
| **Title** | The Man Behind The Computer of the U.S. Olympic Sports Medicine Committee |
| **Subtitle** | Person To Person |
| **Name** | Scholastic Coach |
| **Author** | Unknown |
| **Published on** | Saturday, January 1, 1983 |
| **Subject** | ACES; APAS; Baseball; Biomechanics; Digitize; Discus; EMG; Exercise Machine; Favorite; Force Plate; Golf; Media; NASA; Olympics; Performance Analysis; Science; Shoes; Space; Sports; Steroids; Tennis; Track and Field; Volleyball |
| **URL** | https://arielweb.com/articles/show/adi-pub-01043 |
| **Date** | 2013-01-16 15:40:44 |
| **Label** | Approved |
| **Privacy** | Public |

This article features an interview with Gideon Ariel, a computer science guru who has been working with the U.S. Olympic Committee to analyze top athletes' performance using computerized biomechanical analysis. Ariel, a former Olympian himself, explains how he uses both direct and indirect methods to analyze athletes' movements and techniques, identifying minute flaws that, once corrected, can significantly improve performance. He also discusses the role of genetics versus training in athletic performance, arguing that while genetics are crucial in explosive events like sprinting, technique plays a much larger role in other events. Ariel's work has been applied in various sports, from volleyball to discus throwing, and has contributed to the success of many athletes.

The article discusses the role of technology and science in sports, particularly in coaching and athlete performance. Ariel, a sports scientist, argues that technology is not replacing athletes but rather providing coaches with sophisticated tools to enhance performance. He compares this to engineers using computers and other advanced equipment to design a bridge. Ariel also discusses the use of high-speed photography in sports, revealing misconceptions in traditional coaching methods. He suggests that coaches should focus more on the sciences and predicts that microcomputers with appropriate software for analysis will be available for coaches in the near future. Ariel also discusses the potential of biomechanics in sports, the use of drugs among athletes, and the importance of training the nervous system. He concludes by predicting that the U.S. women's volleyball team will win the gold medal in the Olympics due to their systematic training.

## Synopsis

The article features an interview with the chairman of biomechanics and computer science for the Olympic Committee, Ariel, who criticizes the current system of funding and support for athletes. Ariel advocates for a more transparent and athlete-focused approach to funding, with a larger percentage of each dollar going directly to the athletes. He also discusses his contributions to the Olympic Committee, including computer technology and shoe research, and his desire to see more funding put into the sports medicine program. Ariel expresses concern over the lack of focus on producing potential gold medalists at the Olympic training center. He also discusses his patented inventions, including a computerized running shoe and a computerized rehabilitation and exercise machine with artificial intelligence. Ariel believes that all exercise machines will be computerized within five years and that this technology will revolutionize training, rehabilitation, and injury prevention.

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Below find a reprint of the 8 relevant pages of the article "The Man Behind The Computer of the U.S. Olympic Sports Medicine Committee" in "Scholastic Coach":


# MAN BEHIND THE The Computer of the U.S. Olympic Sports Medicine Committee

PERSON TO PERSON

**SC:** *How did you get involved in the field of computerized biomechanical analysis?*

***ARIEL:*** I was born in Israel and competed in two Olympics (1960 and 1964) as a discus thrower. I came to the U.S. on an athletic scholarship to the U. of Wyoming. After graduating with honors, I moved to the U. of Massachusetts for my M.D. and PhD in exercise science. I then jumped into the PhD program in computer science. I was teaching in the computer science dept. when I decided to start my own company—the Coto Research Center in California. It is a co-venture with Penn Central. Our $5-million complex in Coto de Caza is probably the most sophisticated sports research center in the world.

**SC:** *What specific projects are you working on at the moment?*

***ARIEL:*** We're working with the U. S. Olympic Committee in analyzing our top athletes in the throwing events and we have a permanent training center for the women's Olympic volleyball team. We're also working on various designs and inventions such as tennis rackets and shoes.

**SC:** *You have said that your theories are based on Newtonian physics. Could you elaborate a little on that?*

***ARIEL:*** Anything that moves obviously has to observe Newtonian physics, which means force equals mass times acceleration. That's basic, something you learn in high school. Now, when athletes try to throw a baseball faster or kick a soccer ball harder, they have to obey the same principle because basically they're trying to overcome gravity and create inertial forces in their body systems.

To do that, they need internal mechanisms—muscles and other physiological aspects. Say an athlete wants to throw a javelin farther. The javelin had better leave his hand at a certain velocity and a certain angle. We can calculate these velocities and angles and see which are the most efficient to get the most distance. That's the point—to get the most distance. They don't measure how beautiful you look, but how far you throw.

On the other hand, we are also working with gymnasts and other aesthetic athletes, such as divers and figure skaters. We want to quantify the feedback that the judge is looking for so that he will say the performance is 9.6 and not 9.2.

**SC:** *But how can a judge be that accurate?*

***ARIEL:*** We try to define the factors that affect judgment. For example, in figure skating we found that the wobbling effect of the trunk is extremely important. In other words, the skater can go up and do a double axel, but if his trunk is wobbling a bit, he'll usually wind up with a low score. It's not so much how straight the leg is or how beautiful the fingers are in the air, it's mostly the massive parts of the body that are sending the message to the judges.

**SC:** *How about a non-gravity event, such as swimming?*

***ARIEL:*** We try to measure what kind of interaction between the body surface and the water will produce the greatest propelling force. Sometimes it's not necessarily what makes sense. For example, it used to be thought that if you stretch your arm as far as possible and pull it as fast as possible through the water—the classic Johnny Weismuller style—you

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might find it inefficient.

Maybe you want to turn your hand with a bent elbow to create more surface against the water. Also, the speed of the arm through the water shouldn't be too fast or you'll miss too much resistance; you'll create water movement that isn't advantageous. You want to move the arm at a certain velocity. We want to find out what that is. Of course, different people have different velocities.

Also, we want to learn how to reduce friction with the water. For example, should you really shave your body or not? What kind of suit should you wear?

**SC:** *We know that you're also working with our top sprinters and hurdlers. So how do your theories apply to the explosive events?*

***ARIEL:*** With sprinters, you want to know what stride length will produce the best results. With Ed Moses, the great hurdler, we know that he has characteristics we can't take credit for, that are genetic.

For some reason, when he comes over the hurdle and touches the ground, there is no blocking force. In other words, his center of mass is already ahead of his feet. Most hurdlers, when landing, have a force that pushes them backward. They stop themselves just a little.

With Ed Moses, there is no braking force, so that even though he's not the fastest person in the world, he becomes that when he runs over the hurdles. He has taught us what to look for in other hurdlers, to learn whether they are running the hurdles most efficiently. Moses also takes 13 steps between hurdles in the 440, where most athletes take 14 or 15, and other things like that.

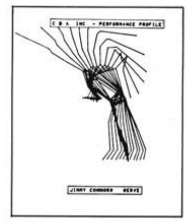
We try to define the characteristics that contribute the most to each event. Another example: Al Oerter, 45 years old, threw the discus over 240 feet two weeks ago, far surpassing his gold-medal throws in the 1956-60-64-68 Olympics (184-10½, 194-2, 200-1½, and 212-6½).

Maybe Al Oerter is still 25 biologically. We've tried to determine whether aging can really deteriorate performance. Well, in the case of Oerter, it does not. He has more problems with technique than with age. So we concentrate on the technique.

**SC:** *Is there a theoretically correct way to execute specific skills in order to produce the best result?*

***ARIEL:*** Let's take the discus. We know that if the discus leaves the hand at a certain velocity and a certain angle, it will go a certain distance. We want to maximize the velocity. Let's assume that the angle is a technical problem that anybody can correct. But it is very difficult to generate the speed.

Now, speed obviously doesn't come from the hand. It comes from the lower part of the body: the trunk, the hips, the shoulders, the upper arm. There is a coordination that produces a certain whipping action. Not everyone can produce that. Doing it with the whole body, which consists of about 16 segments that interact with one another, is very difficult.




Now, suppose you have a deficiency in one of those 16 segments, or springs. It could be the thigh or the shank or the trunk. You can only be as strong as your weakest link—you cannot be stronger. If you don't use your legs correctly—the harder you push with your arms—the energy will not go into the implement, but back into your legs.

So you have to execute in a way that will transfer all the energy to the last segment—in this case, the wrist and the hand—and then be transferred to the discus.

There is a way for each person to do this in order to maximize his efficiency. We can calculate it with our methods. The only reason we use a computer is because there are about five million calculations in every skill.

**SC:** *Could you go through some of the basic processes you use in biomechanical analysis?*

***ARIEL:*** There are two methods of doing it: direct and indirect. The direct method has the athlete coming to our laboratory, where we put electromyogram electrodes on him to determine how his muscles fire. We let him throw from a force platform, and every time his foot hits the platform, we get the amount of force generated in his feet.

At the same time, we film him at a very high speed—200 or 300 frames per second, sometimes 500 frames per second. In golf, it's even higher than that—5,000 frames per second. Then we project these pictures into a digitizer, a screen that is sensitive to each of the coordinates of the body. We utilize either a manual digitizer with which we cannot see the body segments very well, or an automatic digitizing system which uses image analyzers that can look at the picture and define certain points on the body.

These values then go into the computer, which give us the parameters of the athlete's motion in three dimensions, as the human body is always changing its plane of motion.

The three-dimensional analysis requires sophisticated equipment, but it gives us the velocities, the accelerations, the forces, and the energy in the physical space in which the athlete produced them. That gives us the efficiency and deficiencies of every motion.

**SC:** *How does this differ from your indirect method?*

***ARIEL:*** In the indirect method we try to see what the East Germans are doing, or what the Russians are doing, or what the Japanese are doing—in volleyball, for example. When we prepare for the World Championships or the Olympics, we go out and film our rivals and bring the information here.

Let me give you one example: Our women's volleyball team went to Peru for the world championships three weeks ago. When we played against China, Japan, and Russia, we knew exactly where to spike the ball and where to be on the court when they spiked to us. We knew at what velocity they could move to the right or to the left or forward. We knew how high to go to go over their blocks.

For the first time in our history, we beat China easily, 3-0 in 54 minutes. We beat Russia 3-0 and we beat Japan 3-0. Now, I'm not saying our computerized analysis was the entire reason for our success. But our one failure lent even

# GURU OF THE COMPUTER

more credence to our methods. Peru beat us 3-0—and Peru was *the one team we hadn't bothered to analyze*. We had considered them "easy" and saw no reason to waste time on an analysis!

So China, whom we had beaten 3-0, won the world title. Peru finished second, the U.S. third, Japan fourth, and Russia fifth.

We call this method of analysis "formation analysis." Not only do we analyze the best player on the team, but how this person interacts with other people.

**SC:** *Don't you have a special kind of analysis for this?*

***ARIEL:*** We use a sophisticated statistical method called cluster analysis. The Air Force uses it to determine the clusters of the enemy and how they are concentrated, and they use probability tests, depending on whether the enemy has or doesn't have missiles. Or if they have so many soldiers that can move so fast. Or what kind of land there is: Are there mountains or are there valleys?

The military can then make a statistical prediction on whether it's best to use the Air Force or to use tanks or to use the Navy—things like that.

We are using the same method for volleyball. We say: "If they are very fast and very strong on the right side and they can move the ball to the left side at a certain speed and they can spike the ball at a certain angle and a certain speed, we concentrate on those specific zones." It worked fantastically against China. They fell completely apart, because we were ready for everything they tried to do.

**SC:** *How did you get the statistical information for this analysis?*

***ARIEL:*** We went to the World Cup the year before and we went to a few international meets and just filmed them from the stands. They didn't know what we were doing. We had ABC signs on our arms and they thought we were from the media. Then we brought the films back to the Coto Center and did a lot of work—coming away with a 600-page report.

But the thing that most people don't know is that in this high-skill sport, athletes *commit to the motion* before the situation exists. In other words, if Floheimer, our best spiker, is going for a spike, the opponents don't wait for her to spike.

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When they see her running for the spike, they already commit themselves to certain positions. That's because although they may not know statistically, they have the experience to set themselves at certain points.

The same thing was true when we worked with Jimmy Connors. Connors had certain deficiencies in his service motion and positioning. When McEnroe would hit a ball at him, Connors would just randomly take a position. Now, imagine if Connors knew that when McEnroe went to the right at a certain velocity, the ball would go to a certain point 90% of the time. That kind of information could be invaluable in any individual game like tennis or team game like volleyball.

**SC:** *Didn't we see something about your working with the Dallas Cowboys on the same thing?*

***ARIEL:*** Yes, we are working with Bob Ward, the training coach. We believe that formation analysis is in the future of every team. You know how big football is. But ask a coach what he's going to do next week and how certain he is that it will work in a certain situation, and he'll only give you a guess.

But ask General Motors about car sales or going a certain way or if a motor is going to blow up, and they will bring in a dozen experts in a moment. They've calculated everything to the nth degree—though they did let Japan beat them to formation analysis.

**SC:** *We'd like to back up a bit to direct analysis. You've said that the human eye can't discern faults in an athlete's technique because the faults are often too minute. Let's say that you put an athlete through the analysis and you come up with the flaws in his motion. If these flaws are so minute, is it physically possible for the athlete to make corrections?*

***ARIEL:*** Sometimes it's difficult. Take someone like Ben Pucknett, the world-record holder in the discus. For him to throw another five feet, he had to correct a flaw in his stance. In other words, when he completed his turn in the discus, he was completely open. He had already lost about 10 inches of pull on the discus.

We can work on such flaws for a week to 10 days and improve a throw by five to 10 feet. With the world-class athletes, very small changes can make a very big difference.

Take weightlifting. A guy can clean and jerk, say, 500 pounds. To get to the 515-pound level, it might take him a year or a year and a half. But if he could just change a minute flaw in his technique—he might be bending his knees a little too late or bending forward a little too much or keeping his body a half inch too far from the weight—it could make a big difference. Adding a half inch to the height of the heel off the floor can affect the weightlifter by 10 to 15 pounds.

**SC:** *But, can the athlete make these corrections once you have pointed them out?*

***ARIEL:*** Oh, yes. It's not difficult. It's a matter of repetition. It takes only about a week to create a new motor pattern. But you don't change the whole thing. Athletes are changing all the time anyway, and no athlete does the same thing all the time. With Al Oerter, we had to stretch his arm a little. We moved his axis of rotation farther from the body. It took two or three weeks, but he was able to adapt to it.

**SC:** *Is it possible for this to lead to a decrease in performance? For example, Rod Laver had less than classic strokes, but achieved tremendous success. Now, if you had put him through a motion-analysis study, you might have found a thousand little flaws. Yet, somehow, the sum of the parts resulted in fabulous success. Would it have been detrimental to tinker with his motion?*

***ARIEL:*** You have said a most important thing. It's not how a technique *looks*. It's what it accomplishes. For example, I could have a ballerina throw the shot and she would look beautiful, very smooth. But the shot would land ten feet from her. People will say a player has "classic" form or that he "looks terrible." But it doesn't matter.

We analyzed Laver. He had a good underspin, but he could not "bring the racket under the ball." We filmed him at 5,000 frames per second and found that the racket was at exactly 90°. It *looked* as though he was going under the ball, but the ball was already 20 feet ahead of him!

**SC:** *Isn't this also true of a lot of field*



*men in track?*

***ARIEL:*** Brian Oldfield looked terrible in the shot, but he could throw the ball 75 feet. Then he tried to look "good" and he threw only 68 feet. He came here about a month ago for analysis. He still looks "good", but he cannot produce the force. When he was throwing like an animal, he just did it better.

The same thing happened with Mac Wilkins. He decided to imitate Wolfgang Schmidt, who had just broken his record by two inches. For years, he tried to imitate the East German, because he thought it was a better technique. Well, it was a better technique—for the East German, not Mac Wilkins.

We had to convince him to throw the way he had been throwing. It was only two inches short of the world record. He had had a good technique. It took him

**"Ask a coach what he's going to do next week and how certain he is that it will work, and all he can do is give you a guess."**

months to get back to where he was before.

**SC:** *At least one coach has said that training can only produce a 5% gain in sprinting performance. Do you think that's true? Would it also be true of other sports?*

***ARIEL:*** 5% of what? If you can run the 100-meters in 10 seconds, 5% would give you the world record by far. 5% in sprinting is a tremendous improvement. Let's take a guy who can throw the discus 200 feet. 5% would be 10 feet, and that's a big improvement in the discus. Usually, when people say that, it sounds like "*Only* 5%." But from 10 seconds to 9.5 would make a sprinter the greatest athlete of all time.

Take Carl Lewis in the long jump. He has jumped 28'7". Add to that 5% and he would beat Bob Beamon's record. They said that no one would ever beat Beamon's jump. I said it, too. Now, if a guy were throwing the shot 50 feet and he could improve "only 5%," I might tell him to try playing the violin: He might be more successful.

So I think it's relative. In sprinting, you're right. Sprinting is a genetic event—you are a born sprinter. No one can take a guy 20-years-old who runs the 100 meters in 12 seconds and make him run 10.5 even. But if you have a 17-year-old who can run the 100-meters in 10.3, he may be a potential world record holder.

**SC:** *What percentage of most athletic performances is due to genetics and what percentage is due to coaching and training? Or is that quantifiable?*

***ARIEL:*** Well, it's quantifiable, but we just haven't done it yet, so I'm just guessing. In the explosive events, where you don't need much technique, like the long jump or the sprints, the technique is not the main thing—the genetic characteristics are. You cannot make a Volkswagen go like a Masserati; I don't care how you tune it. You first need the Masserati, and if it's untuned, you have to know how to tune it. That's where the coaching comes in.

Now take the discus-thrower: He should have the genetic characteristics, but technique plays a much greater role in his event. He has to turn and he has to time it—he has to use a certain technique to be successful. So in technique events—gymnastics, figure skating, throwing events, high jump (even more than long jump, which is basically a sprint event), pole vault—you've got to have the technique as well as the genetics.

Sometimes, the most talented person will not break the world record because he didn't have the right technique. And sometimes an inferior person—genetically, at least—can still achieve the world record because of superb technique.

Take a guy like Bob Beamon: Obviously, his 29'2½" jump was unbelievable. He never jumped over 28 feet before or after that.

Take Carl Lewis: He has jumped over 28 feet maybe 25 times, but he still hasn't jumped over 29 feet. So Lewis probably has the potential, but he needs to improve his technique. Maybe a little technique change will add the one or two percent he needs to break Beamon's record. I think he can do 29'5" or 29'6".

I don't think anyone will ever jump 30 feet, because you have to produce a level of force that would break the bones. So this is a species limitation. There is some species limitation, of course. No one will ever jump 9 feet in the high jump, for example. You would have to create a force that would break the bones.

**SC:** *You have said in the past— and this is a direct quote—that "You can provide coaches with the tools to make the best athletes." As you know, Scholastic Coach goes to coaches. So perhaps you could be a little more specific about that.*

***ARIEL:*** Many people have said, "Wait a minute. You are making a science out of sport. You are destroying sport, because everything is becoming computerized. Pretty soon athletes won't have to do anything, they'll just have to look at computers."

That's a false assumption. What I have said is that we have developed a very sophisticated tool for the coach. Let's say that three engineers graduate one, two, three in their class. They have to design a bridge. The first one doesn't have a pencil and paper. I don't care how smart he is. He's never going to figure out a design in his head.

The second engineer has a pencil and paper—thus, he can do everything that the computer can do. He can simulate, he can write formulas, he can draw the bridge. He can design the bridge, but it might take him a year or two. By that time, the materials might already be old and there would be a new technology.

Now, the third one has the computer and cameras and other sophisticated equipment. He can simulate, calculate, bring in historical factors, have cars going over the bridge before actually building it by using the computer to see if it will sink or fall. He has the tools to express his thinking in the fastest way. He's not a better student and he isn't smarter than the other guys. But he has the tools.

It's the same thing with NASA when they tried to land a spacecraft on the moon. They didn't throw out 1,000 space ships and hope that one would hit the moon. They sent out one and missed by 10 feet. From the earth to the moon, and they missed by 10 feet.

Now, what we're doing in athletics is trying to shoot at the moon with 10,000 spaceships. It's all random, because we

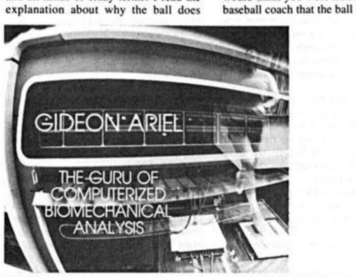


aren't using the right tools. We don't *have* the tools. What I am saying is that we should provide the coach with the sophisticated tools that will tell him how fast his athletes are running, how fast the arm moves, how fast the wrist moves.

In baseball, for example, there are all kinds of stories about how the ball leaves the hand—a knuckleball or a curveball and all kinds of crazy terms. I read the explanation about why the ball does what it does. But when you analyze it, the explanation has no resemblance to the truth. In fact, Sports Illustrated did a TV show on high-speed photography, and for the first time you could see that the ball leaves the hand way before you follow through with the hand.

Now, if you told a coach that you shouldn't follow through in baseball, he would think you were nuts. If I told the baseball coach that the ball left the hand when it was approximately parallel with the shoulder, he would tell me, "Come on, that's impossible. You stretch forward."

I would say, "Yes, you stretch forward, but that's the result of the movement." I don't say that you shouldn't stretch forward, but the ball left the hand way, way before that.




## PERSON TO PERSON

***Part 1 last month cut off the master of biomechanical analysis in the middle of an explanation of how scientific investigation is furnishing the coach with sophisticated tools on how fast his athletes are running, how fast the arm moves, how fast the wrist moves—and how high-speed photography has revealed the exaggerated role of "a good follow-through"! We pick up right from that point.***

**SC:** *These are things that coaches have been teaching for years—following through, keeping your eye on the ball, and that sort of thing. Now you are saying that these really have no effect on what is actually taking place.*

***ARIEL:*** It has no effect, and it is also misleading. In basketball, for example, how many kids do you see flipping their hand when they follow through on a jump shot? They practice this flip on their follow-through. But the fact remains that the ball leaves the hand at 45°, and all that flipping happens after the ball leaves. Now, how many youngsters never make the team because they are concentrating on the wrong thing?

**SC:** *What should they be concentrating on, and what should the coach be concentrating on?*

***ARIEL:*** Let's stick with basketball. If we know that the ball leaves the hand when the wrist is at 45° and the elbow is at 90° and the shoulder is at approximately 90° to the body, and we know that this is the most efficient way to shoot a basketball, you can film the youngster and spot the deficiency right away.

If the shoulder—the upper arm in relation to the body—is at 100°, the kid is creating a pattern that's going to affect his shooting ability in the future. He'll never be a good shooter. He's in a mechanically disadvantageous situation.

Take a weightlifter. His key is to try to stretch his leg all the way for the clean, and wait for the weight to come as high as possible before he goes under the weight. Well, the Russians try to go under the weight before it reaches its maximum height. So why did we let our youngsters do it the wrong way for so long?

**SC:** *Our hammer-throwers tell us that the same thing is true of their event.*

***ARIEL:*** Absolutely. Do you know that our hammer-throw record doesn't even qualify for the Olympics? It is the only event for which we cannot qualify. We have the strongest and fastest people on earth, and yet we have a national hammer-throw record that is surpassed by Russian schoolboys. How come?

It isn't because the Russians are superhuman. They're simply using an entirely different technique. We're still throwing the way Hal Connolly used to throw. True, Connolly set a world record. But, technically, it's no longer the best way to throw. Technical changes have revolutionized the event.

We have just a few hundred hammer throwers and they are all trying to imitate one another—the blind leading the blind. Take a guy like Ed Burke, who held the American record for 10 years before he quit. We discussed it a few months ago, and he decided that, at age 45, he was going to resume throwing. Just two weeks ago, he threw the ball 241 feet—the second best throw in the U.S.—and 6 feet farther than the record he held for 10 years.

A change in technique accounted for his progress at age 45. If he had known this technique 10 years ago, he probably would have thrown 260 or 270 feet. We now know the right way to throw the hammer, but we don't do it because of tradition. It's very difficult to change people's minds.

**SC:** *Let's say a coach or athletic administrator were interested in adapting some of your findings or even instituting a whole analysis program. The equipment that you have been talking about seems complex and expensive. Where would the administrator start?*

***ARIEL:*** Computers are getting cheaper and cheaper. In fact, we are now designing systems that will run on microcomputers and be able to do what the multimillion dollar computers did in the past. Every athletic program is going to have this kind of system.

But you are right: Coaches will have a problem with the technology. Meanwhile, they can use high-speed cinematography. It's certainly better than guessing. Coaches should also focus more on the sciences. They should have scientific knowledge, and I think the educational system should provide it.



**SC:** *Do you envision a day when the coach will be able to buy a microcomputer with the appropriate software to do the analysis?*

***ARIEL:*** We are working right now on developing the software that took us 10-12 years to develop on the very expensive computers. It can run right now on the inexpensive computers. You can use it in conjunction with a regular home TV and video system. I think it will be available within the next six months to a year. That includes formation analysis and regular analysis. After all, Pac-Man is not going to keep people interested for too much longer!

**SC:** *If a coach or athletic administrator wanted to get involved in this now, are there any basic premises or research results that he can adapt to his program?*

***ARIEL:*** If he is in California, he can come to our research center and work something out with us. We've worked with a lot of students on PhD dissertations. On the east coast, they can visit our center in Emerson, Mass. Obviously, though, we cannot accommodate everyone. But the technology is available, and we would be glad to work with any interested coaches.

**SC:** *In what sports would these techniques be the most useful? It seems that you have been working largely with individualized sports—tennis, golf, track, and so on. Is it possible to adapt these analysis techniques to team sports?*

***ARIEL:*** I mentioned the formation analysis that we use with the women's volleyball team. I don't see how any team sport can be played very effectively without formation analysis. It also enables you to analyze the individuals on the team for deficiencies or specific qualities.

For example, it would enable a coach to screen for a player who can run to the right at a certain speed or catch a ball within a certain reaction time. Even though that player may be the 25th rated man on the squad, he might be the one the coach wants. I think this is the way of the future. So there is no reason why our methods can't be used in team sports, too. We're using them all the time with the women's volleyball team.

**SC:** *You have said that some sports, such as basketball, soccer, and hockey, don't promote adequate strength and flexibility. Could you explain that?*

***ARIEL:*** Just playing these team sports isn't enough. All of them could use more resistive training. But it should be functional resistive training, not just lifting free weights, which is not likely to have much carryover effect. You have to have a specialized program for the specific sport, so that the physiology of the body can anticipate certain stresses. This can help prevent injury. Injury often occurs not because of the situation a person gets into but because of a weakness of the muscle at a certain angle.

**SC:** *Is enough information available on the specific muscle groups to focus on in each sport?*

***ARIEL:*** I believe there is, and we are doing research in this area all the time. Again, though, we are more involved in individual sports. So we are finding out which programs will benefit the long jumper, and it's obviously not the same as for the shot-putter.

With the volleyball women, we want a high vertical jump, so we're using sophisticated computerized machines to create it. We've been able to increase their vertical jumps three to four inches.

In football, we develop different kinds of muscles, and of course the quarterback would want to train differently from the linebackers or the receivers. In basketball, since we're dealing with very tall people with very long bones, we have a lot of special injuries.

**SC:** *To change the subject. In track and field, performance curves seem to be flattening out some. The increments of improvement seem to be much smaller than they were 10 to 20 years ago. You have said that no one can jump over 30 feet because it would break the bones. So how much improvement can we expect in the next 10 years or so?*

***ARIEL:*** We enjoy playing this kind of game, although it can be no more than opinion. We think that in the 100-meters, the limitation factor is about 9.5, in the long jump it's probably about 29'6", in the high jump it's probably 9', in the shot put it's probably 80 to 82', in the javelin (aerodynamics permitting) it will probably get to 340'. This is what we try to simulate on the computer, but it is not necessarily accurate.

**SC:** *Do you think we're likely to see another anachronistic performance like Bob Beamon's jump?*

***ARIEL:*** As I said before, I think Carl Lewis has a chance to break Beamon's record—that is, if he isn't psychologically destroyed by the media.

**SC:** *In what events do you think the records are very soft and could be shattered?*

***ARIEL:*** All of the records in the women's events are going to be improved by a great percentage. That's because women never had the tradition or the time to train as vigorously as men. Now that they are getting into that, with heavy weights and heavy training schedules, especially in the endurance events, I think that they will get closer and closer to the men.

In the power events, because of hormonal differences, women are not as strong as men. But here also you will see a tremendous improvement, as it wasn't until recently that the women began training like the men in these events.

Our women's volleyball team could beat almost any men's team in the world. The players are very strong. They can squat-lift 500 pounds. Each of them is close to the American record in many events—sprinting and long distance. Almost all of them are running the mile in close to five minutes—some of them under five minutes. That shows what eight hours a day of training can do!

The men will have to improve more gradually, because they are already close to the limit in many events. But there still is a long way to go in the power events, especially in track and field—the discus, the javelin, the hammer, things like that.

**SC:** *The strength events have been particularly prone to drug abuse—steroids and so forth. Do you know exactly how bad the situation is, and do drugs actually enhance performance?*

***ARIEL:*** Since I am on the Olympic Committee, I asked one of the physicians whether he knew the percentage of drug use among our power athletes. *The answer was 100%!*

It has become a pharmaceutical Olympics. Athletes are using anabolic steroids to improve their strength. The thing is: How do you beat the system and go undetected? The latest fad is a pituitary gland hormone called a "growth hormone" that causes unusual growth.

I don't know what will happen in the future. But we all hear about the Russians and the East Germans using these drugs, but the Americans use them just as much.

The only solution is science. We are experimenting on our new computerized machines with electrical stimulation. Maybe one day there will be a rule against that, too, but at least you don't put drugs into the body.

We attach electrodes to the body and stimulate only 15 to 20 volts. We try to stimulate the muscles at the same time the athlete trains on a machine and generates certain speeds in the limbs (arms and legs).

**SC:** *What kind of results have you been getting? How do the results compare with steroids?*

***ARIEL:*** We are getting better results than with steroids. How do we know? Because we also have a group using steroids—we're not giving them the steroids, we just know they are using them and we don't discuss it.

Now the question, of course is: What if you use the electrical stimulation and the computerized machine and also the steroids? Well, we also have a group doing that. And we find even more improvement.

But the improvement is not significant. Let's say that you could lift 100 more pounds using steroids and 105 more with just electrical stimulation. Using both, the improvement may be 120 pounds—or just a few pounds more than with just electrical stimulation. Maybe at this point, the athletes will realize that it's not worth taking the chance for such a minute gai...

Basically, the way a muscle contracts is muscle to muscle and the central nervous system recruitment of motor units. The more you can recruit in a short period of time and the stronger the muscle is, the greater force you can create. Now, if you can create the same thing without using drugs, maybe there will no longer be any reason for drugs.

What anabolic steroids do is increase muscle-to-muscle strength, but they don't improve the efficiency of the central nervous system. When you use the computerized exercise machine with certain programmable methods of training, you don't improve the muscle to muscle as much, but you do improve the central nervous system's control of the muscle.

Personally, I believe that is more important, because the strongest man in the world is not necessarily the person who can throw the shot the farthest. Brian Oldfield was not that strong a man in comparison to other throwers, but he could throw the farthest because his central nervous system was tuned better.

It's like a car: It's not how large the pistons are, but how the distributor is working or whether the injection timing is going right. So, to discourage drug use, we'll have to show the athletes how to apply science to improve their performance.

That's where I believe biomechanics will contribute most to sport. If it doesn't, we may wind up with a bunch of athletes who are inhuman—thanks to their diet of growth hormones and steroids. They'll be "chemical robots."

**SC:** *So you're saying that the focus in biomechanics will be on the nervous system rather than the muscle groups?*

***ARIEL:*** I believe that's the trend, and that it is the only trend that can save sports. We have to improve techniques and improve the methods by which we're doing it and teach the central nervous system to get the most out of the muscles rather than to try to build big muscles with chemicals.. What steroids are doing is just building muscle tissue.

**SC:** *How do you do this? How do you train the nervous system?*

***ARIEL:*** Let's say that I want to create a certain pattern between the legs and the arms in throwing the shot. To do that, I program my exercise machine in a way that will maximize the throwing efficiency. We know through biomechanics what that program is. I put the athlete on the machine, and every time he doesn't do it right, a curve comes on the screen and shows him what the optimal performance would be and where he is at that point. So he is working toward a goal. When he gets close to that, we go outside and try to create the carryover from the exercise, which apparently works very well here.

With the women's volleyball team, we put them under the bar and let the bar accelerate at the same rate that will produce a certain height. If they cannot push the bar fast enough, it is indicated right away on the screen. In this way, we are motivating the central nervous system to fire the proper points with the proper amount of force.

I call this neuromuscular training, versus just putting weight on the shoulder and just going down and up. This bears no resemblance to the jump you want to create.

**SC:** *Is this a motivational type of training, in which the athlete gets a direct feedback?*

***ARIEL:*** That is one aspect of it. Another aspect is for the muscle to recruit in a certain pattern, and the pattern is extremely important.

**SC:** *Can you predict what we may expect from the U.S. Olympic team as a direct result of your methods?*

***ARIEL:*** Well, I don't want to take credit for anything. But I predict that our women's volleyball team will win the gold medal, because they have the system and they have trained here eight hours a day. They know where they are going and where they are going to be. I can tell you at three o'clock in the morning or nine o'clock in the morning where they are going to be. We have worked with the girls systematically every day. I can't really take the credit for that. It's really the coach, Arie Selinger, who implemented that.

Now, we should also win more gold medals because of genetic freaks like Carl Lewis, if he doesn't hurt himself. But that is completely independent of our system. He is just a genetic freak.

We could win many more medals if we had an organized system. If I were to phone *anyone* on the Olympic Committee right now and ask where the fencing team is, he would say, "Are you crazy? How should I know?" An answer like that tells me that the fencing team is not going to do very well. I'm not saying that we should work out like the East Germans—by no means. We should drop sports before we start emulating the East Germans. But I'll tell you what: The East Germans have a good system, and they know exactly what each athlete is doing and where he is. They are doing it *their* way, which is the Communist way.

We should use our system—the capitalistic system of free enterprise—to support our team, not just by sending a check to the Olympic Committee, but clearly specifying the purpose for which the check should be used. If I send a million dollars, I want to know where every cent goes—to postage, to salaries, to the retirement funds, or to the athletes.

To my knowledge, a very small percentage of each dollar is going to the athletes. And I know because I am on the Olympic Committee.

**SC:** *What is your exact title on the Olympic Committee?*

***ARIEL:*** I am the chairman of biomechanics and computer science for the Olympic Committee. At least until your article comes out!

**SC:** *Why? Are you planning to retire?*

***ARIEL:*** No, I was thinking they might kick me out (laugh). No, no. But I'm the guy who criticizes the system all the time. I'm on the side of the athletes. I want to see 95 cents of every dollar go to the athletes. I helped with a lot of contributions to the Olympic Committee—computers and so on—and some shoe research that I did produced a $2 million contribution. I'd like to see this money put into the sports medicine program.

**SC:** *Well, has it?*



***ARIEL:*** The sports medicine program has seen some of that money, but it has had nothing to do with the success of our athletes. It's funny, every time I visit the center in Colorado Springs, I ask how many athletes have been there. Last summer it was fantastic: about 3,000 athletes were training. I asked how many had a chance to win an Olympic medal. *The answere was none!*

I don't get it. We have a fantastic dental program. We have a fantastic vision program. We are even doing research on biting. How essential is all this to our Olympic effort? We appear to be missing the point. I would think that our Olympic training center should be concentrating on producing potential gold medalists.

**SC:** *Earlier in our conversation, you mentioned something about computerized inventions.*

***ARIEL:*** We've patented two of them. The first is a computerized running shoe that records the number of hits you make on the ground. At the end of a week, you can put the information into your little Radio Shack computer and it will tell you how many miles you went. It's a great little motivator.

But our biggest invention is a computerized rehabilitation and exercise machine that we think will revolutionize the way people train and rehabilitate from injury. The thing we have added is computer-control. It has an artificial intelligence that adapts the machine to the exerciser as opposed to the exerciser adapting to the machine.

**SC:** *When will this thinking machine be unloosed on the public?*

***ARIEL:*** It is already available. The first 50 machines were ordered by a hotel chain. Executives traveling around the world can bring their own little computer diskette or cassette with them. Say they're staying one night in San Francisco. They can put their diskette into the machine and the machine will tell them what exercises to do.

Since the machine will know where the executive came from the day before, it can also allow for jet lag! So the executive can carry his own fitness pack around the world.

**SC:** *Do you see this as the exercise trend of the future?*

***ARIEL:*** In my opinion, all exercise machines will be computerized within five years. Since the human body is the most intelligent computer ever created, there is no reason to train on dumb machines.

The trend will also include the motivational aspects. For instance, we now have a deal with Atari where we'll have young children exercising on a machine with a motivational feedback device. Like, if the kid broke a record or did very well, Cinderella would appear for some gesture or the computer would say, "Shame on you, you just gained five pounds."

Motivation is essential in all exercise.

**SC:** *Will the computerized exercise machine also aid in the rehabilitation of injuries?*

***ARIEL:*** No question about it. We've had great success in this area. The machine can sense your pain and release the pressure at certain angles.

Take knee rehabilitation. At a certain angle, you might be weak and at a certain angle you might be strong. So the computer will enhance the resistance where you are strong and diminish the resistance where you are weak.

We are going to look for injuries that occur under certain conditions. Injuries don't just happen. Situations in the body allow them to happen. If you can identify the danger before it happens, you can put the athlete on a program that will avert the injury.

This is where computers will come in very strongly: as a documentation and a warning signal that something is going bad.