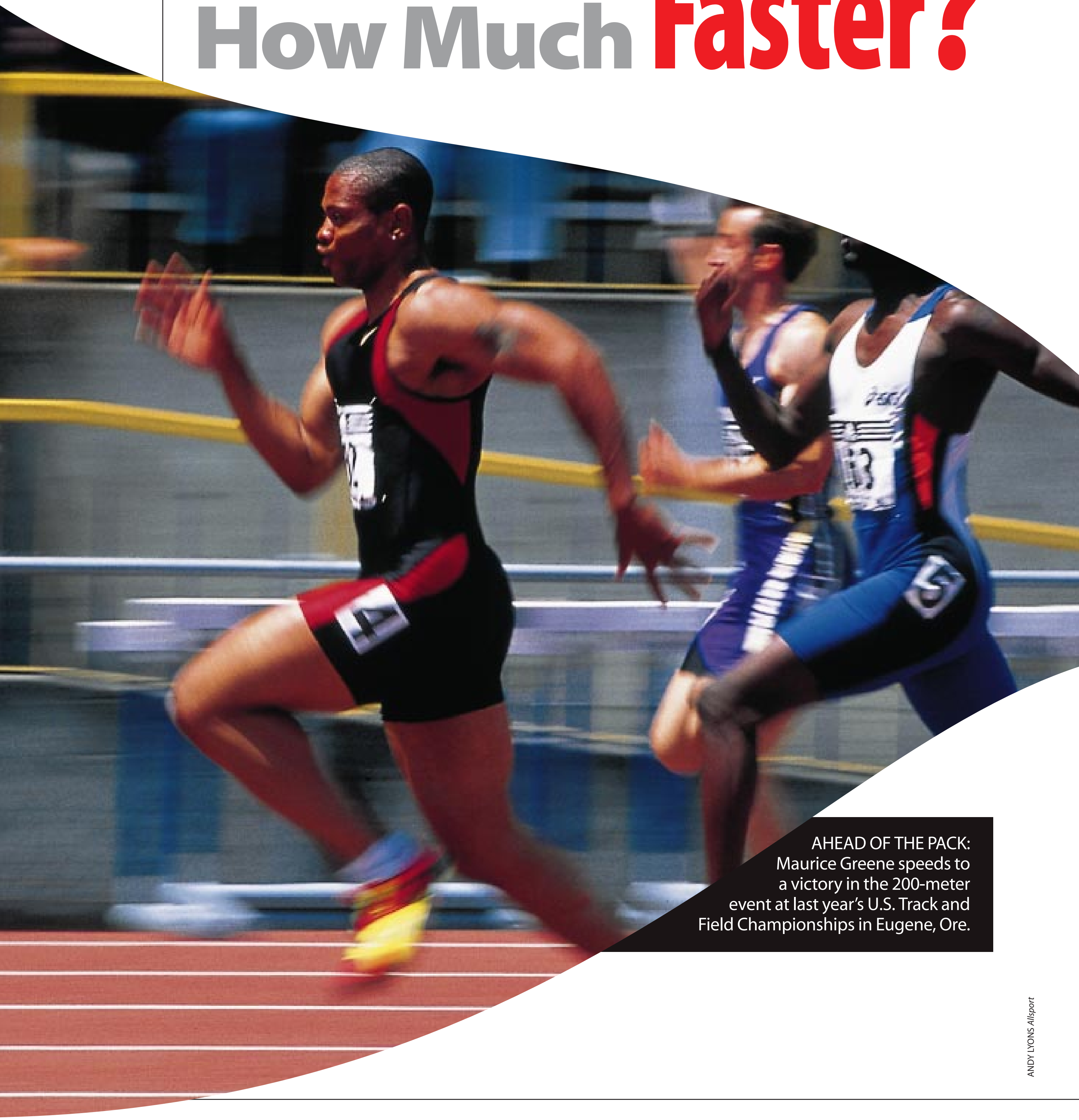
How Much Higher? How Much Faster?



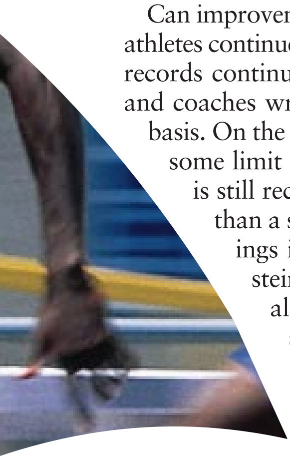
AHEAD OF THE PACK: Maurice Greene speeds to a victory in the 200-meter event at last year's U.S. Track and Field Championships in Eugene, Ore.

ANDY LYONS *Allsport*

Limits to human performance are not yet in sight

by Bruce Schechter

Last year, during a rare stationary moment, runner Maurice Greene paused to reflect on world records. "You don't try to break them," he told a reporter. "You prepare the best you can, and they will come." A few weeks later in Athens, Greene's faith and preparation were rewarded when he set a new world record for the 100-meter dash, completing 45 precise and powerful strides in exactly 9.79 seconds. Greene had bested the previous record by five hundredths of a second—an eye blink, but also the single largest reduction in the past 30 years in this event, the ultimate sprint in track and field.



Can improvements in this and other sports go on? If athletes continue to refine their preparation, will world records continue to be the reward? Sports scientists and coaches wrestle with these questions on a daily basis. On the one hand, it is clear that there must be some limit to human performance: nobody who is still recognizably human will ever run faster than a speeding locomotive or leap tall buildings in a single bound. But so far no Einstein of the athletic universe has come along to set down the limits, although some have tried.

Ever since the early years of the 20th century, when the International Amateur Athletic Federation began keeping records, there has been a steady improvement in how fast athletes run, how high they jump and how far they are able to hurl massive objects of every description, themselves included, through space. For the so-called power events—those that, like the 100-meter sprint and the long jump, require a relatively brief, explosive release of energy—the times and distances have improved about 10 to 20 percent. In the endurance events the results have been even more dramatic. At the 1908 Olympics in London, John Hayes of the U.S. team ran a marathon in a time of 2:55:18. Last year Morocco's Khalid Khannouchi set a new world record of 2:05:42, almost 30 percent faster.

No one theory can explain such improvements in performance, but perhaps the most important factor has been genetics. "The athlete must choose his parents very carefully," says Jesus Dapena, a sports scientist at Indiana University, invoking an oft-cited adage. Over the past century the composition of the human gene pool has not changed appreciably; evolution operates on a far longer timescale. But with the increasing global participation in athletics—and ever greater rewards to tempt athletes—it is more likely that individuals possessing the unique complement of genes for athletic performance can be identified early. "Was there someone like [sprinter] Michael Johnson in the 1920s?" Dapena asks. "I'm sure there was, but he was probably a carpenter in the mountains."

RUNNING ON GENETICS

Identifying genetically talented individuals is only the first step in creating world-class athletes. Michael Yessis, an emeritus professor of sports science at California State University at Fullerton, president of Sports Training in Escondido, Calif., as well as a consultant to many Olympic and professional teams, maintains that "genetics only determines about one third of an athlete's capabilities. But with the right training we can go much further with that one third than we've been going." Yessis believes that U.S. runners, despite their impressive achievements, are "running on their genetics." By applying more scientific methods, "they're going to go much faster." These methods include strength training that duplicates what they are doing in their running events as well as plyometrics, a technique pioneered in the former Soviet Union.

Whereas most exercises are designed to build up an athlete's strength or endurance, plyometrics focuses on increasing an athlete's power—that is, the rate at which she can expend energy. When a sprinter runs, Yessis explains, her foot stays in contact with the ground for only a little under a tenth of a second, half of which is devoted to landing and the other half to pushing off. Plyometric exercises help athletes make the best use of this brief interval.

Nutrition is another area that sports trainers have failed to address adequately. "Many athletes are not getting the best nutrition, even through supplements," Yessis insists. Each activity has its own particular nutritional needs. Few coaches, for instance, understand how deficiencies in trace minerals can lead to hamstring injuries.

Focused training will also play a role in enabling records to be broken. "If we would apply the Russian methods of training to some of the outstanding runners we have in this country," Yessis asserts, "they would be breaking records left and right." He will not predict by how much, however: "Exactly what the

LIFTING FOR SPEED: Olympic runner Ato Boldon takes advantage of training insights about the importance of upper-body strength for runners.

AL BELLO *Allsport*

limits are it's hard to say. They're not going to be humongous, but there will be increases even if only by hundredths of a second. They will continue, as long as our methods continue to improve."

One of the most important new methodologies to be applied to sports training over the past several decades is known as biomechanics, the study of the body in motion. A biomechanic films an athlete in action and then digitizes her performance, recording the motion of every joint and limb in three dimensions. By applying Newton's laws to these motions, a biomechanic can determine what the athlete is doing to help her performance and what is holding her back. "We can say that this athlete's run is not fast enough; this one is not using his arms strongly enough during takeoff," says Dapena, who uses these methods to help high jumpers. Generally, the changes that a biomechanic can make in athletic performance are small. "We can't dismantle an athlete's technique," he notes. "We are just putting the icing on the cake."

To date, biomechanics has helped athletes only to fine-tune their techniques. Revolutionary ideas still come from the athletes themselves. "Normally athletes, by trial and error, come up with some crazy thing," Dapena explains. For example, during the 1968 Olympics in Mexico City, a relatively unknown high jumper named Dick Fosbury won the gold by going over the bar backward, in complete contradiction of all the received high-jumping wisdom, a move instantly dubbed the Fosbury flop.

The story of Fosbury's discovery illustrates the role of serendipity in advancing biomechanics. When Fosbury was growing up in Portland, Ore., he learned to jump over the high bar using the scissors kick—hopping over the bar with his rear end down—that was taught to children. In high school, his coach tried to convert him to the "correct" international style, which involved straddling the bar face down, in a forward roll. Fosbury, a gangly adolescent, found the technique difficult to master, so his coach allowed him to use the childish scissors in one meet. His first jump was an unimpressive 5 feet 4 inches. The problem, as he saw it, was that his rear kept knocking the bar. So he modified his approach to what he called "kind of a lazy scissors." As the bar moved higher, Fosbury found that he was beginning to go over flat on his back. "I'm upside down from everybody else," he recalled. "I go over at six feet, and nobody knows what the heck I'm doing."

CLEARING THE HIGHER BAR

Fosbury himself did not know what he was doing. That understanding took the later analysis of biomechanics specialists who put their minds to comprehending something that was too complex and unorthodox to have ever been invented through their own mathematical simulations. Even before Fosbury's strange jump, scientists had long known that when a high jumper leaps, his center of mass—the point at which the mass of a body appears to be concentrated—rises to a height determined by the energy generated by his muscles. Most of the time, when standing, sitting or running, our centers of mass are more or less within our bodies, so if we want our bodies to clear a bar, our center of mass must clear the bar as well.

Fosbury accidentally discovered that this is not always true: when the human body is arched backward, the center of mass can be made to move to just outside the back. In this position, a jumper's body can clear the bar while his center of mass travels beneath it. Thus, for the same energy expenditure, an athlete doing the Fosbury flop can clear a higher bar.

The inspiration provided by Fosbury also required another element that lies behind many improvements in athletic performance: an innovation in athletic equipment. In Fosbury's case, it was an improvement in the cushions that jumpers land on. Traditionally, high jumpers would land in pits filled with sawdust; flopping over the bar and landing backward in the pit would have been a recipe for injury. But by the time Fosbury was in high school, sawdust pits had been supplanted by large, soft foam cushions, ideal for flopping.

Other sports have benefited from better equipment. Speed skating was recently revolutionized when the Dutch introduced the "clap skate," a skate with a hinge that keeps the blade on the ice longer, providing more speed. Skaters were slow to adopt this innovation, but when they did, the results revolutionized the sport, shaving seconds off previous records.

Clap skates are not the only innovation: pole vaulters have taken advantage of springier, fiberglass poles. To a lesser extent, runners have been helped by better shoes and special elastic tracks that do not absorb as much energy as previous surfaces did. The springy surface returns energy to a runner's stride that would otherwise be consumed by an ordinary track. Still, the improvements possible through these technologies are not as critical as basic athletic ability. Dapena puts the importance of equipment in perspective when he says, "If you ask, 'Would you like to have Michael Johnson's body or his shoes?' I'll take the body."

But materials do make a big difference. Gideon B. Ariel, one of the fathers of biomechanics and the founder of the Olympic Training Center in Colorado Springs, compared the performance of Jesse Owens with that of Carl Lewis. In 1936 Owens ran the 100-meter event in 10.2 seconds, much slower than the 9.86 Lewis achieved in 1991. "Of course, what Jesse Owens was running on was not the same surface that Carl Lewis ran on," Ariel explains. Owens ran on a clay track that absorbed more energy than the modern tracks on which Lewis set his record. "Imagine you're running on the beach in very deep sand. Your joints might be very fast, but you don't make the progress. If you run the same on the road, you will be faster. You're really not faster, you are more efficient—you don't lose as much energy." Ariel was able to analyze films of Owens running and determine that his joints were moving as fast as Lewis's. He determined that had Owens and Lewis run on the same track the results would not have been nearly as lopsided, although Lewis would probably still have run faster.

PUSHING THE LIMITS

Given the best training and the best equipment, how fast can a Michael Johnson, Maurice Greene or another genetically gifted athlete hope to run? Ariel addressed this question in 1976. He concentrated on power sports such as sprinting and jumping, because, he reasoned, these are most easily analyzed using the tools of Newtonian mechanics. "In the power events, you have anatomical restrictions like the strength of the bones and the strength of the muscles. At some point, at a certain level of force, the human body will not be able to sustain it, and a bone will crack or a tendon will come off," Ariel says. "We use data from various research institutions that show the strength of bones, the strength of connective tissues and stuff like that." To be on the safe side, Ariel decided to increase these estimates by 20 percent and then calculated the breaking point. "It is straightforward mathematics to do this calculation," he says. "I think we are pretty accurate, and the proof is that since 1976 nobody has done better than we predicted, because the human body didn't change." Specifically, Ariel predicted that no one would ever run 100 meters in less than 9.6 seconds, jump higher than 8 feet 5 inches or throw a shot farther than 75 feet 10.25 inches, and so far no person has succeeded in beating those estimates.

The limits in endurance events, which depend more on physiology than mechanics, are far harder to calculate. The reason is that to figure physiological limits requires a deep understanding of metabolism at a cellular level, something that cannot be captured by a video camera. "I'm not sure we are close to the limit," Ariel says. "Somebody might come who will run a sub-four-minute mile for 10 miles, and that would break a world record by an unbelievable amount. If you can do it for one mile, maybe you can build a training routine where you can do it for two, three or four miles."

NOT OVER YET: DECLINES IN TIMES CONTINUE FOR THE MILE

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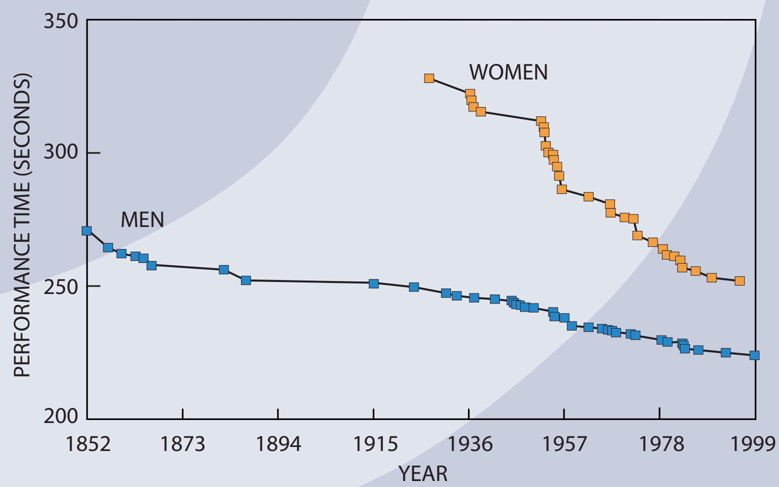

In the end, most people who have attempted to examine human performance are eventually humbled by the resourcefulness of athletes and the powers of the human body. "Once you study athletics, you learn that it's a vexingly complex issue," says John S. Raglin, a sports psychologist at Indiana University. "Core performance is not a simple or mundane thing of higher, faster, longer. So many variables enter into the equation, and our understanding in many cases is very, very fundamental. We've got a long way to go." For the foreseeable future, records will still be made to be broken.

BRUCE SCHECHTER is a freelancer based in Brooklyn, N.Y., and the author of *My Brain Is Open: The Mathematical Journeys of Paul Erdös* (Touchstone Books, 2000).

FURTHER INFORMATION

ATHLETICS 2000. Edited by Peter Matthews. SportsBooks, Worcester, England, 2000.

JENNIFER JOHANSEN; SOURCE: ROB WHITTINGHAM *Association of Track and Field Statisticians*