ON SPORTS / By Sam Walker

The Lactic Acid Test

New Research on Sports Stars Reveals Biology Is Destiny; Mr. Phelps's Flexible Feet

Lance Armstrong, *record-holder—as the most probed and studied athlete.*

Alessandro Trovati/AP

WHEN LANCE ARMSTRONG pops off his bike Sunday after completing the final stage of the Tour de France, he'll have a slew of records you already know about and one you probably don't: He's the most poked, prodded, calibrated and medically researched athlete in sports history. Scientists know that his heart is at least 20% larger than a normal person's, he produces one-third less lactic acid than do other top cyclists and delivers oxygen to his legs at a rate higher than all but maybe 100 of his fellow earthlings.

While Mr. Armstrong has a comfortable lead in this department, there's a growing pack behind him. From Sydney to San Francisco, an army of people in lab coats is slowly painting a clearer portrait of what separates the world's most dominant athletes from the merely great ones. And given all the money at stake in sports, the research continues to spread beyond universities to Olympic development centers, private trainers and even shoe companies.

Most of the research done on elite athletes is closely guarded, either for competitive reasons or simple medical privacy. But some of it is beginning to emerge in scientific journals and from trainers who want to compare notes. At a time when athletes are often better known for their steroids infractions, exorbitant incomes and increasingly petulant behavior, these raw measurements offer a new (and blissfully impersonal) way to marvel at them.

So what do we know?

While genetics is only one part of the formula for greatness, scientists agree that in order to be truly dominant, an athlete has to be—to some degree—a genetic freak. Olympic champion swimmer Michael Phelps, for instance, propels himself through the water with a pair of feet that operate like flippers. Not only are they large (size 14), they're so outrageously flexible that the swimmer can lie down flat on his back, legs outstretched and, while doing so, touch the tips of his toes to the floor. "He's not your average

Please Turn to Page W6

SPORTS

On Sports / By Sam Walker

The Lactic Acid Test

Continued From Page W1

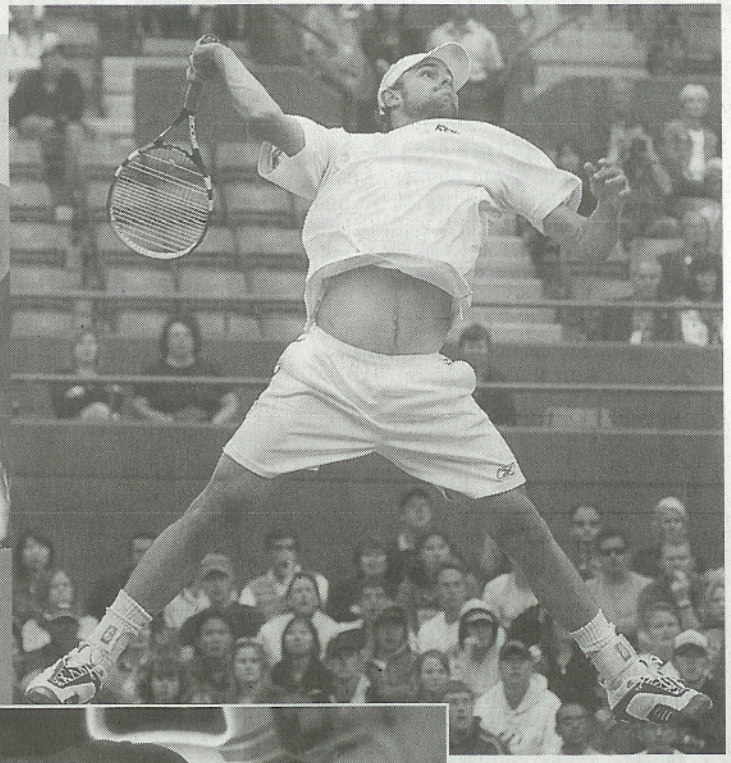
bear," says his coach, Bob Bowman.

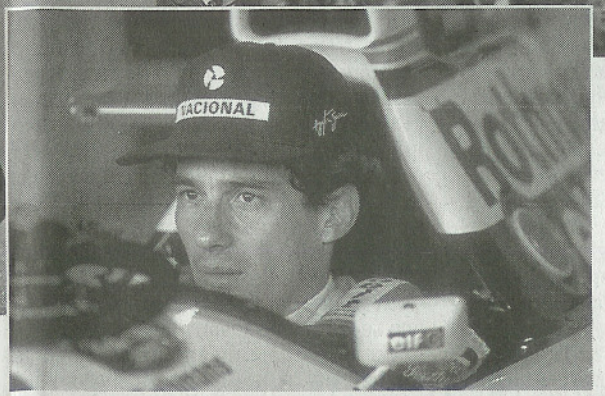
Andy Roddick, owner of the fastest recorded tennis serve (155 miles an hour), owes much of his power to the unusual flexibility of his ribs and spine. Bob Prichard, president of Somax Sports, a California clinic that works with top athletes, says Mr. Roddick's ability to arch his back increases the effective external rotation of his arm to 130 degrees, 44% better than the average tennis pro. While Mr. Roddick's legs help him generate power, they're not exceptional: Even though he's 6-foot-2, says his coach, Brad Gilbert, "the guy can't dunk a basketball."

Mia Hamm, the now-retired soccer star, may owe some of her famous stamina to a genetic anomaly. In a test run by the Gatorade Sports Science Institute, she produced less than one liter of sweat an hour, 25% to 50% less than normal. Bob Murray, the institute's director, says this trait allows Ms. Hamm to perform for longer stretches without having to stop to guzzle fluids.

Piling Up the Data

In some cases, new knowledge about elite athletes doesn't come from elaborate testing, but the simple accumulation of data over time. In the six years since the National Basketball Association began keeping records at its annual camp for likely draft picks, the league has measured the skills of more than 300 players. With a healthy data sample, NBA trainers now know that a typical point guard should be able to finish the league's standard sprint drill, which involves running from a standing start from one baseline to the farthest free throw line (75.2 feet), in about 3.3 seconds.





(clockwise from left) Armando Franca/AP; Dave Caulkin/AP; Pascal Rondeau/Allsport/Getty

ers he's tested, the lowest score belongs to the late Formula One champion Ayrton Senna, whose average reaction time was closer to 240 milliseconds, or 20% better

Outstanding specimens *(clockwise*

Texas, which

Nonetheless, it may be a long time before scientists understand any one athlete better than Lance Armstrong. The most extensive study of the defending Tour de France champ was performed in five sessions over seven years by the Human Performance Laboratory at the University of took Mr. Armstrong's

In some cases, new knowledge about elite athletes doesn't come from elaborate testing, but the simple accumulation of data over time. In the six years since the National Basketball Association began keeping records at its annual camp for likely draft picks, the league has measured the skills of more than 300 players. With a healthy data sample, NBA trainers now know that a typical point guard should be able to finish the league's standard sprint drill, which involves running from a standing start from one baseline to the farthest free throw line (75.2 feet), in about 3.3 seconds.

So when Tony Parker of the San Antonio Spurs turned in a time of 2.98 during a closed practice session, the coaches on hand knew they were witnessing greatness—once they made sure their stopwatches weren't broken. "We made him run it again," says Spurs' strength and conditioning coach Mike Brungardt.

One of the longest continuous studies ever done on top athletes involves measuring the reaction times of elite race-car drivers. Over two decades, Jacques Dallaire, founder of a North Carolina company called Human Performance International, has tested the "decision speed" of nearly 600 elite drivers using a relatively simple machine with lights that flash in different sequences.

His findings show that an average human takes about 300 milliseconds to make a reactive decision, while an elite driver (someone like Jeff Gordon or Danica Patrick) can do it in 270 milliseconds. While this 11% difference may not seem significant, Mr. Dallaire says, it's a huge advantage at high speeds. Of all the drivers he's tested, the lowest score belongs to the late Formula One champion Ayrton Senna, whose average reaction time was closer to 240 milliseconds, or 20% better than normal. At top race speeds, Mr. Dallaire says, that's the spatial equivalent of about five car lengths.

A major goal of this research is to distinguish the physical characteristics that can be improved by rigorous training from those an athlete has to be born with. On the far end of the spectrum, scientists are already doing this: Researchers at the U.S. Olympic Training Center have developed a series of four tests for things like "maximal oxygen uptake" and "power output at lactate threshold" that can determine whether someone has the natural ability to be a top endurance athlete.

Arguably, the more precise these tests become, the more tempted overzealous parents and trainers will be to use them to push kids toward sports they are predisposed to succeed at, rather than sports they enjoy. It's also true that to some fans, learning about an athlete's genetic freakishness only diminishes their appreciation for the hours of grueling work that are required to exploit all that potential.

Lately scientists have been chipping away at some of the smaller gradations of performance. Last year, for instance, researchers at Duke University and New York's Hospital for Special Surgery published a study on linemen about to enter the National Football League. Due to the constant pounding these athletes take, nearly a third of them had developed a condition called HEPS (that's hyperconcavity of the endplates of the vertebrae with expansion of the space between disks). As ugly as that sounds, the data showed something surprising: Players who had developed HEPS were also less likely to report having lower back pain. In other words, the condition appears to be *desirable*.

(clockwise from left) Armando Franca/AP; L

Outstanding specimens *(clockwise from left): U.S. Women's Soccer team star player* **Mia Hamm;** *2005 Wimbledon men's finalist* **Andy Roddick;** *Grand Prix Hall of Fame driver* **Ayrton Senna**

Nonetheless, it may be a long time before scientists understand any one athlete better than Lance Armstrong. The most extensive study of the defending Tour de France champ was performed in five sessions over seven years by the Human Performance Laboratory at the University of Texas, which took Mr. Armstrong's weight and body-fat measurements and analyzed his blood and breathing as he pedaled a stationary bike.

Improved Mechanics

While these tests weren't unique, the study seems to be the first opportunity scientists have had to examine one of the world's greatest athletes repeatedly during his prime years of performance. During the duration of the study (despite being diagnosed and treated for cancer), Mr. Armstrong managed to improve his mechanics and fitness to the point that his pedaling power, relative to his body weight, rose by 18%.

What makes Mr. Armstrong so exceptional, says the study's author, Ed Coyle, isn't one physical factor that's leagues beyond anyone else, but the fact that he has several extraordinary traits, each of which exists in only a few hundred humans. When you add up the odds of all these things being consolidated in one body, Dr. Coyle says, "He's probably one in a billion."