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Racer blades: Do high-tech artificial limbs give athletes an edge?

By Scientific American, adapted by Newsela staff
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Germany's Markus Rehm makes a world record jump of 7.14 meters in the men's long jump final during the 2012 Paralympics in London, England, August 31, 2012. Photo: AP Photo/Matt Dunham

Paralympic long jump champion Markus Rehm hoped to compete in the 2016 Rio de Janeiro Olympics. Rehm uses a blade prosthesis, a high-tech artificial limb designed to replace legs and feet that were removed below the knee. He wouldn't have been the first athlete to use blade prostheses at the international games. Four years ago, Oscar Pistorius made history as the first amputee Olympic athlete to do just that. But Rehm was disqualified in July when he failed to prove that his carbon-fiber "blade" didn't give him an advantage. His case is a reminder that the technology's effect on performance is still unclear.

Blade prostheses share some characteristics with biological limbs. The blades store energy as they bear the runner's weight and then release it as the runner pushes off the ground. In this way, blades are very similar to a leg's muscles and tendons, which also spring and contract. But an important difference is the foot, which on a blade prosthetic does not rotate or generate its own energy. A biological foot has muscle fibers that help it push off the ground. This creates energy efficiency, says David Morgenroth, an assistant professor at the University of Washington. "Your muscles don't have to put all of the work back in with every step as you're running."

A runner with biological limbs is able to adjust the stiffness of his or her leg muscles and the angle at which a foot hits the ground. But the stiffness and shape of a blade cannot be changed. Each blade is made for a particular athlete to run under very specific conditions. In certain scenarios "that can be a disadvantage," Morgenroth says.

Less Effort At Top Speeds

The blades do have competitive benefits, however. Once a runner on blades accelerates to top speed, he or she can move the prostheses faster and with less effort. This is because the blades weigh less than a competitor's lower legs and feet. Researchers disagree over the total effect of these pros and cons on overall performance.

In 2008, the International Association of Athletics Federations (IAAF) banned Pistorius from competing against so-called "able-bodied" competitors. In an attempt to reverse the ban, the sprinter underwent a series of tests at Rice University. The researchers concluded that Pistorius used 17 percent less energy than "able-bodied" sprinters. The tests also revealed that it took the runner 21 percent less time to reposition his legs between strides. Big disagreements arose over how to interpret the research.

Researchers Peter Weyand and Matt Bundle saw a clear overall advantage in Pistorius's faster leg swings and more efficient stride. They said these could create up to a seven-second advantage in the 400-meter race.

The other researchers—including the Massachusetts Institute of Technology's Alena Grabowski—determined that there was "insufficient evidence" to prove that Pistorius' prostheses gave him an advantage. Their work helped eventually overturn the IAAF ban. The sprinter would go on to compete at the 2012 Summer Olympics in London.

Athletes Must Offer Proof

Rehm's lower right leg was severely damaged in an accident when he was a teenager. Using a blade prosthesis, he won the German national long jump title in 2014. But officials later banned him from competing in the 2014 European Championships due to concerns that his blade gave him an unfair advantage. In 2015, the IAAF changed its rules regarding prostheses. In order to compete, amputee athletes now have to prove that their prosthesis does not give them an edge. In a bid to compete in the 2016 Rio Olympics, Rehm turned to Grabowski.

Long jumpers such as Rehm rely on a fast run-up sprint followed by an efficient takeoff to propel them over a sand pit. During takeoff a jumper pushes off of one leg to quickly get as high in the air as possible. In general, the faster the run-up speed, the farther a competitor will jump. Grabowski found, however, that Rehm uses a fundamentally different method because of his prosthesis. The blade may limit his top sprinting speed (a disadvantage) but it enables a better takeoff (an advantage), Grabowski says.

Ultimately, the researchers could not decide whether Rehm's prosthetic gave him an overall advantage. This ended his hopes of competing in the 2016 Rio Olympics. Rehm is now part of an IAAF group that's studying prosthesis use in athletic competition. He hopes to compete in the 2017 IAAF World Championships.

The Race Continues

Grabowski's research is far from the finish line. In March, she and several other scientists published a new study. They found that athletes with a left leg prosthesis are at a disadvantage in track events of 200 meters or more. Having their blade leg on the inside of the counter-clockwise curve made them about 4 percent slower than those wearing right leg prostheses. Grabowski hopes her research will eventually help scientists "design better prostheses."

The question of whether a prosthesis offers athletes an unfair advantage may never be fully answered. Careful lab testing is important, but it can never replicate what actually happens on the track.