

New Legs for Aspiring Champions

Researchers at the University of Tokyo are working with Paralympic athletes in pioneering new 3D-printed prosthetics.

by Tim Hornyak

Five mornings a week, Saki Takakuwa goes to a track and spends a grueling four hours sprinting and jumping in preparation for the Tokyo 2020 Paralympic Games. As if that's not challenging enough, she does it with a prosthetic leg.

Takakuwa is setting new standards, using prototype running prosthetics that push the envelope in design and technology. Weighing about two kilograms, each "leg" consists of a 3D-printed socket that's laced with web-like crimson ridges and a blade forged from layers of carbon fiber, studded with running spikes. "This blade reproduces natural running to a high degree," says Takakuwa. "The movement is very close to that of a real ankle."

Born in Saitama Prefecture in 1992, Takakuwa was an aspiring, sixth-grade track athlete when she felt a pain in her left leg. Doctors soon discovered a tumor below her left knee, and the diagnosis was tragic: it was bone cancer requiring amputation of the lower leg.

Takakuwa didn't let her disability slow her down. After adapting to an artificial leg for daily use, she tried a sports prosthetic and was surprised by how quickly she could run. Inspired by the writing of Paralympian Mami Sato, whose impassioned presentation helped Tokyo win the 2020 Games, Takakuwa decided to join her high school track and field team and never looked back. She won gold in the 100-meter and the long jump at the Asian Youth Para Games, and placed seventh at the London 2012 Paralympic Games in the 100-meter sprint for her category. She now has her sights on the Tokyo 2020 Games.

"As an athlete, I'm looking for a fast prosthetic that can help me win medals in the Paralympics," says Takakuwa. "But designs that are cool or cute also increase my motivation, and can help change social perceptions of prosthetics."

Takakuwa is collaborating with Professor Shunji Yamanaka, head of the University of Tokyo's Prototyping & Design Laboratory. An award-winning industrial designer, Yamanaka has created a wide range of slick concepts and commercial products including a luxury sedan, a 35mm film camera and a tabletop humanoid robot. Every day, millions of Tokyo commuters unknowingly use one of his greatest creations, the smart card readers at JR East turnstiles.

Visiting Yamanaka's lab, which he started five years ago, is like entering the workshop of a latter-day Leonardo da



SKETCHES COURTESY YAMANAKA LABORATORY, INSTITUTE OF INDUSTRIAL SCIENCE, THE UNIVERSITY OF TOKYO

Sketches of the prototype prosthetic and the 3D-printed carbon fiber model, which is strong enough to withstand the effects of sprinting and jumping.

Vinci. Tucked into a museum-like structure on the Komaba Campus in Meguro, it's a hive of students fleshing out concepts on laptop screens. The walls are lined not only with design and architecture books but prosthetics and plastic skulls, a token of how Yamanaka draws inspiration from biology. He has designed the conference table and the ergonomic chairs we're sitting in as well as several robots and mysterious electromechanical devices littering the space. He even pulls out several panels of a science-fiction manga he illustrated, another example of his fertile imagination. It was a real-life event, however, that motivated him to enter the prosthetics field: the Beijing 2008 Olympic and Paralympic Games.

"I'm always thinking about the relationship between artifacts and humans," says Yamanaka, who began researching prosthetic legs in 2008. "I saw an athlete running at the Games and felt there was a kind of ideal relationship between him and his prosthetic legs. They were joined perfectly to his body and worked perfectly. I wondered how such harmony was possible, and began researching."

While standard, mass-produced prosthetics for everyday activities are widely available to people with impairments in Japan, sports prosthetics are handmade and expensive. Yamanaka met with many prosthetics users to learn about their needs. He saw how the J-shaped blades from an Icelandic manufacturer act like springs, propelling athletes forward while running, noting how they function without trying to look like a natural leg. This functional look is also a key part of Yamanaka's prosthetic design philosophy.

Yamanaka and his collaborators use 3D printers to create the sockets that Takakuwa has been experimenting with. The process begins when nylon powder is deposited as layers,



Sprinter Saki Takakuwa, who lost her lower leg to cancer, appreciates both the performance and the look of her prosthetic leg.

then melted together with a laser. This builds up the material into a resilient structure that's tough enough to withstand the impact of sprinting and jumping.

"If we make these sockets with a 3D printer, we could provide them at low cost to many people," says Yamanaka. "When this technology is fully established, the computer will actually measure users' bodies and ensure a proper fitting." And that could not only help propel sprinter Takakuwa to the finish line, but be a potential life-changer for aspiring Paralympians everywhere.

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Professor Shunji Yamanaka is an award-winning industrial designer who is developing prosthetics for up and coming Japanese Paralympians.