



Jim Wilson/The New York Times

Cameron Clapp sitting on the track in Oklahoma City with his running legs, one of three prosthetic pairs he uses, attached. He was taking a break after a workout.

Getting a leg up, thanks to robotic limbs

By Michel Marriott

Blond and buff, Cameron Clapp is a teenage star.

Dressed fashionably in a faded T-shirt, baggy shorts and sneakers, he recently strolled the crowded sidewalks of Times Square in New York. He walked confidently, flashing the megawatt smile that brightens his Web site and various photographs in newspapers and magazines that have chronicled his story as he travels the country.

Few, if any, of the onlookers had an idea that he epitomizes a new generation of people who are not only embracing all types of breakthrough technologies but also incorporating them into their bodies.

For people who see Cameron Clapp for the first time, he is an object of wonderment: a young man walking tall on shiny robotic legs.

"I make it look easy," said Clapp, who is 19 and still shows flickers of the cocky skater he was before he became what he calls "a severe case."

Clapp lost both his legs above the knee and his right arm just short of his shoulder after falling onto train tracks almost five years ago near his home in Grover Beach, California.

After years of rehabilitation and trying a series of prosthetics, each more technologically sophisticated than the last, he finally found his legs.

"I do have a lot of motivation and self-esteem," Clapp said, "but I might look at myself differently if technology was not on my side."

In the last few years, technology has definitely been on his side, in the form of the C-Leg. Introduced by Otto Bock HealthCare, a German company that makes advanced prosthetics, the C-Leg combines computer technology with hydraulics. It literally does the walking for the walker.

Blazing advancements, including lightweight composite materials, keener sensors and tiny programmable microprocessors are restoring remarkable degrees of mobility to amputees, said William Hanson, president of Liberating Technologies, a company in Holliston, Massachusetts, that specializes in developing and distributing advanced prosthetic arms and hands.

But something more subtle, and possibly far-reaching, is also occurring, some technologists say.

The line that has long separated human beings from the machines that assist them is blurring as complex technologies become a visible part of people who depend on them.

Unlike pacemakers and fabricated

heart valves that are embedded in the body, these technologies are, so to speak, worn on their users' sleeves.

Increasingly, amputees, especially young men like Clapp and soldiers who have lost limbs in Afghanistan and Iraq, are choosing not to hide their prosthetics under clothing as previous generations did.

Instead, some of the estimated 1.2 million amputees in the United States proudly polish and decorate their electronic limbs for all to see.

Long an eerie theme in popular science fiction, the integration of humans with machines has often been presented as a harbinger of a soulless future, populated with flesh-and-metal cyborgs, RoboCops and Terminators. But major universities like Carnegie Mellon and the University of California at Berkeley, as well as companies and the U.S. military, are exploring ways in which people can be enhanced by strapping themselves into wearable robotics, or exoskeletons.

"There is a kind of cyborg consciousness, a fluidity at the boundaries of what is flesh and what is machine, that has happened behind our backs," said Sherry Turkle, director of the Initiative on Technology and Self at the Massachusetts Institute of Technology, who is writing a book on robots and culture. "The notion that your leg is a machine part and it is exposed, that it is an enhancement, is becoming comfortable in the sense that it can be made a part of you."

Research at MIT in the 1970s led to the development of the Boston Digital Arm, one of the most realistic looking arm prosthetics in the world, manufac-

tured by Liberating Technologies.

Over the years, prosthetics like the C-Leg and the Boston Digital Arm have benefited from the explosion of improving technologies for personal computers and cellphones.

For example, Hanson of Liberating Technologies said that smaller and more powerful microprocessors and rechargeable batteries have helped his company make electronic limbs more reliable. Statistics on how many amputees use artificial limbs are not available.

While some users are eager to display their prosthetic marvels, many of which are paid for by private and public health insurance, others like to have them modeled to appear more human. Besides selling prosthetics, Liberating Technologies, for one, offers 19 kinds of silicon sleeves for artificial limbs to make them seem more natural.

"There are two things that are important; one is functionality and the other is cosmetic," Hanson said. "Various people weigh those differences differently. There are trade-offs."

Hope Harrison, a professor of history and international affairs at George Washington University in Washington, had a leg amputated in 1979. Harrison, 43, said she had used a range of prosthetics, but preferred the C-Leg now. She also prefers to wear it with a natural-looking cover.

"It's one thing to see a man with a Terminator leg," Harrison said, referring to the cybernetic character played by Arnold Schwarzenegger in the blockbuster movie series. "It may inspire people to say, 'Cool.' But body image for women in this country is model

thin and long sexy legs."

But young men, especially those who have been using personal electronics since childhood, are comfortable recharging their limbs' batteries in public and plugging their prosthetics into their computers to adjust the software, Hanson said.

"I love my Terminator legs," said Nick Springer, 20, a student at Eckerd College in St. Petersburg, Florida, who lost his arms and legs to meningococcal meningitis, a rare and often deadly bacterial disease that he got at summer camp when he was 14.

Like Clapp, Springer uses the battery-powered C-Leg system. Springer said he had never been shy about his legs, which rely on sensors to monitor how the leg is being placed on terrain and microprocessors in the knees to control how the limbs' hydraulic system creates a natural step.

With hard work, Springer said, his legs, which can cost more than \$40,000 each, helped give him back his mobility. He wore a kilt to his high school prom in Croton-on-Hudson, New York, and even donned Dr. Martens boots on his artificial legs to attend rock concerts with friends.

Michael Chorost, a science writer and consultant who is 40 and lives in the San Francisco Bay area, suffered his own disability by losing his hearing four years ago. Soon after, he had a device known as a cochlear implant placed surgically under the skin behind his ear to restore his hearing. The device requires him to wear a microphone on the side of his head.

Clapp, who has his own Web site, cameronclapp.com, is a contract patient advocate for the Hanger Orthopedic Group, a company in Bethesda, Maryland, that provides prosthetic services and makes sockets that attach to artificial legs.

This month, Clapp was at a Hanger clinic in Oklahoma City to have new leg sockets built and to compete with other amputees in the Endeavor Games, an annual sporting event for athletes with disabilities.

Clapp is described as an agile runner and swimmer. It helps that he has three sets of legs: one for walking, one for running and one for swimming.

He talked about how digital technologies swept recorded music from vinyl records to downloadable MP3 files and how similar technological leaps are sure to improve prosthetics in his lifetime.

"It's going to create new stuff," Clapp said brightly.

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Amputees at Hanger Prosthetics in Oklahoma City being refitted for artificial limbs.