

## BREAKTHROUGHS

# A Step Beyond Human

MIT professor and double amputee Hugh Herr is building the world's most advanced prosthetic foot. By Andy Greenberg



Cyborg evangelist: Herr wears a pair of his disability-defying PowerFoot devices.

**O**N HIS WAY TO A LUNCH MEETING a few years ago Hugh Herr was running late. So he parked his Honda Accord in a handicapped parking spot, sprang out of the car and jogged down the sidewalk. Within seconds a policeman

called out, asking to see his disability permit. When Herr pointed it out on his dashboard, the cop eyed him suspiciously. "What's your affliction?" he asked dryly.

Herr, a slim and unassuming 6-footer with dark, neatly parted hair, took a

step toward the officer and responded in an even tone: "I have no [expletive] legs."

Blurring the boundaries of disability is a trick that Herr, director of the biomechanics group at MIT's Media Lab, has spent the last 27 years perfecting. At age 17 both of Herr's legs were amputated 6 inches below the knee after a rock climbing trip ended in severe frostbite. Today he's one of the world's preeminent prosthetics experts. His goal: to build artificial limbs that are superior to natural ones. His favorite test subject: himself. "I like to say that there are no disabled people," says Herr, 45. "Only disabled technology."

Herr swaps his feet out to suit his needs. He generally walks on flat carbon-fiber springs inside his shoes but sometimes replaces them with longer carbon bows for jogging. When he goes rock climbing—often scaling cliffs of expert-level difficulty—he switches to one of multiple pairs of climbing legs he's built himself, including small, rubber feet on aluminum poles that stretch his height beyond 7 feet, spiked aluminum claws that replace crampons for ice climbing or tapered polyethylene hatchets that wedge into crevices.

"The fact that I'm missing lower limbs is an opportunity," he says. "Between my residual limb and the ground, I can create anything I want. The only limits are physical laws and my imagination."

Over the last several years that imagination has been working overtime. Late next year Iwalk, a company Herr founded in 2006,

plans to release the PowerFoot One, the world's most advanced robotic ankle and foot.

Most prosthetic feet are fixed at a clumsy 90 degrees. The PowerFoot, equipped with three internal microprocessors and 12 sensors that measure force, in-

ertia and position, automatically adjusts its angle, stiffness and damping 500 times a second. Employing the same sort of sensory feedback loops that the human nervous system uses, plus a library of known patterns, the PowerFoot adjusts for slopes, dips its toe naturally when walking down stairs, even hangs casually when the user crosses his or her legs.

The PowerFoot is the only foot and ankle in the world that doesn't depend on its wearer's energy. With a system of passive springs and a half-pound rechargeable lithium iron phosphate battery, the foot—made of aluminum, titanium, plastic and carbon fiber—provides the same 20-joule push off the ground that human muscles and tendons do. It automatically adjusts the power to the walker's speed, but users can also dial that power up or down with a Bluetooth-enabled phone. (And soon, Herr says, with an iPhone application.) One test subject told Herr that his nonamputated leg often tires before his prosthetic-enhanced one. "This is the first time that the prosthesis is driving the human, instead of the other way around," says Herr.

Herr frequently wears a pair of his new creations. The next to try the PowerFoot will be the Department of Defense, which is looking for prostheses for the nearly 1,000 soldiers who have lost limbs in Iraq and Afghanistan. The Veterans Administration and the Army are among the investors who funded his MIT research. Veterans, he argues, also make the perfect early adopters, given their athletic, active lifestyles. "These are remarkable people," says Herr. "If the PowerFoot can work for them, it can work for anyone."

Iwalk hopes to put the PowerFoot on the general market in 2010, priced in the low five figures. The startup has raised \$10.2 million from investors, including General Catalyst Partners and WFD Ventures.

Herr's motives extend beyond profit. In 1982 he and a friend climbed Mount Washington in New Hampshire, a place infamous for its unpredictable and nasty weather. They were caught in a snowstorm, losing their way in a near-complete whiteout and subzero temperatures. After three and a half days of crawling along a frozen river, Herr's lower legs were practically destroyed by cold. A member of the rescue team sent after them, 28-year-old

Albert Dow, was killed in an avalanche.

"I feel a responsibility to use my intellect and resources to do as much as I can to help people. That's Albert Dow's legacy for me," says Herr.

Within three months of his amputations Herr was rock climbing with simple prosthetics. Within six months he was in a machine shop, building new feet, using the skills he'd learned at a vocational high school in Lancaster, Pa., where he grew up.

While he had previously focused on merely working a trade, Herr became a nearly obsessive student, earning a master's in mechanical engineering at MIT and a Ph.D. in biophysics at Harvard. Once, when his hands suffered from repetitive stress disorder while he was writing his doctoral thesis, he attached a pencil to a pair of sunglass frames and typed with his head. "He's driven to the point of exhaustion, physical degradation," says Rodger Kram, a professor of integrative physiology at the University of Colorado at Boulder, who worked with Herr at Harvard. "Every step he takes, he's forced to think about making prosthetics better."

Herr wants to transform how people define disability. Last year he sat on a panel of scientists that confirmed that Oscar Pistorius, a South African sprinter with no legs below the knee, should be allowed to compete in the Olympics. Herr helped discredit arguments that Pistorius got a metabolic advantage from his carbon-fiber legs. (Pistorius missed qualifying by a fraction of a second.)

Herr has tasted athletic discrimination, too. Because he uses special climbing prosthetics, many dispute his claim to be the second in the world to free-climb a famously challenging pitch near Index Mountain, Wash. "When amputees participate in sports, they call it courageous," he says. "Once you become competitive, they call it cheating."

Herr even believes that in the coming decades Paralympic athletes will regularly outperform Olympic athletes. We may need special disability laws for humans who decline to have their bodies mechanically enhanced, he says.

"Disabled people today are the test pilots for technology that will someday be pervasive," Herr explains. "Eliminating disability and blurring man and machine will be one of the great stories of this century." **F**