Mind Over Matter: The World Of The Rheo Knee

Massachusetts Institute of Technology



Adapting to user walking style and terrain via a microprocessor that sends signals to magnetic fluid in the artificial joint — and optimizing control over time — the Rheo Knee helps below-the-knee amputees enjoy active lives.

An irony lies deep at the heart of modern society. Though technology is an outgrowth of our vigorous imagination, it can, at times, take on a life of its own. With gigabytes of empowering information at our fingertips, microprocessors far smarter than we are, clappers that turn off lights and clickers that open garage doors, it's easy to become complacent and become overwhelmed by our own creations.

However, some wills appear to be made of sterner stuff. There are inspiring stories — of a triple-amputee-turned-triathlete; of a soldier who, after losing his legs to a landmine in Afghanistan, fulfilled his dream of running alongside the president of the United States; and of a mountain-climber, amputated below the knees, who was able to climb again. It is people like these who refuse to let their handicaps define who they are, who reclaim what is theirs. It is people like these — and many others — for whom the Rheo Knee™ makes all the difference.

Technology as Healing

The hypotheticals above aren't hypothetical. They're flesh-and-blood Rheo Knee wearers. In fact, that very mountain climber is one of the principal investigators of the Rheo Knee, Hugh Herr, Ph.D. A graduate student and aspiring mountain climber, Herr was stranded on Mount Washington in minus-20-degree temperatures for four days in 1991. He suffered severe frostbite that ultimately resulted in the amputation of both legs.

After being fitted with conventional prostheses, Herr wondered how he could get back to his old passion. The answer was technology. Not satisfied just getting around, Herr, now director at the Massachusetts Institute of Technology's Biomechatronics Group, invented a specialized foot device that allowed him to get back to mountain climbing. After that, as part of a personal quest to extend technology as a means for healing, he led a team of MIT researchers in the invention of the Rheo Knee, a microprocessor-controlled artificial knee.

A Smarter Knee

Artificial knees have used microprocessors for about a decade, and these can be programmed to give the user a more natural gait compared with conventional leg prostheses, which cause users to stumble and limp. But Rheo Knee is unique, even among other microprocessor-controlled knees.

> *Artificial intelligence is an important feature that sets the Rheo Knee apart from other prosthetic devices. The Rheo Knee adapts automatically to the individual's personal walking style and continually learns while optimizing control over time.*

The Rheo's Dynamic Learning Matrix Algorithm™ constantly learns from and responds to changes in the user's walking pattern and the surrounding environment. As the range of walking speed and activity increases, the Rheo Knee adapts appropriately, optimizing cadence response for individuals as they progress to higher levels of function.

Built-in sensors measure how far the knee is bent and how much pressure it is bearing. This feedback is communicated, as frequently as 1,000 times per second, to a magnetic fluid made up of oil and tiny iron particles inside the artificial joint. A magnetic charge is cast across the fluid and as more tension is exerted, the magnetic field becomes stronger and the chain formed by the iron particles becomes more rigid.

Wearers of the Rheo Knee are freed from thinking, and worrying, about their knees. Instead, the knee thinks so the user can act. Ossur, the Icelandic company that manufactures and distributes the Rheo Knee, is pleased with its reception since coming onto market in February 2005. "Sales have gone through the roof," says Tabi King, marketing communications manager of Ossur North America.

The Rheo Knee's intelligence hasn't gone unrecognized by the media. Discover and The Wall Street Journal have reviewed it, Fortune and Time listed as a top 2004 invention and Popular Mechanics awarded Herr its Breakthrough Leadership Award in September 2005.

A Soldier's Story

Amputees hail from every walk of life and number 1.6 million in the U.S. alone. National Guardsman Sgt. Mike McNaughton is part of a special and growing segment of this population: soldiers returning from Iraq and Afghanistan. In January 2003, while leading a mine-removal team that had cleared an astonishing 150,000 antipersonnel and 47 antitank mines in just seven months near Bagram, Afghanistan, McNaughton saw a flash of smoke and tasted TNT on his lips.

"We have an amputee!" he heard the medics yelling. He knew from Army training not to look at his injury, but he also knew he had lost a limb and that his life would never be the same. "I flew up in the air and all I could think was that I had just spoken with my wife two hours before," McNaughton recalls. McNaughton, who had volunteered for mine removal duty, was rechecking an area declared mine-free and had rejoined the military after Sept. 11, 2001, has never been one to take the easy way out. After receiving a Purple Heart, undergoing 11 operations, spending four months in Walter Reed Army Medical Center and eventually losing his right knee, McNaughton — during a visit from President Bush — announced that he would run again. After being fitted with a prosthetic knee in 2004, McNaughton made good on his promise and ran alongside the president for a mile around the South Lawn track.

Seeking a full recovery, McNaughton was fitted with a Rheo Knee in 2005. "Before the Rheo, I used a C-Leg, another micro-processor knee with technology that's almost 10 years old. The C-Leg is like a car with a governor on it, but the Rheo is like one without one. The Rheo is the Lamborghini of prosthetics. Because of its artificial intelligence, it knows my walking style. The Rheo does the thinking and adjusting for me, even when I'm walking down ramps and stairs. It's like a part of me, an experience I haven't had with other prosthesis."

McNaughton, now an operations manager at the Department of Homeland Security in Baton Rouge, plays soccer with his kids, has run marathons, and plans to complete the New York Marathon in a few years. And he and his wife had a baby boy in December 2005.

The Future: Keep Moving Forward

As McNaughton trains for marathons on his Rheo Knee, Herr and his colleagues — at the helm of an emerging discipline called biomechatronics, the interfacing of robotic prosthetics with the human nervous system — are busy developing a prosthetic ankle that might be viewed as the successor to Rheo Knee.

Herr, as part of a $7.2 million U.S. Department of Veterans Affairs research project designed to help returning amputee soldiers, will have three small sensors implanted in his leg below his knee. These sensors measure electrical impulses given off as the amputee-user flexes leg muscles in ways that once moved the ankle; this feedback is conveyed to a computer chip that activates the prosthetic ankle's motor. Though this device may sound futuristic, its application and value for veterans and others comes down to the most basic of human impulses. And it's what compels Herr to do what he does for himself and others everyday: the desire to keep moving forward.

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