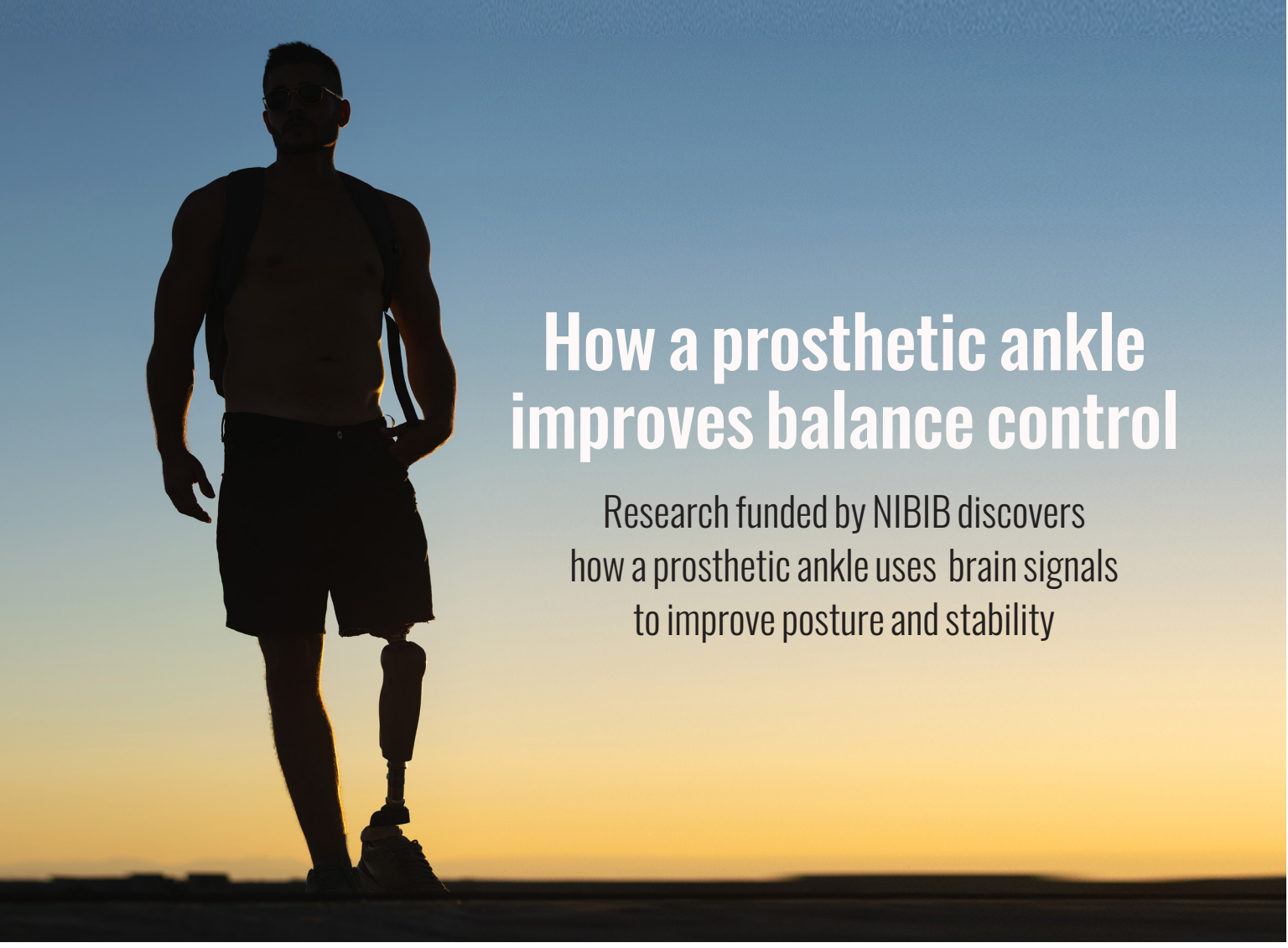


How a prosthetic ankle improves balance control

Research funded by NIBIB discovers how a prosthetic ankle uses brain signals to improve posture and stability

When someone loses a leg or other limb, a prosthetic device (a tool designed to replace a missing part of the body) can play a role in improving their quality of life by helping with mobility and stability. However, while most prosthetic devices are beneficial, current lower-limb devices can't provide continuous control of balance or posture. Without proper neural (brain and nerve) control, people with lower-limb devices are more likely to fall or have difficulty walking on certain surfaces.

Researchers funded by the National Institute of Biomedical Imaging and Bioengineering (NIBIB) are working on an ankle prosthetic that can use the remaining muscles—and the muscles' neural signals—to improve amputees' stability and ability to hold an upright position.

How important are lower-limb prosthetics?

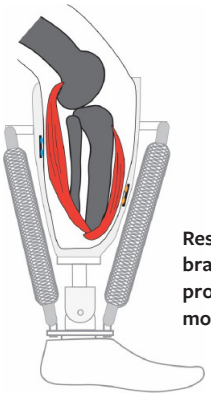
About 2 million people in the United States are living with an amputation, with lower-limb amputations being the most common. Many people choose to use a prosthetic device to help with walking and other types of movement.

What types of prosthetics are there?

There are a few kinds of lower-limb prosthetics:

- **Passive devices** are designed to support the body, but they generally do not move on their own. They can be static or adjustable and are usually designed to look like a natural limb. These devices are not powered and do not have a natural range of motion. Most lower-limb prosthetics are passive devices.
- **Powered devices** are designed to function more naturally. They can be controlled to move based on the movement of an amputee's residual limb (the part of the limb that remains after an amputation) or based on other signals from the body. These signals are measured with sensors, which feed information to a computer model to control balance and movement.

IMAGE CREDIT: GETTY IMAGES



Researchers are working on a brain-controlled ankle prosthetic that can improve mobility and postural control.

What is the research?

Electrical, or neural, signals that travel from our muscles to our brain help us move our entire body, including our limbs. Even after amputation, these neural signals play a major role in moving residual limbs. He "Helen" Huang, Ph.D., and her research group are developing a new computer model to control a lower-limb prosthetic device that anticipates the person's intended balance or motion. This system uses direct electromyographic (dEMG) control. In 2021, the research team released a case study report that evaluated how well a dEMG-controlled ankle prosthetic worked on a person with a transtibial amputation (where the limb is removed below the knee).

After an amputation, a person no longer has neural signals that once moved the entire limb, so they will generally need to build new signals to use their muscles in the residual limb differently. In Dr. Huang's system, dEMG sensors detect these new neural signals from the residual limb muscles. When initially using the dEMG-controlled ankle prosthetic device, the limb will move unnaturally while the computer model learns how the person intends to move it. People using a dEMG-controlled prosthetic would work with a physical therapist to help "train" their residual muscles to work with the device. This training will help the computer model better control the device to create a more natural balance and movement.

FAST FACT

One of the first known prosthetics was a wooden and leather toe found on an Egyptian mummy that dates to **950-710 B.C.**

SOURCE: UNIVERSITY OF MANCHESTER

Even after amputation, electrical signals travel from our muscles to our brain to move residual limbs.

How does this dEMG prosthetic work?

- Researchers place surface electrodes (sensors) on the person's residual limb. These sensors detect electrical signals—the EMG—in a person's residual muscles.
- When the person contracts their residual muscle (like flexing their foot), the EMG activity is sent to a computer model.
- The computer model learns how to interpret the person's movement intentions to create a tailored dEMG prosthetic system.
- The dEMG controls the pneumatic artificial muscles (part of the prosthetic device that uses pressurized air to contract or extend), which allows the person to naturalistically control their ankle based on their intentions.

What were the study results?

The research team evaluated one person's stability when he used his passive prosthetic ankle and, after finishing physical therapy, when he used the dEMG-controlled prosthetic ankle. The study found that his stability while wearing the dEMG-controlled prosthetic ankle noticeably improved. He even had improved control when standing on a foam surface and with his eyes closed. The synchronization between his residual limb and the dEMG prosthetic was also much higher than it was with his usual passive device.

Researchers are now expanding this study to include several more people who have lost their lower limbs. ■

IMAGE CREDITS: TOP LEFT, NEUROMUSCULAR REHABILITATION ENGINEERING LAB UNC/NC STATE; TOP RIGHT, GETTY IMAGES; BOTTOM LEFT: COMMONS.WIKIMEDIA.ORG