Your Guide to Consumer Information

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Nutrition

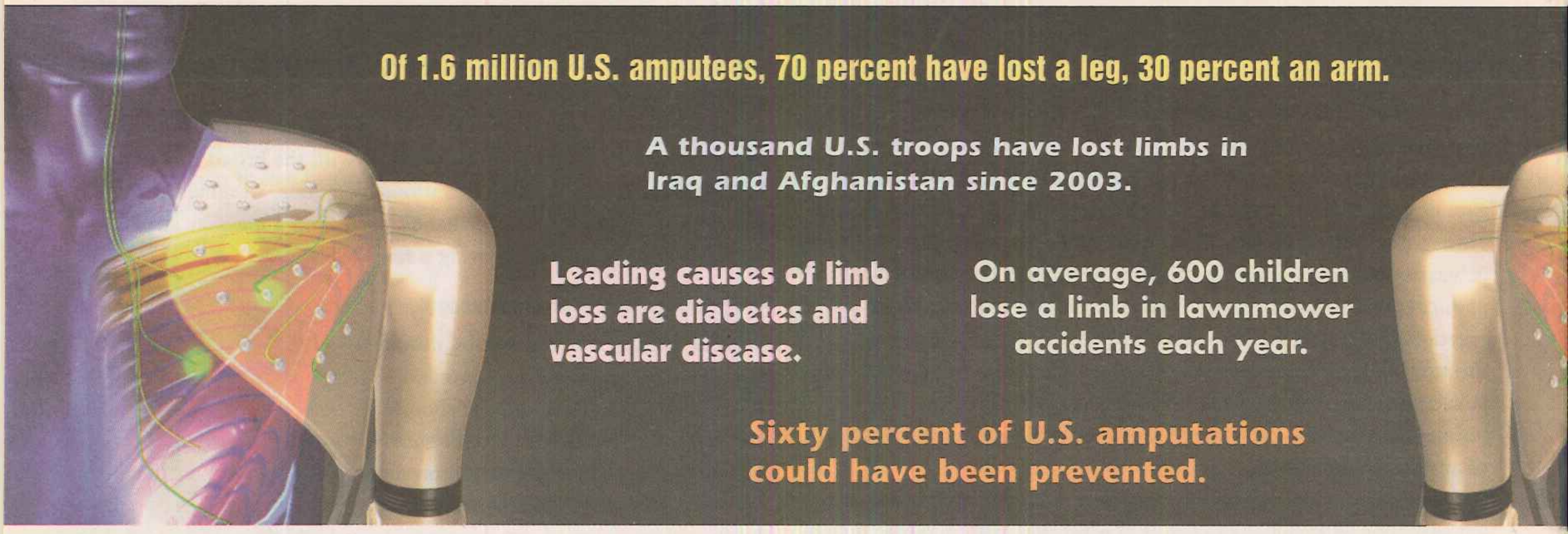
Susan Haines, RD

Heat-related illness

Aaron Burnett, MD

Hernia repair

Roderick Brown, MD



Of 1.6 million U.S. amputees, 70 percent have lost a leg, 30 percent an arm.

A thousand U.S. troops have lost limbs in Iraq and Afghanistan since 2003.

Leading causes of limb loss are diabetes and vascular disease.

On average, 600 children lose a limb in lawnmower accidents each year.

Sixty percent of U.S. amputations could have been prevented.

Prostheses

Innovations fine-tune function

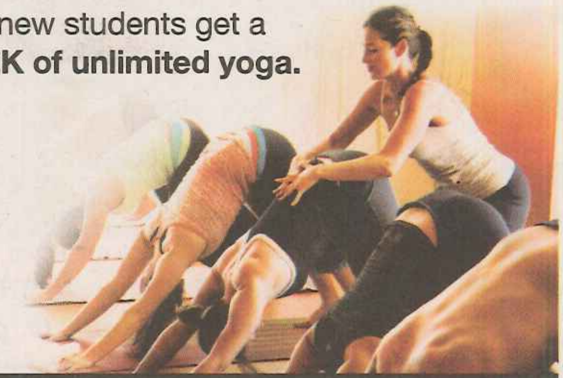
By Todd Anderson, CP, FAAOP

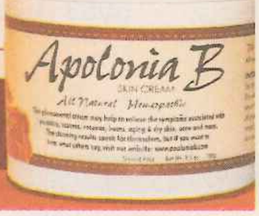
In any circumstance, the loss of a limb is a life-altering event of enormous proportions. Things a person used to do without thinking—walking, eating, grasping, to name just a few—become either impossible or incredibly difficult without the missing limb. For many suffering from limb loss, a prosthesis—what used to be called an artificial limb—can partially replace lost function.

In the last 20 years the science of prosthetics has seen a burst of innovation, supported largely by advances in computer and material science. This article highlights some exciting recent innovations—and future technologies and interventions—in the field of prosthetics.

Microprocessors in prostheses

Silicon chips that contain a central processing unit, called microprocessors, and their supporting software have replaced simple mechanical systems to control the more sophisticated prostheses. For above-the-knee prostheses such as the C-Leg knee joint, manufactured by Otto Bock HealthCare, a German firm with North American headquarters in Minneapolis, the microprocessor has software algorithms based on the walking habits of thousands of people.





How a myoelectric prosthesis works

An upper limb prosthetic system consists of a socket that the residual limb fits into (which creates the interface with the prosthesis) and the prosthetic system itself. The system can be body-powered, using simple cable technology, or "myoelectric."

Here's how a myoelectric system is controlled: Every time muscle fibers contract they generate micro-volt electrical charges. These electrical charges can be picked up on the surface of the skin by sensitive electrodes that are built into the prosthetic socket, which is where the user's limb interfaces with the prosthesis.

When a user fires the muscles that would open a sound hand, for example, the electrode recognizes this signal, and then sends a control signal to the prosthesis' electronics, which tells the system to flex, extend, or rotate, depending on the user's needs. Duration and strength of the signal can also be utilized to increase grip force or speed of the prosthesis.

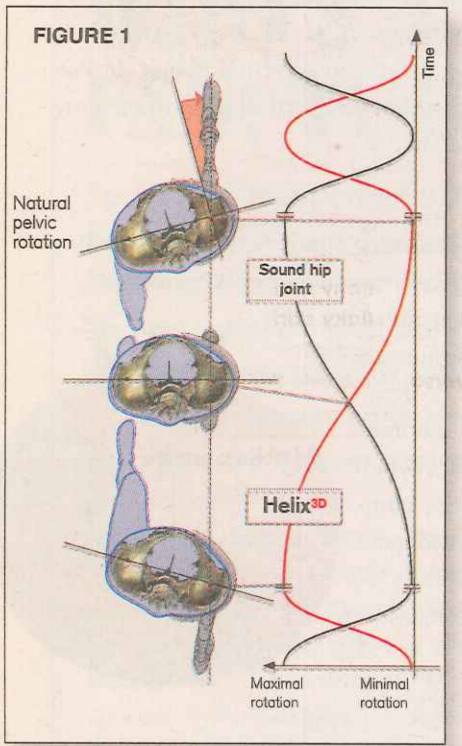
A great thing about the system is that any signal can be used to control any prosthetic function, so people who may have only a single, active muscle can still open and close a hand, rotate a wrist, and flex or extend an elbow joint.

The software reads real-time sensor information to make immediate adjustments in the hydraulic controls of the knee joint, helping it support a user whenever it isn't needed to swing freely. The result for users is stability, confidence, and fewer falls, allowing them to live with greater independence. There is also a powered knee on the market that can ascend stairs, and we expect to see knees that will know even more about the user's situation, such as whether the person is walking backwards, to create even greater stability.

Prosthetic feet are also getting a boost from microprocessors. Several manufacturers are making feet that actively change the angle of the ankle depending on whether the user is going up or down stairs or slopes.

Microprocessors are used in upper-limb prostheses, too. They can assess and relay sensor information from the fingertips of a prosthetic hand, for example, and then tell the hand to automatically squeeze harder if a held object begins to slip. They also process a person's myoelectric control signals (see sidebar above). A myoelectric signal is an electrical impulse that contracts muscle fibers. Microprocessors read these signals to flex and extend an elbow joint with just the right amount of force. This allows users to actively lift a 13-pound bag of groceries—or take out a credit card to pay for them.

FIGURE 1



Software has also created virtual fitting and training solutions. Patients can train with computer games that offer feedback loops, and even try out different prosthetic solutions—virtually and in 3-D.

Advanced prosthetic hips

Amputees with a hip disarticulation (the entire thighbone is missing) or hemipelvectomy (part of the pelvis is missing) account for a very small percentage of lower-limb amputees. Because of this, solutions for their complex walking issues haven't changed much for decades—until now.

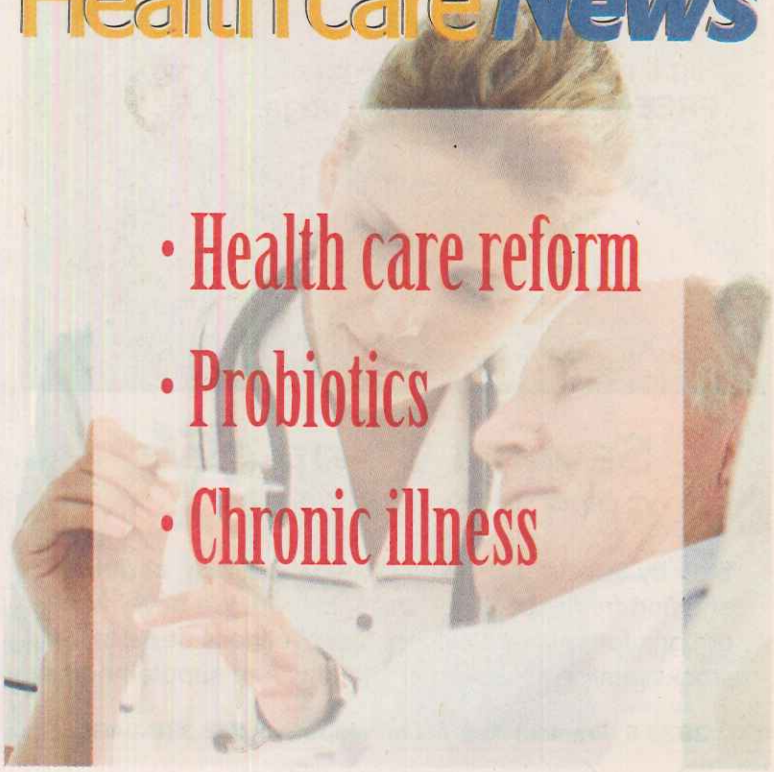
The old style of prosthetic hip was basically a hinge, and didn't account for the natural movements of the pelvis during walking. Users often had to "hike" or lift their hip up to clear their toe, and the joint couldn't compensate for natural rotation that occurs during normal walking.

But a new hip ingeniously changes shape and orientation during walking, allowing the prosthetic leg to mimic normal pelvic motion by contracting upwards to clear the toe, while also rotating up to 10 degrees. People who have hip-level limb loss have even greater mobility challenges than those whose amputations are lower on the leg. This new hip (see Figure 1 below, left), called the Helix 3D, has made a huge difference for them by providing a more natural walking pattern. This makes it easier on the sound side and the rest of the body, while also making the amputation less noticeable.

Targeted muscle reinnervation (TMR)

This advance, originated by Todd Kuiken, MD, PhD, at the Rehabilitation Institute of Chicago, combines a new surgery with new prosthetic technologies. The surgery, intended for people who have lost their arm up through their shoulder, has been performed on several dozen people to date. It takes the four main nerves that once controlled an amputated hand or arm and surgically integrates those nerves into the pectoral muscle in the chest. Following reinnervation (a process that may take up to several months), the surface of the chest musculature attains multiple nerve sites. Powerful electrodes in

Prostheses *to page 34*



Prostheses *from page 29*

the prosthetic interface can then detect and amplify electrical nerve impulses (the user's "control" signals) originating at these sites, using them to control the prosthesis.

In previous systems, an amputee would have to first engage the elbow joint to extend the arm, then engage a wrist rotator to turn the hand, and finally engage the hand itself to open up—one thing after the other. TMR takes advantage of the nerves that originally participated in those functions, so the user can reach, turn, and open all at once, with a greater range of motion and without having to think about each motion separately.

Unique materials and ingenious mechanisms

The implementation of plastics created a revolution in prosthetic fabrication. Now there are also unique applications of carbon fiber, silicones, and urethanes to create a whole new breed of solutions.

Tough, lightweight carbon fiber is used to create flexible prosthetic feet, the rugged housing that protects the "brains" in microprocessor-controlled knees, and even in sockets that hold what is left of the limb, called the "residual limb."

Targeted muscle reinnervation combines a new surgery with new prosthetic technologies.

The unique properties of silicones and urethanes help create a liner (which is a little like a sock in a shoe) for much improved interfaces between an amputee's skin and the socket of the prosthesis. One new material, called Polytol, has multiple properties. It can be flexible and conform to the body where necessary—like on the back edge of a socket that might be sat upon. But it can also be reinforced for stiffness where the socket is connected to the prosthetic joint—a great advantage in comfort and weight for the user.

Fabrication technology—making things better

One of the most important aspects of a prosthesis is the interface that connects the prosthetic components to the user, described above as the "socket." Until now, plaster casts were taken of a residual limb and then a thermoplastic check socket was made before the socket could be finalized.

New technologies have made this process more efficient. With photometric systems, which work with computer-aided design, specific photos are taken of a patient's residual limb and then digitized, allowing clinicians to generate 3-D models in a computer and alter them if necessary. The end result is an exact replica of the patient's limb carved from foam, which then serves as the model for the check socket. Patients and clinicians have no plaster mess to deal with, and the clinician can store the files as a permanent part of the patient's digital record.

These are just a few of the exciting innovations happening right now. Of course, new materials and systems only matter if they improve the lives of prosthetic users—that is, make is easier to pour a glass of milk, or carry a sleeping child from the car into the house. And they do. Lighter-weight devices, smarter control, and increased security all help provide highly improved function, and we expect to see even more improvements as we look to the future. ◘

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