PHYSICAL therapytimes
a multi-disciplinary online resource

January 4, 2010

Amping Up Current Therapy

Functional electrical stimulus and the changing times

By Bob Stott

It may surprise many to learn that the brain and body effectively run on electricity, and more remarkably, the same kind of electricity that runs our household appliances.

The individual nerve cells in the brain discharge a current of electricity along the neurons – like a computer, controlling millions of nerve fibers – which, in turn, charge the particles in each of the cells and basically transmit the orders from the brain to the muscles and internal organs.

Without this electricity, the human body could not function. Even the simple act of making a fist – for many, a barely conscious effort – is controlled by literally thousands of electrical signals from the brain. While the human body has demonstrated incredible resilience against long-term damage, like any operating system, an interrupted electrical pathway means that signals do not reach their intended destinations.

For patients affected by paralysis resulting from spinal cord injury (SCI), head injury, stroke, or other neurological disorders, interference with the electrical signals between the brain and the muscles results in various forms of paralysis.

Many physical therapists and occupational therapists laboriously working to retrain these patients' muscles have opted to return to the source, adding electricity to the regimen in hopes of regaining their former range of function.

A Hand Up In Therapy

Patients afflicted with a stroke, brain injury or SCI sometimes display neurological problems – including an inability to grasp objects or other routine tasks involving their hands.

Intent upon improving patient hand function and voluntary movement, Valencia, Calif.-based Bioness Inc. has developed the NESS H200 Neuroprosthetic and Rehabilitation System, indicated for the treatment of upper limb paralysis from hemiplegic stroke, traumatic brain injury or C5-C6 spinal cord injury. The system contains a custom-fit orthosis that uses functional electrical stimulation (FES) to sequentially activate muscle groups in the forearm to produce functional movement patterns in the hand.

"Personally, I've used this system on both my stroke patients and my spinal cord injury patients, and what we're finding is that by utilizing neuromuscular electrical stimulation during functional activities, we're having a quicker recovery, or a more full recovery," says Rusty Mattingly, OTR/L, an occupational therapist with Frazier Rehabilitation Institute in Louisville, Ky.

The NESS H200® Hand Rehabilitation System is a rehabilitation system designed to use mild FES to improve hand function and promote motor recovery in people with medical conditions such as stroke, traumatic brain injury and spinal cord injury.
(Courtesy: Bioness)

He continues, "We do a lot of adaptation for functional skills rather than recovery, and really the H200 actually falls right in line with what our treatment model here is: focus on recovery first, especially in the spinal cord population. We are also using it on our brain injury population, because we're finding out, with the addition of the sensory input of the neuromuscular e-stim and the functional stimulation, it helps their brain utilize the plasticity that is available to help them function. "

The type of FES utilized by the H200 system allows therapists to help patients move their hands through patterned physical activities that the patient could not otherwise complete. While providing necessary electrical feedback to the nervous system, facilitating neuroplastic changes in the brain, this technology also addresses the patient's musculoskeletal limitations – relaxing muscle spasms, increasing muscle strength and mass, and increasing joint range of motion.

"I'm the only PT in our clinic, and I use the H200 system every day, with every client that comes in," says Tami Toms, MPT, a physical therapist at the Advanced Recovery Rehabilitation Center in Sherman Oaks, Calif. "It's a marvelous tool, and definitely the easiest device to use for the hand that I've come across."

She adds, “When a client sees that a therapist can work with it fairly easily, it helps the client feel like they can succeed with it. If I was going to ask Mrs. Jones to work on grabbing a soup can from the cupboard, she simply puts the control unit around her neck, with the device opening and closing her hand, and she can go under the cupboard and work on that task. Adding FES to exercises already in place makes this an invaluable tool for my patients.”

One Size Fits All

Traditionally, FES technology with cumbersome wires was not only a time consuming task, but also one that could not be easily administered outside of a rehabilitation facility. The H200 system, on the other hand, is not only wireless, but has five surface electrodes integrated into the system to stimulate and activate the hand and facilitate neuromuscular re-education. Therapy programs and function modes are also pre-programmed, providing the clinician and the patient control over hand activation.

“Previously, neuromuscular stimulation was used as a pseudo-FES, in which the therapist or a trained family member would actually try to facilitate the initiation of the electrical stimulation to the right muscle group at the right time,” says Mattingly.

“The problem with this was that patients and family members had a hard time determining where they need to place the electrodes. There’s always a question as to where the electrodes go. It really is tough for them to understand that sometimes just a little bit of movement – and I’m talking about millimeters – can make a big difference.”

The NESS H200 has two main parts: the orthosis and the control unit. The orthosis attaches to the forearm and wrist, and connects to the control unit. Inside the orthosis, electrodes deliver mild stimulation that helps your hand move. The control unit also has a rechargeable battery for extra convenience. *(Courtesy: Bioness)*

With the H200 system, the electrode placement is already predetermined by the therapist.

Therefore, every time the patient puts it on, whether at home or during therapy sessions, the electrodes are in the right place, the programming is set up to do exactly what the therapist is trying to accomplish. For example, if the therapist is trying to accomplish tone modulation or neuromuscular input to utilize neuroplasticity, these settings are preset into the system.

"Traditionally, when using other FES devices, we would have to take each electrode and try to find the same place where it went the day before," says Toms. "However, with this device, once I fit it for 'Mrs. Jones,' it's reproducible, the same, every day. When that happens, both the therapist and the client are successful, and this success carries over to their program at home. That's the beauty of this device – that it can be used at home."

She adds, "Also, the H200 electrodes are cotton, rather than those sticky electrodes that we used to have. And they're meant to dry, so you leave them in the device, and overnight they dry and you just take them out with your fingers. There's little individual slots; they go right back in. They're like puzzle pieces; you know exactly how to put them back in. It's incredible what they've done."

On the Recovery "Fast" Track

While hand orthoses using FES are helping patients attain a better "grasp" of their former range of function, continuing research into other FES applications has yielded several interventions for patients suffering from mobility issues, specifically from gait dysfunction.

Among the most promising studies in the field of FES application is the FastFES project, a research study in the department of physical therapy at the Newark-based University of Delaware, funded by the National Institutes of Health, to study the effect of FES and fast walking on daily function and quality of life in people with hemiparesis after stroke. This study involves the development of a treadmill walking program customized for each participant to improve walking patterns, increase walking speed, and reduce the energy cost of overground walking.

According to the director of the FastFES project, Stuart A. Binder-Macleod, PT, PhD, FAPTA, "The project itself combines two interventions that complement each other in terms of helping to reduce specific gait impairments in patients who have had a stroke. When stroke patients walk, they tend to either not get their involved limb and hip into much extension – they'll step forward, and then kind of step to the limb, so they don't get good hip extension. Therefore, the limb is not in a good position during the phase of the gait that really helps to propel them forward."

To develop this groundbreaking study, Binder-Macleod combined his research in muscle physiology and electrical stimulation with the motor control and locomotion expertise of project co-director Darcy Reisman, PT, PhD – the "Fast" complementing his "FES" experience.

Unique among FES approaches, the FastFES project uses a variable frequency train to stimulate the muscles into action. Unlike electrical stimulation tools, which typically use a frequency of 30 Hertz to stimulate the muscles, the body's central nervous system always varies the frequency, and the FastFES project researchers have spent several years of research discovering the combination of frequencies that would best activate the muscle.

"With a variable frequency train, it starts off at a very high frequency and then lowers the frequency, and what that does is take advantage of the 'catch-like property' of skeletal muscle," says Binder-Macleod. "By generating that force very quickly, the muscle is then able to use a much lower frequency to maintain that same force. You can't wait a couple of seconds to generate force from a muscle, otherwise you're going to fall on your face. You have to generate forces very quickly, and the faster you generate the force, the faster you can walk."

Another distinct aspect of the FastFES project is that this intervention stimulates not only the patient's ankle dorsiflexors, but also their plantarflexors, an often overlooked but crucial muscle for providing the forward propulsive force for gait.

"To date, virtually all FES approaches have stimulated the ankle dorsiflexors, and the vast majority of them only stimulate that muscle," says Binder-Macleod. "Yet, no one has really looked very carefully at the kinetic and kinematic changes as a result of that stimulation. Although the dorsiflexion stimulation really helps to improve the patient's ankle, it actually reduces their knee flexion. I'm not saying that it makes them worse; however, there is a cost associated with it."

He continues, "This really provides fuel to the fire here for stimulation of the plantarflexors, and what we found is that additional plantarflexor stimulation is able to compensate for this loss. We can get the knee to bend more because the ankle plantarflexors actually help with bending the knee, especially if it's in a good position when patients are walking faster."

As research continues to push the frontier of FES applications, more therapists and rehabilitation specialists are gradually turning to this for patients formerly believed to be beyond their ability to help. In this new spark of innovation, patients are being given a second chance.