

## Electrical Stimulation In Cerebral Palsy

Children and adults with cerebral palsy may have one or more of a variety of movement disorders and primary involvement of both lower limbs, one side of the body or all of the body including the muscles of speech and respiration. Because of the diversity of motor control in cerebral palsy [CP], general scales of functional ability have been developed to improve communication among medical caregivers. It is important, however, that any therapy is evaluated according to the specific functional changes in each individual with cerebral palsy. Interpretation of the literature can be difficult because researchers often have used a general, categorical scale to evaluate the significance of their intervention. For example, if the child with CP is able to walk without crutches or a walker before intervention, such as electrical stimulation, and he still walks without ambulatory aids after intervention, there is no change on the categorical scale. More specific measures might reveal that after ES the child walked with a more even stride pattern, took longer steps, maintained a more normal walking speed, used less energy to walk a measurable distance and fell down fewer times each day. These changes would not be noted unless more specific measurements were made by the investigators.

Because of the differences in the assessment tools employed by researchers, there is controversy in the literature about the efficacy of ES. When specific problems are addressed and objective measurements are employed, the results of ES are clinically promising and often statistically significant. It is reasonable to consider the following objectives for the use of ES in cerebral palsy.

### Maintain Or Gain Joint Range Of Motion

There are a number of potential causes for the development of joint contractures in cerebral palsy including the inability to move, the effect of gravity, the presence of involuntary muscle contraction that prevents movement and the presence of obligatory primitive reflexes resulting in abnormal posture. Electrical stimulation has been successfully combined with positioning and voluntary effort, when possible, to correct contractures and maintain range of motion [ROM]. It is critical to the success of ROM protocols to use a comfortable ES protocol one or more times each day. When the body segment to be moved is relatively small [fingers, wrist or ankle], the muscle pull created by ES alone may accomplish the goal. When the body segments are larger, at the knee or hip for example, ES may assist the patient in exercising to the end of their range. Whenever possible it is advantageous to combine ES with voluntary effort. Most home programs can be accomplished with skin electrodes and inexpensive stimulators.

### Management Of Spasticity [One Form Of Involuntary Muscle Activity]

The use of ES to manage spasticity [or involuntary muscle contraction because of increased stretch reflex sensitivity] dates back to the 1700's and there is a wealth of literature related to ES and spasticity in the last 60 years. Not everyone may benefit from ES to reduce spasticity, but the majority of cerebral palsy patients have been relieved of pain and movement restriction when their spasticity was reduced. Procedures that paralyze muscle, such as medications, a chemical nerve block or surgically cutting the nerve, will reduce spasticity but they result in a weaker or a completely paralyzed muscle. The advantage of ES is that it acts to reduce spasticity (without causing

weakness or paralysis) and previously unrecognized movement abilities may be unmasked or discovered. In this case, the CP may appear to be “stronger.”

A number of ES protocols with skin electrodes have been studied. All of these protocols would point to the efficacy of a home program for optimal success. The use of a sensory level stimulus intensity over the spastic muscles, or over areas of skin that receive a similar nerve supply as the spastic muscles, have significantly reduced spasticity during clinical tests and during everyday activities. The use of skin electrodes to train muscles, or to contract muscles for exercise, have resulted in less spasticity and improved function. When ES is used regularly in other parts of the body, for example to control the hand, spasticity has been documented to be less in the lower limbs.

Electrical stimulation of the spinal cord and brain has been studied in cerebral palsy for 40 years. Enthusiasm varied with the investigators, but those who did objective measurements reported a high percentage of reduced spasticity, improved motor control, increased passive and active range of motion, greater muscle strength, improved bladder function, improved coordination of breathing and fewer respiratory infections.

The specific physiological mechanisms of spasticity modulation are not completely understood, but there is a consensus among researchers and clinicians regarding the merits of an ES trial to reduce interfering spasticity. The side effects of ES are minimal. If spasticity is made worse on the initial treatments, the effect will subside within 1-2 hours. If this should happen, a preliminary trial of low intensity, or sensory-level ES is indicated. If the patient is using their spasticity to initiate movement or to stabilize a joint, then the reduction of spasticity may make them temporarily less capable. So, it is important to utilize the expertise of a therapist who can evaluate the effects of ES on spasticity and provide an ES training protocol to improve muscle performance and suppression of spasticity over time.

It is important to remember that the maximum benefit of ES for spasticity may not be realized until ES has been used for 1-2 hours each day for 1-3 months. It is equally important to realize that the reduction of spasticity may increase joint range of motion, unmask existing volitional control and improve hand use or walking. If ES is discontinued, spasticity usually can be expected to return. For this reason, many patients elect to continue to use ES throughout their life.

### Improvement In Voluntary Movement And Walking

In addition to the modulation of interfering spasticity, ES can be incorporated into a variety of therapeutic strategies to enhance voluntary movement and function. The stimulation may act as a sensory cue to encourage recruitment and improve timing of muscle activity. ES may be employed to contract the muscles of interest so the patient can exercise with the stimulation. These activities can be carried into functional tasks such as using the hands, standing, shifting weight from one leg to the other, and walking. Regardless of the objective for adding ES to the rehabilitation protocol, ES must be comfortable and available at home if the user is to be compliant. Inexpensive, small ES devices that can be programmed and triggered to meet the changing needs of the patient are essential.

In cerebral palsy, as in other disorders involving injury to the brain or spinal cord, it is important to determine why muscles appear weak or are not doing their job. It is important to answer five questions. First, is the weak muscle being recruited at all? Second, if it is active, is there enough muscle recruitment to do the job? Third, is the muscle coming on too slowly or too late to be of use in walking or the functional task of interest? Fourth, is the muscle on the other side of the joint [the antagonist] coming on at the wrong time? Fifth, if the antagonist is on at the wrong time is it because it is being stretched and showing spasticity or is it on at the wrong time because the brain is telling it to be on at that time? For example, there are many possible reasons why a CP child walks on their toes. The muscles that normally position the foot for swing may not be coming on enough or rapidly enough. Or, one or more of the calf muscles may be on at the wrong time. If it is spasticity, there are conservative treatments. If one of the muscles is out-of-phase, or told by the brain to be on in swing, there is no known conservative therapy to change that pattern. If it is the tibialis posterior muscle that is out-of-phase, it is possible to surgically remove its attachment and re-attach it on the top of the foot where it will work in the correct phase of gait. This would not sacrifice or lengthen the Achilles' tendon that provides ankle stability for walking. Or, the toe-walking child may not have anything out of order in the leg or ankle, but is walking on the toes in order to balance over their feet because of joint contractures at the ankle, knee or hip or inappropriate muscle activity in the hip or knee.

In each of the first four scenarios above, electric stimulation may have an important role in encouraging muscle recruitment and suppressing spasticity. When the muscle is out-of-phase, a skilled team of rehabilitation specialists is required to make surgical and therapeutic decisions that will improve function and not impose penalties on walking or hand use. Intramuscular, fine wire electromyography [or assessment of individual muscle activity] during upright activity or walking is the only way to determine if individual muscles are appropriate in their timing. This assessment is not available in all rehabilitation centers, but there are more than 50 laboratories in the United States and there are similar laboratories in a number of other countries. Assessment of muscle activity with skin electrodes can lead to errors in surgical decisions and penalize the rehabilitation outcome.

### Considerations In Establishment Of Functional Goals

Utilization of ES along with other therapeutic strategies must be reasonable, goal specific and individualized for each CP patient. An expected outcome of 4 hours wheelchair sitting tolerance in a bed-ridden patient is just as appropriate as the goal of elbow extension and hand opening in order to grasp an object. It is not uncommon for families and medical caregivers to strive for independent walking in young CP children who show potential for ambulation. Unfortunately, it also is common for families and medical caregivers to forget that the energy demand may be excessive and it will become even greater in the adolescent years. Household or limited community ambulation may be most appropriately combined with wheeled mobility for community activities so that energy can be reserved for education, gainful employment and enjoyment of life.

### Neural Prosthetic Applications

Neuroprostheses are devices which aim to substitute for the control of bodily functions which have been impaired by neurological damage. Some individuals prefer to

use external ES systems or neuroprostheses. A small, wearable stimulator with skin electrodes may be the device of choice for applications requiring only a few channels of stimulation. The Handmaster external neuroprosthesis, developed in Israel, is a combined cutaneous electrical stimulation and bracing system for control of the hand. Expected outcomes from the daily use of such a system include reduced spasticity, improved range of motion, potential improvement in volitional control and improved hand function.

Implanted ES systems have been successfully used in research studies and clinical trials over the past 40 years. Implanted ES electrodes or systems can control specific muscles for joint stability and useful limb movement. Commercially available implanted systems for the hand and upper limb have been developed for spinal cord injury patients [NEC system in Sendai, Japan and the Freehand System from NeuroControl, Inc., in Cleveland, Ohio]. The severely paralyzed CP patient may be a candidate for a fully implanted ES system to provide hand function.

There are a number of commercially available, small, wearable ES systems with skin electrodes and footswitch triggers to assist in standing, weight shifting from one leg to another, transfers and walking. Researchers have shown that implanted electrodes do improve muscle control and walking in CP children. Recent technological advances promise to bring new capabilities to the clinical world of ES in the years to come. The injectable, microstimulator will offer the advantages of implanted ES control of one or many muscles, as required, without the need for invasive surgery. This technology is not commercially available at this time.

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See:

General Considerations in the Clinical Application of Electrical Stimulation  
Electrical Stimulation in Stroke and Brain Injury

References:

ES in Cerebral Palsy  
ES in Stroke and Brain Injury  
Comfort in Electrical Stimulation  
ES in Pain Modulation  
ES in the Modulation of Spasticity  
ES for Improving Joint Range of Motion  
ES and Muscle Performance  
ES in Walking