

## Electrical Stimulation In Cerebral Palsy

Barry M.J. (1996) Physical therapy interventions for patients with movement disorders due to cerebral palsy. *J. Child Neurol.* 11 Suppl 1, S51-S60.  
Abstract: The purpose of this paper is to present evidence of the efficacy of physical therapy interventions for patients with cerebral palsy and identify goals for these patients. Studies suggest that neurodevelopmental treatment and Vojta techniques improve postural control. Little evidence supports the efficacy of early intervention, but researchers have not yet studied effects on the family. Strengthening, electrical stimulation, the use of orthoses, and seating show positive effects in studies of small numbers of subjects. For severely involved children, ease of care and comfort are important goals, as well as prevention of deformity, which is important for all children. To the extent possible, therapy should prepare a child for independent adult life. In early intervention through school age, therapy focuses on promoting communication, self-care, and mobility. Independence is a key issue for adolescents transitioning into adulthood. The rehabilitation and health needs of adults with cerebral palsy need to be addressed. Research needs to determine the effects of physical therapy not only on impairment but also on function and disability

Bensman A.S. and Szegho M. (1978) Cerebellar electrical stimulation: a critique. *Arch. Phys. Med. Rehabil.* 59, 485-487.  
Abstract: Cerebellar electrical stimulation has been advocated as a beneficial treatment device for improving function in cerebral palsy, but a review of the literature raises questions as to its efficacy and safety. Evaluation of one reported study showed that only 32% of people with implanted cerebellar stimulators had significant improvement in function. This is in contrast to 68% to 92% improvement levels claimed by advocates of the procedure. There is evidence of potential long-term damage to the cerebellum from the device. Further studies are indicated, following the criteria established by the 1976 Medical Device Amendment to the Drug and Cosmetic Act dealing with medical device regulation and control

Bergstrom M.R., Johansson G.G., Laitinen L.V., and Sipponen P. (1966) Electrical stimulation of the thalamic and subthalamic area in cerebral palsy. *Acta Physiol Scand.* 67, 208-213.

Bogey R.A., Perry J., Bontrager E.L., Gronley J.K. (2000) Comparison of across-subject EMG profiles using surface and multiple indwelling wire electrodes during gait. *J Electromyogr Kinesiol* 10, 255-259.

Botte M.J., Keenan M.A. (1987) Reconstructive surgery in the upper extremity in the patient with head trauma. *J Hand Trauma* 2, 34-45.

Botte M.J., Waters R.L., Keenan M.A. (1988) Orthopaedic management of the stroke patient: Part I: Pathophysiology, limb deformity and patient evaluation. *Orthop Rev* 27, 637-647.

Botte M.J., Bruffey J.D., Copp S.N., Colwell C.W. (2000) Surgical reconstruction of acquired spastic foot and ankle deformity. *Foot Ankle Clin* 5, 381-416. Abstract: With the aging population and improved methods of emergency transport, the number of surviving stroke and brain injury patients continues to increase. Aggressive rehabilitation of appropriate candidates is justified. In the period of

spontaneous recovery, efforts are made to prevent fixed contractures using passive mobilization, splinting, nerve blocks, and electrical stimulation. If deformity persists and the patient is no longer recovering, operative management can help alleviate the functional and hygiene problems associated with these limb deformities.

Brandell B.R. (1982) Development of a universal control unit for functional electrical stimulation (FES). *Am. J. Phys. Med.* 61, 279-301.

Abstract: In collaboration with the College of Engineering the author has developed a laboratory, or clinic, based, battery operated "universal" control system, designed to improve disabled gait in upper motor neuron disabilities, especially stroke, hemiplegia, and cerebral palsy, by applying several channels of FES (Functional Electrical Stimulation) to the lower limb muscles while the patient is walking. The timing of the FES pulses, which can be applied to as many as six of the patient's muscles, is determined by potentiometer controlled one-shot timers, which are triggered by any of three switches in the sole of either shoe. Combinations of inverters, flip flops, AND gates and OR gates in the externally connected logic circuits determine the sequence of delays and pulses applied to the patient's muscles. This paper describes and diagrams some of the logic circuits and as an example of the possible application of the concept of a "universal" control unit reports the modifications of gait induced in a hemiplegic, four year post-stroke, patient. The characteristics of this patient's gait with FES in comparison to its characteristics without FES are demonstrated with motion picture frames, EMG recordings and graphic tracings of her right knee and ankle joint positions. They include more symmetrical timing of her right and left stance and swing phases, increased dorsiflexion of her right ankle in the swing phase, followed by a more distinct heel strike, and improved flexion--extension sequences of the knee and ankle joints and an increased heel rise in the stance phase. The author concludes that the gait characteristics of some hemiplegic patients will improve as they become adapted over a period of weeks or months to a control logic, which lessens their functional limitations by the use of a properly timed and amplified sequence of FES pulses. He suggests that the FES control requirements for individual patients should be determined experimentally with a control system "universally" adaptable to a wide range of disabilities, and that these control parameters could then determine the design of portable units, which may be used on a long term basis. These units would include only the operational options needed to duplicate the gait corrections found to be practicable for each individual patient, by the testing procedure, through a universal logic unit as described in this paper

Campbell J.M., Ball J. (1978) Energetics of Walking In Cerebral Palsy. In: Waters R., et al: Energetics: Application to the Study and Management of Locomotor Disabilities. *Ortho Clin No Am* 9:351-377.

Campbell J.M., Meadows P.M. (1992) Therapeutic FES: From Rehabilitation to Neural Prosthetics. *Assistive Technology* 4, 4-18.

Carmick J. (1993) Clinical use of neuromuscular electrical stimulation for children with cerebral palsy, Part 1: Lower extremity. *Phys. Ther.* 73, 505-513.

Abstract: This report, part 1 of a two-part case report on the clinical use of neuromuscular electrical stimulation (NMES) for children with cerebral palsy, documents the functional changes that occurred with the application of NMES to the lower extremity of three male children, 1.6, 6.7, and 10 years of age, all with

hemiplegia due to cerebral palsy. Neuromuscular electrical stimulation was used in conjunction with a dynamic-systems, task-oriented model of motor learning. The children tolerated NMES well and at times demonstrated carryover after the removal of NMES. The youngest child showed immediate change in the ability to walk and run symmetrically. The two older boys demonstrated significant improvement in locomotor efficiency in a short time, although they were of an age when this improvement was not expected. One boy's Physiological Cost Index (PCI) measurement (a measure of locomotor efficiency) improved fourfold, and the other boy's PCI measurement improved by a factor of two. The results show preliminary evidence for the usefulness of NMES as an adjunct to the physical therapy program for improving function in children with cerebral palsy

Carmick J. (1993) Clinical use of neuromuscular electrical stimulation for children with cerebral palsy, Part 2: Upper extremity. *Phys. Ther.* 73, 514-522.

Abstract: This report, part 2 of a two-part case report on the clinical use of neuromuscular electrical stimulation (NMES) for children with cerebral palsy, documents the functional changes that occurred with the application of NMES to the upper extremity of two children, 1.6 and 6.7 years of age, with hemiplegia due to cerebral palsy. The NMES was used as an adjunct to a dynamic-systems, task-oriented physical therapy program. The youngest child showed immediate improvement in the ability to crawl and use both hands together. The older child demonstrated increased sensory awareness and use of the nonfunctional hand. Preliminary findings suggest that NMES may be a useful physical therapy tool for enhancing muscle strength increasing sensory awareness, and assisting motor learning and coordination

Carmick J. (1995) Managing equinus in children with cerebral palsy: electrical stimulation to strengthen the triceps surae muscle. *Dev. Med. Child Neurol.* 37, 965-975.

Abstract: A new therapeutic proposal for the management of equinus in children with cerebral palsy is to strengthen the calf muscles instead of weakening them surgically. Prior research indicates that in children with cerebral palsy the triceps surae muscle is weak and needs strengthening. Neuromuscular electrical stimulation (NMES) was used as an adjunct to physical therapy. A portable NMES unit with a hand-held remote switch stimulated an active muscle gait cycle. Results are discussed for four children, who showed improved gait, balance, posture, active and passive ankle range of motion, and foot alignment. The toe walkers became plantigrade and the equinovalgus posture of the foot decreased. Spasticity did not increase

Carmick J. (1997) Use of neuromuscular electrical stimulation and [corrected] dorsal wrist splint to improve the hand function of a child with spastic hemiparesis. *Phys. Ther.* 77, 661-671.

Abstract: This case report describes a program for a child with spastic hemiparesis who had previously received physical therapy with neuromuscular electrical stimulation (NMES). After a year without physical therapy, he returned to continue to receive NMES to strengthen muscles, increase sensory awareness, and improve hand function. The child quickly regained his previous level of functioning and made additional progress. After 38 sessions, he still lacked adequate wrist stability for independent hand function. A dorsal wrist splint was used to stabilize the wrist while NMES facilitated muscle activity of the hand and wrist. While wearing the splint, the

child could use his hand independently without adult interference or "assistance," thus allowing motor learning to occur. After 24 additional sessions (i.e., 9 months of using the splint), the child could use the hand for activities such as tying his shoelaces without the splint. No increase in spasticity was seen in spite of strengthening the spastic finger flexors

Cooper I.S., Upton A.R., and Amin I. (1980) Reversibility of chronic neurologic deficits. Some effects of electrical stimulation of the thalamus and internal capsule in man. *Appl. Neurophysiol.* 43, 244-258.

Abstract: Stimulation of the thalamus and internal capsule with Medtronic deep brain stimulation electrodes produced improvement in pain, hemiparesis, dystonia, torticollis, tremor, speech impairment and epilepsy. Stimulation at voltages above or below clinically effective levels (e.g., 6 V, 0.3 ms, 74 Hz) resulted in a loss of clinical efficacy. Somatosensory evoked responses (short and long latency) and depth electrode recordings were helpful in localisation and 'biocalibration' of electrical stimulation

Dubowitz L., Finnie N., Hyde S.A., Scott O.M., and Vrbova G. (1988) Improvement of muscle performance by chronic electrical stimulation in children with cerebral palsy. *Lancet* 1, 587-588.

Galanda M. and Zoltan O. (1987) Motor and psychological responses to deep cerebellar stimulation in cerebral palsy (correlation with organization of cerebellum into zones). *Acta Neurochir. Suppl (Wien.)* 39, 129-131.

Abstract: The study includes 68 cases of cerebral palsy stereotactically operated on from 1977. Deep cerebellar stimulation treatment was performed. The motor and psychological responses to electrical stimulation of 305 points of subcortical regions of cerebellum, mostly lobus anterior were analysed. The characteristic response-- slight motor jerk immediately-- followed by relaxation and feeling of pleasure, even laughing, to the electrical stimulation from selected points was always found. The level of stimulating current must be adjusted individually. The higher current increased pathological posture, muscular tonus and was conducted with the state of fear. The lower current was without detectable influence on the patient. On the trajectory of electrode, nearly perpendicular to the sagittal plane were narrow areas, which recurred as the strips, from where it was possible or not to elicit characteristic response. The most convenient target is in the region of brachia conjunctiva cerebelli. Localization of the point of stimulation in respect to organization of cerebellum into sagittally oriented zones and the parameters of stimulation seem to contribute to the diversity of responses to cerebellar stimulation

Galanda M. and Hovath S. (1997) Different effect of chronic electrical stimulation of the region of the superior cerebellar peduncle and the nucleus ventralis intermedius of the thalamus in the treatment of movement disorders. *Stereotact. Funct. Neurosurg.* 69, 116-120.

Abstract: The stereotactic target for essential tremor is usually restricted to the nucleus ventralis intermedius of the thalamus, where total immediate suppression of tremor is obtained by continuous chronic electrical stimulation. According to authors' experience in cerebral palsy, chronic stimulation of the region of the superior cerebellar peduncle can diminish spasticity and dyskinesias. The effect of this stimulation is gradual and persists, so stimulation is applied 3-8 times daily for 15-20 min, and is accompanied by a feeling of pleasure. After interruption of chronic

stimulation, the effects last for days or weeks. It is suggested that the changes in synaptic connections-- reactive synaptogenesis--can also contribute

Gill S., Curran A., Tripp J., Melarickas L., Hurran C., and Stanley O. (2001) Hyperkinetic movement disorder in an 11-year-old child treated with bilateral pallidal stimulators. *Dev. Med. Child Neurol.* 43, 350-353.

Abstract: Pallidal stimulation is widely used in the treatment of movement disorder in adults but is less well reported in the treatment of dystonia in children. Despite inconsistent results in the past, its use in dystonia in Parkinson's disease is again attracting interest with promising results. Bilateral as well as unilateral pallidotomies have been performed and are felt to be required in some cases of dystonia. Use of depth electrodes to provide long-term electrical stimulation to pallidum and other basal ganglia structures has recently become more widespread. This technique is felt to have a lower morbidity, especially in bilateral procedures. Here we present the case of an 11- year-old boy with severe hyperkinetic movement disorder who showed sustained improvement after bilateral pallidal stimulation implantation

Gottlieb G.L., Myklebust B.M., Stefoski D., Groth K., Kroin J., and Penn R.D. (1985) Evaluation of cervical stimulation for chronic treatment of spasticity. *Neurology* 35, 699-704.

Abstract: Electrical stimulation of the spinal cord (SCS) to reduce spasticity was evaluated in seven patients who, along with their physicians, perceived significant and prompt benefit from stimulation. In two 24- hour test periods, on or off stimulation, we used two independent methods of evaluation: quantitative measures of joint compliance and stretch reflexes, and a standardized neurologic examination. Neither method did better than chance in determining whether SCS was actually being received. Problems with the experimental protocol are discussed, but the results cannot be interpreted as supporting the efficacy of SCS as a treatment for spasticity

Gracanic F. (1977) Use of electrical stimulation in external control of motor activity and movements of human extremities. Actual situation and problems. *Med. Prog. Technol.* 4, 149-156.

Abstract: Functional electrical stimulation (FES) is used in control of motor activity and movements in patients suffering movement handicaps due to central nervous system damage. The method is analyzed from the viewpoint of physical medicine, biocybernetics and technological development. Systems developed to date are presented and a critical survey of the method in light of indications is provided. Special attention is devoted to the present applicability of the systems of FES and to their potential use

Gracanic F. (1978) Functional electrical stimulation in control of motor output and movements. *Electroencephalogr. Clin. Neurophysiol. Suppl* 355-368.

Abstract: In patient with damaged upper motor neurones we show the therapeutic effect of electrical stimulation (called FES) of peripheral mixed nerves on the restoration of motor activity and movements. The results of neurophysiological, kinesiological and clinical observations are presented. We discuss the possible mechanisms, especially the spinal ones, which are fundamental for such a rhythmic activity as gait. We discuss them also from the point of view of activation of proprioceptive feedback mechanisms and of achieved sensory reinforcement influencing the spinal reflex mechanisms as well as the preserved supraspinal

integrated activity which contributes to the long- term FES effect. The stimulation modes, the control of stimuli in relation to the needs of individual patients (hemiplegia in adults, paraparesis, cerebral palsy in children and multiple sclerosis) as well as the motor deficit are discussed. We conclude that the electronic system used for this purpose represents a functionally active orthotic aid with therapeutic effects

Hazlewood M.E., Brown J.K., Rowe P.J., and Salter P.M. (1994) The use of therapeutic electrical stimulation in the treatment of hemiplegic cerebral palsy. *Dev. Med. Child Neurol.* 36, 661-673.

Abstract: The effect of electrical stimulation of the anterior tibial muscles of children with hemiplegic cerebral palsy was studied. 10 children received electrical stimulation, applied by their parents daily for an hour for 35 days; they were compared with 10 matched controls. Active and passive ranges of movement of the ankle, and knee and ankle motion during walking were measured before and after therapy using electrogoniometers. The results showed a significant increase in passive range of movement among children receiving electrical stimulation. Gait analysis of knee and ankle motion showed little change

Keenan M.A., Perry J., Jordan C. (1984) Factors affecting balance and ambulation following stroke. *Clin Orthop Rel Res* 182, 165-171.

Keenan M.A., Perry J. (1990) Evaluation of upper extremity motor control in spastic brain-injured patients using dynamic electromyography. *J Head Trauma Rehabil* 5, 13-22.

Kerrigan D.C., Gronley J.K., Perry J. (1991) Stiff-legged gait in spastic paralysis: a study of quadriceps and hamstring activity. *Am J Phys Med* 70, 294-300.

Leyendecker C. (1975) [Electrical stimulation therapy and its effects on the general activity of motor impaired cerebral palsied children; a comparative study of the Bobath physiotherapy and its combination with the Hufschmidt electrical stimulation therapy (author's transl)]. *Rehabilitation (Stuttg)* 14, 150-159.

Abstract: The purpose of this study was to answer the following questions: (1) Is it more effective to treat spastic cerebral palsy with the Hufschmidt electrical stimulation therapy combined with the Bobath neuro- development treatment or only with the Bobath therapy? (2) Can a general increase in activity be obtained by the electrotherapeutic muscle stimulation? A test group (combined Hufschmidt/Bobath therapy) and a control group (Bobath), both consisting of 10 subjects, were observed for four months. The duration of observation was divided into two four months treatment periods with a rest interval of two months in between. At the start of therapeutic measures, motor activity and psychic condition were tested with corresponding motometric and psychodiagnostic techniques; three check-up examinations were carried out at the end of the first, and at the beginning and end of the second period of treatment. The motor-metric control examination showed that at the end of the first period the test group had achieved by far the better results, but at the end of the second therapeutic period, both groups were equally successful. The combined electrophysiotherapy hence reached in a relatively shorter t

Metherall P., Dymond E.A., and Gravill N. (1996) Posture control using electrical stimulation biofeedback: a pilot study. *J. Med. Eng Technol.* 20, 53-59.

Abstract: The investigation studied the effects of biofeedback on the sitting posture of

a 14 year old girl with cerebral palsy. The subject's posture was quantified using a video analysis technique which established the threshold of poor posture at 30 degrees from the vertical plane. A stimulator system was designed using an adapted drop foot stimulator and a custom made controller with a mercury tilt switch as the posture angle transducer. If posture became greater than 30 degrees tactile electrical stimulation was administered to the subject's lower back. Repetitive stimuli occurred on non-correction of posture, with a maximum of 4 consecutive stimuli, upon which an alarm was activated. 10 training sessions of 20 min duration were completed over a 4 week period, monitored using a data logger. Following initial improvement the daily results show a gradual deterioration in posture, whilst post-trial video analysis indicates a significant improvement in posture. An improved response to the alarm stimulus is observed. Reasons for these conflicting findings are discussed

Miyazaki M.H., Lourencao M.I., Ribeiro Sobrinho J.B., and Battistella L.R. (1992) [Functional electric stimulation (FES) in cerebral palsy]. *Rev. Hosp. Clin. Fac. Med. Sao Paulo* 47, 28-30.  
Abstract: Our study concerns a patient with cerebral palsy, submitted to conventional occupational therapy and functional electrical stimulation. The results as to manual ability, spasticity, sensibility and synkinesis were satisfactory.

Montgomery J., Perry J. (1987) Stroke patient gait and orthotics indications. In: Brandstater M., Basmajian J. [Eds]: *Stroke Rehabilitation*. Baltimore, Williams & Wilkins.

Mooney V., Perry J., Nickel V.L. (1969) Surgical and non-surgical orthopaedic care of stroke. In: American Academy of Orthopaedic Surgeons [Eds]: *Instructional Course Lectures, Vol XVIII, J2*. St. Louis, C.V. Mosby Co.

Pape K.E., Kirsch S.E., Galil A., Boulton J.E., White M.A., and Chipman M. (1993) Neuromuscular approach to the motor deficits of cerebral palsy: a pilot study. *J. Pediatr. Orthop.* 13, 628-633.  
Abstract: Six children with mild cerebral palsy (CP) entered a study of overnight low-intensity transcutaneous electrical stimulation (ES) to the leg muscles. After 6 months, statistically significant improvement was noted on the Peabody Developmental Motor Scales scores in gross motor, locomotor, and receipt/propulsion skills. When ES was withdrawn for 6 months, there was uniform loss in scores. Reinstitution of ES resulted in further significant improvements in total gross motor, balance, locomotor, and receipt/propulsion skills. In selected cases, overnight ES may be a useful addition to standard rehabilitation services

Penn R.D., Myklebust B.M., Gottlieb G.L., Agarwal G.C., and Etzel M.E. (1980) Chronic cerebellar stimulation for cerebral palsy. Prospective and double-blind studies. *J. Neurosurg.* 53, 160-165.  
Abstract: The effects of chronic electrical stimulation of the cerebellum in patients with cerebral palsy have been studied using objective tests of joint compliance, and standardized assessments of developmental reflexes and motor skills. Of 14 patients studied prospectively for 1 to 44 months, 11 showed improvement in motor function. A double-blind test of 10 patients off and on stimulation for an average 8-week period showed no significant changes. Thus, we have no proof that the functional improvements seen with long-term stimulation are the result of cerebellar stimulation

- Perry J., Waters R.L., Perrin T. (1978) Electromyographic analysis of equinovarus following stroke. *Clin Orthop Rel Res* 131, 47-53.
- Perry J., Giovan P., Harris L.J., Montgomery J., Azaria M. (1978) The determinants of muscle action in the hemiparetic lower extremity (and their effect of the examination procedure). *Clin Orthop Rel Res* 131, 71-89.
- Perry J., Easterday C.S., Antonelli D.J. (1981) Surface versus intramuscular electrodes for electromyography of superficial and deep muscles. *Phys Ther* 61, 7-15.
- Perry J., Garrett M., Gronley J.K., Mulroy S.J. (1995) Classification of walking handicap in the stroke population. *Stroke* 26, 982-989.
- Perry J. (1998) The contribution of dynamic electromyography to gait analysis. In: Rehabilitation Research and Development Service [Ed]: *Gait Analysis in the Science of Rehabilitation*. Washington D.C., Department of Veterans Affairs, pp 33-48.
- Perry J. (1999) The use of gait analysis for surgical recommendations in traumatic brain injury. *J Head Trauma Rehabil* 14, 116-135.
- Perry J., Waters R.L. (1975) Orthopaedic evaluation and treatment of stroke patient. *AAOS Instr Course Lect* 24, 40-44.
- Pinder R.M., Brogden R.N., Speight T.M., and Avery G.S. (1977) Dantrolene sodium: a review of its pharmacological properties and therapeutic efficacy in spasticity. *Drugs* 13, 3-23.
- Abstract: Dantrolene sodium or dantrolene<sup>1</sup> is 1-[[5-(nitrophenyl)furfurylidene] amino] hydantoin sodium hydrate. It is indicated for use in chronic disorders characterised by skeletal muscle spasticity, such as spinal cord injury, stroke, cerebral palsy and multiple sclerosis. Dantrolene is believed to act directly on the contractile mechanism of skeletal muscle to decrease the force of contraction in the absence of any demonstrated effects on neural pathways, on the neuromuscular junction, or on the excitable properties of the muscle fibre membranes. Controlled trials have demonstrated that dantrolene is superior to placebo in adults or children with spasticity from various causes, as evidenced by clinical assessments of disability and daily activities, and by muscle and reflex responses to mechanical and electrical stimulation. It is somewhat less effective in patients with multiple sclerosis than in those with spasticity from other causes. There has been a general clinical impression in controlled trials that dantrolene caused less sedation than would have been expected from therapeutically comparable doses of diazepam. In 2 controlled trials, there was no significant difference between dantrolene and diazepam in terms of reductions in spasticity, clonus, and hyperreflexia, but side-effects such as drowsiness and inco-ordination occurred significantly more frequently on diazepam. Long-term studies have indicated continuing benefit for patients taking dantrolene, though the incidence of side-effects has often been high and there has been a suggestion of exacerbation of seizures in children with cerebral palsy. Dantrolene may be of value in the medical treatment of spasm of the external urethral sphincter due to neurological and non-neurological disease, and animal studies suggest a potential use in the management of malignant hyperpyrexia. Chemical evidence of liver dysfunction may occur in 0.7 to 1% of patients on long-term treatment with dantrolene, with symptomatic hepatitis in 0.35 to 0.5% and fatal hepatitis in 0.1 to

0.2%. The drug commonly causes transient drowsiness, dizziness, weakness, general malaise, fatigue and diarrhoea at the start of therapy. Muscle weakness may be the principal limiting side-effect in ambulant patients, particularly in those with multiple sclerosis, and therapy could be hazardous in patients with pre-existing bulbar or respiratory weakness. The dosage of dantrolene has been fixed in most controlled trials, though long-term studies have indicated the need for individualisation of dosage. The initial dose is usually 25mg once daily, increasing to 25mg two, three or four times daily, and then by increments of 25mg up to as high as 100mg two, three or four times daily. The lowest dose compatible with optimal response is recommended

Ray C.D. (1978) Electrical stimulation: new methods for therapy and rehabilitation.

*Scand. J. Rehabil. Med.* 10, 65-74.

Abstract: Electrical stimulation is emerging as a new therapeutic and rehabilitative agent. Reviewed are pain control, restoration of lost functions and alteration of abnormal movement and other functions using electrical stimulation. Reported for acute and chronic pain control use are transcutaneous, dorsal column, spinal cord, peripheral nerve, and direct brain stimulation methods and results. Overall success ranges up to 50% for chronic pain problems and up to 80% for acute pain; e.g., postoperative incisional pain, sports medicine, and trauma. Restoration of lost function has broad implications for the future. These include phrenic nerve pacing for respiration, foot drop control, restoration of bladder function, and grasp control in the spinal cord-injured patient. Amelioration of abnormal function includes stimulation for epilepsy and cerebral palsy, certain symptoms of multiple sclerosis and scoliosis. The effects of electrostimulation are completely reversible and nondestructive. Technical details of devices and stimulus waveforms are also briefly considered

Scheker L.R., Cheshier S.P., and Ramirez S. (1999) Neuromuscular electrical stimulation and dynamic bracing as a treatment for upper-extremity spasticity in children with cerebral palsy. *J. Hand Surg. [Br.]* 24, 226-232.

Abstract: We have investigated a therapeutic regimen using neuromuscular electrical stimulation (NMES) and dynamic bracing to assess their effectiveness in reducing upper-extremity spasticity in children with cerebral palsy. Nineteen patients between 4 and 21 years of age with documented diagnoses of spastic cerebral palsy were treated. The patients included in the study followed a regimen of two 30-minute sessions of NMES of the antagonist extensors combined with dynamic orthotic traction during the day. A static brace was used at night. Spasticity of the wrist and fingers was assessed periodically using the Zancolli classification. Treatment ranged from 3 to 43 months. After treatment with electrical stimulation and dynamic bracing, all the patients moved up 1 to 3 levels in the Zancolli classification and showed a marked improvement in upper-extremity function. These results show that combining NMES and dynamic orthotic traction dramatically decreases spasticity of the upper extremity in young patients with cerebral palsy

Steinbok P., Reiner A., and Kestle J.R. (1997) Therapeutic electrical stimulation following selective posterior rhizotomy in children with spastic diplegic cerebral palsy: a randomized clinical trial. *Dev. Med. Child Neurol.* 39, 515-520.

Abstract: A randomized controlled trial was carried out to determine the effectiveness of therapeutic electrical stimulation (TES) in improving the function of children with spastic cerebral palsy (CP), who had undergone selective posterior lumbosacral rhizotomy more than a year previously. Children were randomly assigned to groups

to receive TES for 1 year, or to have no TES. The primary outcome was the change in the Gross Motor Function Measure (GMFM), a quantitative and validated measure for use in children with spastic CP. There was a statistically significant and clinically important improvement in outcome for the treated children, with the mean change in the GMFM score at one year being 5.5% compared with 1.9% in the untreated group ( $P = 0.001$ ). TES was simple to use, had no significant complications, and was well accepted by the children and their caregivers, as indicated by an average compliance of 93% for the application of TES on a nightly basis over the course of the study. It was concluded that TES may be beneficial in children with spastic CP who have undergone a selective posterior rhizotomy procedure more than 1 year previously

Taylor P.N., Burridge J.H., Dunkerley A.L., Lamb A., Wood D.E., Norton J.A., and Swain I.D. (1999) Patients' perceptions of the Odstock Dropped Foot Stimulator (ODFS). *Clin. Rehabil.* 13, 439-446.

Abstract: OBJECTIVE: To determine the perceived benefit, pattern and problems of use of the Odstock Dropped Foot Stimulator (ODFS) and the users' opinion of the service provided. DESIGN: Questionnaire sent in a single mailshot to current and past users of the ODFS. Returns were sent anonymously. SETTING: Outpatient-based clinical service. SUBJECTS: One hundred and sixty-eight current and 123 past users with diagnoses of stroke (CVA), multiple sclerosis (MS), incomplete spinal cord injury (SCI), traumatic brain injury (TBI) and cerebral palsy (CP). INTERVENTION: Functional electrical stimulation (FES) to correct dropped foot in subjects with an upper motor neuron lesion, using the ODFS. MAIN OUTCOME MEASURES: Purpose-designed questionnaire. RESULTS: Return rate 64% current users (mean duration of use 19.5 months) and 43% past users (mean duration of use 10.7 months). Principal reason cited for using equipment was a reduction in the effort of walking. Principal reasons identified for discontinuing were an improvement in mobility, electrode positioning difficulties and deteriorating mobility. There were some problems with reliability of equipment. Level of service provided was thought to be good. CONCLUSION: The ODFS was perceived by the users to be of considerable benefit. A comprehensive clinical follow-up service is essential to achieve the maximum continuing benefit from FES-based orthoses

Waters R.L., Perry J. (1978) Surgical correction of gait abnormalities following stroke. *Clin Orthop Rel Res* 131, 54-63.

Waters R.L., Garland D.E., Perry J. (1979) Stiff-legged gait in hemiplegia: Surgical correction. *J Bone Joint Surg* 61A, 927-933.

Waters R.L., Frazier J., Garland D., Jordan C., Perry J. (1982) Electromyographic gait analysis before and after treatment for hemiplegic equinus and equinovarus deformity. *J Bone Joint Surg* 64A, 284-288.

Waters R.L., Botte M.J., Jordan C., Perry J., Pinzur M.S. (1990) SYMPOSIUM: Rehabilitation of Stroke Patients – The Role of the Orthopaedic Surgeon. *Contemporary Orthopaedics* 20, 311-348.

Wright P.A. and Granat M.H. (2000) Improvement in hand function and wrist range of motion following electrical stimulation of wrist extensor muscles in an adult with cerebral palsy. *Clin. Rehabil.* 14, 244-246.

Wright P.A. and Granat M.H. (2000) Therapeutic effects of functional electrical stimulation of the upper limb of eight children with cerebral palsy. *Dev. Med. Child Neurol.* 42, 724-727.

Abstract: Functional electrical stimulation (FES) of the upper limb has been used for patients with a variety of neurological conditions, although few studies have been conducted on its use on the upper limb of children with cerebral palsy (CP). The aim of this study was to investigate the effect of cyclic FES on the wrist extensor muscles of a group of eight children (five boys, three girls) with hemiplegic CP (mean age 10 years). The study design involved a baseline (3 weeks), treatment (6 weeks), and follow-up (6 weeks). FES was applied for 30 minutes daily during the treatment period of the study. Improvements in hand function ( $p < \text{or} = 0.039$ ) and active wrist extension ( $p = 0.031$ ) were observed at the end of the treatment period. These improvements were largely maintained until the end of the follow-up period. No significant change was observed in the measurements of wrist extension moment during the treatment period ( $p = 0.274$ ). Hand function in this group of children improved after they were exposed to FES of wrist extensor muscles. This suggests that FES could become a useful adjunct therapy to complement existing management strategies available for this patient population.