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The Effect of Functional Electrical Stimulation in Adult Spasticity- A Case Study

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ABSTRACT

Cerebral palsy (CP) describes a group of permanent movement disorders of development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing foetal or infant brain. Functional electrical stimulation (FES), also known as functional neuromuscular stimulation (FNS) is the method of applying safe levels of electric current to activate the damaged or disabled neuromuscular system. Recent evidence affirms the rationale of applying FES to paralyzed or paretic muscles in order to modulate central nervous system (CNS) plasticity. Adults with chronic neurological conditions can also benefit from FES treatments but there are gaps in clinical knowledge, awareness and evidence which needs addressing. This is a case report of a 38 year old male having CP with on and off treatment. He reported a fixed flexion deformity at both knees and reduced range of motion at all joints of lower limbs. His functional independence scores were also on the lower side indicating dependence in activities of daily living. Physiotherapy management along with FES was prescribed for 4 weeks, Goniometer for range of motion and Bergs Balance Scale along with Functional Reach test for functional independence were the outcome measures used. Treatment helped the client move from Grade 2 on MAS to Grade 1. Range of motion for all the lower limb joints improved and scores on functional independence scales were also increased. Physiotherapy along with FES can be used as a treatment of choice for modifying spasticity in long standing cases of injuries to central nervous system.

Keywords: Functional electrical stimulation, Adult Cerebral palsy, Spasticity, Physiotherapy

INTRODUCTION

Cerebral palsy refers to a group of neurological disorders that appear in infancy or early childhood and permanently affect body movement and muscle coordination CP is caused by damage to or abnormalities inside the developing brain that disrupt the brain's ability to control movement and maintain posture and balance. The term cerebral refers to the brain; palsy refers to the loss or impairment of motor function. Cerebral palsy affects the motor area of the brain's outer layer (called the cerebral cortex), the part of the brain that directs muscle movement.

In some cases, the cerebral motor cortex hasn't developed normally during foetal growth. In others, the damage is a result of injury to the brain either before, during, or after birth. In either case, the damage is not repairable and the disabilities that result are permanent. **(1)**

The insult to the brain is believed to occur between the times of conception till the age of 2years. The significant amount of motor development occurs during this period, by the age of 8years most of the motor development of the immature brain is complete, and an insult results in a more adult type of neural deficits. The motor

disorders of cerebral palsy are often accompanied by disturbances of sensations, perception, cognition, communication, behaviour, epilepsy and secondary musculoskeletal problems. Worldwide, the prevalence ranges from 0.6 to 7.0 cases per 1000 live births. [(2)]

Spastic CP is the most common type of cerebral palsy, constituting about 80% of cases, associated with injury to the pyramidal tracts in the immature brain. It is velocity dependent increase in muscle tone. [(2)] It is caused by damage to the upper motor neuron in cortex or along the pathways which terminate in spinal cord. It is characterized by increase in deep tendon reflexes and extensor plantar responses. Deformities of joints develop which may become fixed contractures with time. [(3)]

Non operative modalities, such as medication, splinting and bracing, and physical therapy, commonly are used as primary treatment or in conjunction with other forms of treatment such as surgery. A wide variety of medications have been used to treat cerebral palsy. The three most common agents are diazepam and baclofen, which act centrally, and dantrolene, which acts at the level of skeletal muscle. Physical therapy is an essential component in the treatment of patients with cerebral palsy. Physical therapy typically is used as a primary treatment modality and in conjunction with other modalities, such as casting, bracing, BTX-A, and surgery. The therapist plays a crucial role in all aspects of care, including identifying children who may have cerebral palsy, treating their spasticity and contractures, fabricating splints and simple braces, providing family education and follow-up, acting as a liaison with the school and other health care providers, and implementing home stretching and exercise programs with the patients and their families. [(2)]

Many patients with cerebral palsy return for orthopedic care in their thirties and forties when compensatory mechanisms they have relied on in the past begin to fail. This transition from care in the pediatric setting to the adult setting can be challenging for patients and physicians because of a lack of communication between the two systems, fear of the new system, and different treatment styles for adults and children. Common orthopedic problems for adults with cerebral palsy include fatigue, knee instability that arises from long-standing, ankle equinus, degenerative hip disease, flatfoot deformity and scoliosis. Osteopenia also is frequently present in adults with cerebral palsy, which can predispose them to fractures. [(2)]

A patient-centered approach, just as with children, should be used in treating an adult with cerebral palsy. Not all deformities require treatment, and attention should be focused on the deformities that cause pain or interfere with independent function. If mentally able, the adult should be given some responsibility for decisions regarding treatment aims and methods. Some orthotic devices may become cosmetically unacceptable, but it may be possible to compromise with sustainable alternatives. [(4)]

FES also known as the functional neuromuscular electrical stimulation (FNS) or neuromuscular electrical stimulation (NMES) is a method of applying safe levels of electrical current to activate the damaged or disabled neuromuscular system. [(5)] It is an adjunct to exercises and has shown to reduce spasticity and provide increased independence in children with CP.

When a sufficiently strong external electric field is applied to a nerve via a pair of electrodes, depolarization of the axon will occur. If depolarization occurs with sufficient intensity and speed, the membrane will reach threshold and an action potential will fire and propagate bi-directionally. [(5)] FES has been successfully used in children with CP, [(6)] [(7)] stoke rehabilitation, [(8)] traumatic brain injury [(9)] but minimal evidence is available for using FES in long standing cases of neuro-motor injury. This particular study focuses on building evidence to the use of FES even in old chronic cases of neuromuscular damage.

CASE STUDY

A 38 year old male diagnosed with Spastic Diplegic Cerebral Palsy was referred for physiotherapy. Patient gave a history of birth asphyxia and has received physiotherapy on and off for the past 38 years. He presented to us with spasticity (MAS Grade 2) in both lower limbs, moderate risk of fall, balance issues and restricted range of motion. He had a fixed flexion deformity at both his knee joints (As reported by his orthopedic doctor) of 25^0 at left and 30^0 at right knee. There was a decrease in general range of motion at the lower extremity and functional independence scores. Balance score using a Bergs Balance Scale was at 29/56 with moderate risk of falling and Functional Reach Test score was 18cms.

Goals set for him were to reduce spasticity and attain functional independence. Informed written consent was obtained from the client and therapy was explained. Conventional Physiotherapy treatment including Bobath ball exercises along with Functional electrical stimulation was recommended for 4 weeks on a trial basis. Treatment was scheduled 6 days a week with alternate days for FES.

Intervention: Physiotherapy with conventional Bobath therapy was recommended for 6 days a week for 4 weeks. The exercises included a stretch strengthen program for muscles of lower limbs, abdominal and core strengthening exercises, Peripheral Neuromuscular Facilitation techniques involving hold relax method and rhythmic initiation for dorsiflexors. Orthosis (bilateral ankle foot orthosis) were provided to the patient and its use explained.

Sensory evaluation did not reveal any abnormality in perceiving sensation hence FES was given to this client. Functional electrical stimulation 3days a week for 4 weeks, (12 sessions) for muscle relaxation by reduction of tonicity was used. Treatment time was 5 mins, No DC component, this reduces the risk of electrochemical damage. System parameters included BF. SYM., 200 µs, 10Hz, frequency sweep 15Hz, sweep cycle 6/6, 5 mins. The sensation felt by client is strong vibration and intensity was increased until client could feel the sensation.

A total training program was used for dorsiflexors; it is a combined program for nonspecific muscle strengthening by means of alternating current. The training itself is started and ended by a muscle relaxation program (just like warm up and cool down). Programme parameters BF. SYM., 200 µs, 10Hz, 1,5 min. 8 sequences of each 2 min. B.F SYM., 200 µs, 45Hz, contraction rhythm 1/4/1/9, interval time of 2 min after each sequence followed by BF. SYM., 200 µs, 10Hz, 1, 5 min. Sequence of gradually increasing and decreasing stimulation (fast ramp up and ramp down) followed by long interval time. Strong vibration at the start and end of the program. Intensity was adjusted to a level until required contraction was reached. Treatment was discontinued if contraction weakens.

RESULTS

There was a marked reduction in spasticity from Grade 2 on MAS to Grade 1 MAS. Range of motion increased by 30^0 in hip flexion bilaterally, 5^0 improvement in right knee flexion and 15^0 improvement in left. Dorsiflexion range increased by 5^0 on right and 10^0 on left and initiation of isolated plantarflexion on left side was achieved. The flexion deformity at knee was also reduced on both the sides. Berg's balance score improved from 29/56 to 39/56 and functional reach test improved from 18 cms to 25 cms. He can now move around with minimal assistance and is more confident in maneuvering his activities of daily living. The client requires minimal support with external appliance for walking a long distance due to moderate risk of falling and requires minimal supervision for certain complex activities.

Table 1: Comparison of ROM.

JOINT	MOVEMENT	PRE		POST	
		RIGHT	LEFT	RIGHT	LEFT
HIP	FLEXION	60	90	90	110
	ABDUCTION	20	24	20	25
KNEE	FLEXION	105	100	110	115
	EXTENSION	FIXED 25	FIXED 30	20	20
ANKLE	DORSIFLEXION	5	10	10	20

DISCUSSION

The use of FES in adult with spinal cord injury, stroke and head injury has shown marked improvements, likewise use of FES in children with cerebral palsy has been addressed to some extent. [(6-9)] Improvements in range of motion and functional independence have been achieved in children with CP. Never before has a 38 year old neurological case treated with FES been reported. This particular case adds to the pool of existing knowledge on FES, implying that FES can be used for long standing neurological injuries as well.

Over 50 clinical studies are published on application of stimulation for modification of spasticity. Three approaches have been used; first approach uses sensory stimulation over the spastic muscle group, second approach elicits muscle contraction in antagonist muscle group for strengthening and simultaneously stretches the spastic muscle and third approach, most recent approach is by stimulating both agonist and antagonist muscle groups. All the three approaches have been statistically equally beneficial. Many patients are likely to experience a long term reduction in spasticity of about 0.7-1 notch on the 0-5 Ashworth scale, a rather modest effect that justifies prescribing FES for spasticity management. [(5)] The current study also showed reduction in spasticity with the use of FES and physiotherapy treatment. Client moved from Grade 2 to Grade 1 MAS in hip and knee extensors.

Recent evidence affirms the rationale of applying FES to paralyzed or paretic muscles in order to modulate CNS plasticity. FES induces transmission of afferent inputs along sensory pathways originating from both muscular and non-contractile structures. Kimberley et al., in 2004 Han et al. in the year 2003 and Smith et al. in the same year have presented evidence of increased excitability in the contralateral hemisphere following excitation of selected peripheral nerves of both stroke survivors and healthy subjects. A potential role for FES in promoting recovery following damage to the brain is derived from the hypothesis evidence that the cortical representation of body segments is continuously modulated in response to activity, inactivity, and skill acquisition. There seems to be competition among body segments for territorial representation in the sensorimotor cortex due to this continuous ongoing process. [(5)] This potential of recovery following brain damage was exhibited in the current case study wherein the client responded to activity, stretching and movement thereby improving his range of motion and obtaining a better posture and balance.

Functional electrical stimulation shows great promise in this particular client by bringing back some degrees of movement free from awkwardness and pain. While the treatment is not widely available, its apparent effectiveness and safety mean that its use will likely become more widespread.

CONCLUSION

Use of FES along with Exercises in spasticity has shown marked improvement in the present case of spastic diplegia. FES stimulates both agonists and antagonists to bring about an improvement in range of motion in both the lower extremities and decreased fall risk in the patient. Physiotherapy management along with FES will play major role in minimizing disability even after 38 years of injury to brain caused by hypoxia. Research is still limited for such

long standing cases of CP but is continually improving and suggests that FES treatment should be given as an option where appropriate. FES has already helped a significant number of people with other conditions, including stroke and paralysis, and it may be only a matter of time before its use is expanded to include more children and adults with cerebral palsy.

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