

EFFECT OF BIOFEEDBACK TRAINING ON CONTROLLING DYNAMIC EQUINUS DEFORMITY IN HEMIPLEGIC CHILDREN

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Abstract:

The purpose of this work was to assess the effect of Biofeedback training on controlling dynamic equines deformity in hemiplegic cerebral palsied children. The study included sixteen cerebral palsied children from both sexes (ten males and six females). Age of patients ranged from seven to nine years. They were selected from the Institute of Poliomyelitis and Physical Medicine in Imbaba, according to certain criteria. These children were randomly divided into two groups of equal number, control and study groups. The control group received traditional therapeutic exercises Program only, while the study group received a program of traditional therapeutic exercises in addition to Biofeedback training. The treatment was conducted for all patients in both groups for one hour/session, three times/week, one session/day, and for 16 successive weeks. Evaluation was performed and compared before and after the suggested period of treatment, including, measuring of active range of motion of the ankle joints, static strength of dorsi-flexors, function ambulation, equines angle and strength deficits of ankle planter flexor muscles. The results of the study group displayed statistically significant improvements regarding mean values of static strength of dorsi- flexors muscles, active range of motion of ankle joints. On the other hand, results of the control group revealed non-significant changes in all measured parameters. Function ambulation showed statistically significant progress in both of the groups, but the biofeedback group was superior to the control group. The benefits afforded from this study indicate that Children with cerebral palsy and dynamic equinus deformities may benefit from biofeedback treatment for ambulation.

Key Words: Biofeedback, dynamic equines deformity, hemiplegic cerebral palsy, function ambulation, static strength

Introduction:

Cerebral palsy is the commonly used term to describe a developmental disability condition, with a range of dysfunction, dependent on the location and extent of damage to the developing brain (**Cioni et al 1997**)⁽⁹⁾. It can be defined as a neuro-developmental impairment, caused by a non-progressive defect or lesion, in single or multiple locations in the immature brain, causing impairment of motor function (**Barry R.S. , 1982**)⁽⁴⁾. Cerebral palsy is commonly classified according to the type of the present movement problem (spastic, hypotonic, athetoid, ataxic or mixed) or according to the body parts involved (hemiplegia, diplegia or quadriplegia) (**Dabney et al, 1997**)⁽¹¹⁾. Equinus deformity is the most common musculoskeletal abnormality in patients with hemiplegics cerebral palsy(**Damiano et al, 1995**)⁽¹²⁾. Functional equinus, manifested by walking and early heel rise, is defined as inadequate dorsi-flexion for normal gait. The ability to accurately identify an equinus condition, and contracture as the contributing factor in equinus deformity, has important implications for the type of treatment prescribed and the evaluation of treatment effectiveness.(**Juels et al (1998)**)⁽¹⁷⁾.The ability to walk is a major concern for children with cerebral palsy and improving or maintaining the stability is often considered to be the primary focus of most therapeutic interventions (**Jules, 1998**)⁽¹⁷⁾. (**E Dursun et al 1992**)⁽¹³⁾ stated that Calf muscle strength and endurance adversely affect ambulation. **Galli (1978)**⁽¹⁵⁾ concluded that loss of unilateral lower limb control has a major impact on the mobility of the patient. The primary effects of the lower limb paralysis are the unsafe and impaired walking ability, Gait training has not been advocated for persons with cerebral palsy, otherwise muscle weakness and restricted force production have been identified in this population. It was suggested that physical therapists have concentrated too long on the reduction of positive symptoms in central nervous system disorders, such as spasticity, while virtually ignoring negative symptoms of weakness and loss of function (**Barry et al 1982**)⁽⁴⁾. There is no evidence that strengthening exercises are detrimental in this population and the literature indicated that these exercises might be beneficial (**Domiano et al, 1998**)⁽¹²⁾.

A variety of methods to reduce equines deformity because of muscle spasticity has been advocated. Injections of Botlinum or alcohol into the gastrocnemius muscles have been used for a long time, but the results are short-lived (**Mousny 1999**). **O`Byrne (1997)**⁽²⁵⁾ and **Vogt (1998)**⁽²⁶⁾ reported that neurotomy or neurectomy of the gastrocnemius has been recommended for dynamic spastic equinus deformity without a triceps contracture. **Woollacatt et al(1996)**⁽²⁹⁾ emphasized the inadequate motor control of the lower extremity, particularly the anti-gravity muscles, has a major contribution to the decrease of the patient's functional level. According to **Bradley et al (1998)**⁽⁷⁾, the application of

Biofeedback training may be considered as a potential method for voluntary control of the calf muscle in cases of stroke patients. They confirmed that biofeedback training altered the contractile properties of muscle towards a state, usable for functional movements, by increasing the muscle strength of the paralyzed limbs. Moreover, **Morris et al (1992)⁽²³⁾** added that biofeedback training has an essential role in increasing the maximum torque, produced by the calf muscle.

Wolf (1991)⁽²⁷⁾ stated that Biofeedback is a technique used for specific neuromuscular and behavioral disorders specially for patient who has difficulty in accessing the information through normal physiologic process such as proprioceptive or visual, it is also used to inform patient about movement, muscle activity, force, joint displacement, skin temperature and heart rate or other physiologic information by amplifying and displaying these information so that patient can learn how to control these signals.

McCulloch and Nelson 1995)⁽²²⁾ reported that Electromyographic biofeedback may be used for assisting the patient to attain the greatest level of muscle activation in a paretic muscle, and lower level of muscle activation of spastic muscle and to attain balance between agonist and antagonist muscle.

Aim of the study:

The aim of the present study was to investigate quantitatively the effectiveness of a treatment program, including Biofeedback training as a primary tool of treatment, designed to control dynamic equines deformity in hemiplegics cerebral palsied children.

SUBJECTS, MATERIALS AND PROCEDURES

(1) Subjects:

Preparatory to beginning this study, it was determined that the subjects chosen to participate should :

should meet the following criteria:

- (1) Be ambulatory.
- (2) Have free passive range of motion in all joints of the affected lower limb.
- (3) Have ability to perform active ankle dorsi-flexion for at least 5 degrees against gravity.
- (4) Have dynamic equines deformity of the affected limb should be confirmed both clinically and radiologically.
- (5) Have Partial activity of the Calf muscles as demonstrated by the dynamometer,
- (6) Have absence of surgical interference of the Ankle joint.

Sufficient cognition should be demonstrated to understand the requirements of the study

sixteen cerebral palsied children from both sexes (ten males and six females). They were selected from the Institute of Poliomyelitis and Physical Medicine in Imbaba. Age of patients ranged from seven to nine years. Degree of spasticity was moderate according to Ashworth Scale (*Bohannon and Smith, 1987*). All patients were able to stand and walk but in an abnormal pattern. Non of them has demonstrated any contracture of the affected lower limb that may interfere with the ability for full weight bearing, All patients have never received biofeedback training at any time before the study. Patients were divided randomly into two groups of equal number, control and study.

(2) Materials :

For Evaluation :

- a)The Chatillon dynamometer: (*Chatillon MSC muscle strength comarator (handheld dynamometer),produced by Nex Gen Ergonomic, inc.*)
- b) Reflected dots.
- c) Television set.
- d) Video camera.
- e) Video set.
- f) Video tapes.
- g) Ruler, protractor and fine pens.

Form (1): Functional ambulation category

Grade	Description
0	Patient cannot walk, or requires help of two or more people.
1	Patient requires firm continuous support from one person, who helps with carrying weights or with balance.
2	Patient needs continuous or intermittent support of one person to help with balance or coordination.
3	Patient requires verbal supervision or stand by help from one person without physical contact.
4	Patient can walk independently on level ground but requires help on stairs or uneven surfaces.
5	Patient can walk independently anywhere.

Adopted from *Hesse et al (1994)*⁽⁶⁾

For Treatment:

- (a) **Bio – Fed 901** (an audiovisual biofeedback device)

(3) Procedures:

A. Evaluation:

- The static strength of the dorsi-flexor muscle and planter-flexors muscles of the affected ankle, was measured by the use of a leg dynamometer (The Chatillon dynamometer) according to the technique of **Amundsen (1990)**⁽¹⁾.
- Static strength of ankle dorsi - flexors was measured by having the subject sit upright, stabilization by trunk straps, in a chair with their foot flat against the floor. The Chatillon dynamometer is placed on top of the foot, directly below the toe line. The subject raises their foot while keeping the heel of the foot isolated and in contact with the floor. The resistance is applied to the foot using the dynamometer and the amount of resistance measured and recorded.
- Static strength of ankle Plantar flexors was measured by having the subject on supine lying position, stabilization by trunk straps and leg straps to bring all parts of calf muscles into action with their toes pointed upward, with their toes pointed downward. The Chatillon dynamometer is placed on the ball of the foot. The subject isolates the ankle and attempts to straighten their foot as resistance is applied by the dynamometer.

Test for each contraction was for about four seconds against the held stationary dynamometer. During evaluation, the patient's head was kept in the midline to prohibit tonic reflexes. Assessment of strength deficits was calculated according to the formula of **Bohannon and Smith (1987)**⁽²⁾.

- ROM of ankle joint dorsi-flexion was measured by utilizing the reflected dots. The reflected dots were placed on the following landmarks on the child's affected lower limb: tip of the fibula, tip of the lateral malleolus and the center of the second metatarsal head (**Mathieu et.al (2003)**⁽²¹⁾). The angle of the Ankle joint was described by **Greiner et al (1993)**⁽¹⁶⁾, as the angle formed between the lateral aspect of the thigh and lateral aspect of the foot. Range of motion evaluation was performed, while the patient was sitting in the same position assumed during static strength of the calf muscles evaluation, with his/her knee at 90° of flexion. Each patient was allowed to perform three successive maximum active dorsi-flexion trials, during which he/she was photographed. Playing back the recorded videotape, the maximum angle, the patient was able to perform in knee extension, was measured, using a protractor.

- The level of functional ambulation was evaluated, by means of the “functional ambulation category” scale. Each patient was allowed to walk for about 10 meters across the treatment room, during which he/she has been observed by three well-trained physical therapists. Each physical therapist scored the patient independently and the mean value was considered as the actual score.

B. Treatment:

- Patients belonging to the control group were subjected to a traditional physical therapy program included: Stretching exercises for Achilles tendon and hamstring muscle, Proprioceptive training in the form of slow rhythmic approximation, touch and weight bearing, Facilitation of postural reaction (righting, equilibrium, and protection), Gait training program e.g. between parallel bars, using walkers, and climbing stairs.
- Patients belonging to the study group received biofeedback training for the dorsi-flexors of the affected in addition to the previously mentioned traditional physical therapy program, ankle . The patient was seated at the same position and back lying position as that assumed during evaluation. The recording electrode was placed and fixed on the belly of tibialis anterior muscle with the reference electrode 5 cm apart and distal to the active one and on the same line, the ground electrode was placed and fixed on the lateral malleolus of the affected side. The patient was instructed to watch the colored leds and to hear the sound of the loud-speaker, the desired movement was demonstrated, and the patient was given 3 active dorsi-flexion training trials, each consisting of a single, continues 30 seconds contraction of the tibialis anterior muscle with one minute rest between trails. After a verbal command the patient was asked to perform his/her maximal tibialis anterior contraction, the patient was encouraged to do his best on all trails. Each trail was repeated for 10 successive times per session.

All patients of the experimental group were informed, that on feedback (FB) trails, the auditory and visual feedback signals would provide precise information concerning the course of the muscle contraction

Treatment for both groups continued for 16 successive weeks, three sessions per week. Each session lasted about 30 minutes.

Results

Comparison between mean values of all variables in both study and control groups before application of treatment revealed no significant differences ($p > 0.05$). As shown from table (1) and fig. (1), the mean values of the static strength of Ankle dorsi-flexors in the study group before and after the suggested period of treatment were 9.88 ± 1.042 lb and 15.96 ± 2.483 lb, respectively. The mean difference was 5.81, which was statistically highly significant ($p < 0.001$). During the same period, the mean value of static strength of Ankle dorsi-flexors in the control group increased from 10.42 ± 0.883 lb before treatment to be 10.91 ± 0.883 lb after treatment, which indicated a significant improvement ($p < 0.05$).

Table (1): Shows mean values of static strength of Ankle dorsi-flexors in both study and control groups before and aft treatment.

Comparison	Study		Control	
	Pre	Post	Pre	Post
Mean	9.88	11.69	10.42	10.91
SD	± 1.042	± 1.483	± 0.883	± 1.208
MD	2.81		0.49	
% of change	58.8%		5%	
t	5.7434		2.4873	
p	< 0.001		< 0.05	

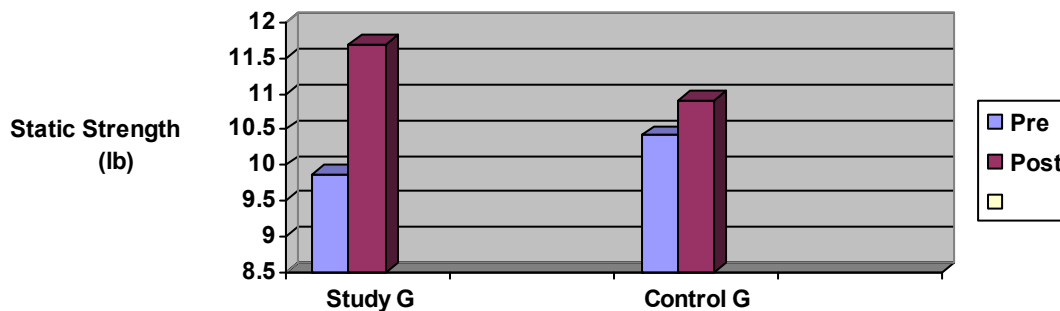


Fig. (1): Shows mean values of static strength of Ankle dorsi-flexion in Both study group and control group

As revealed from table (2) and Fig. (2), the mean value of Ankle dorsi-flexion ROM in the study group before treatment was $9.73 \pm 1.223^\circ$, which increased to $15.67 \pm 2.498^\circ$ after 20 weeks of the combined treatment. The mean difference was 5.93° , which represented a highly significant difference ($p < 0.001$). In the control group, the mean value of Ankle dorsi-flexion ROM underwent an increase from $10.41 \pm 0.53^\circ$

before treatment to be $10.93 \pm 1.280^\circ$ after application of the traditional physical therapy program, with a mean difference of 0.53° , which was also statistically significant.

Table (2): Shows mean values of Ankle dorsi-flexion ROM (in degrees) in both study and control groups before and after treatment.

Comparison	Study		Control	
	Pre	Post	Pre	Post
Mean	17.066	25.4	16.933	22.0
SD	± 3.673	± 3.247	± 4.415	± 2.828
MD	8.333		5.066	
% of change	48.8%		30%	
t	18.784		10.9531	
p	< 0.001		< 0.05	

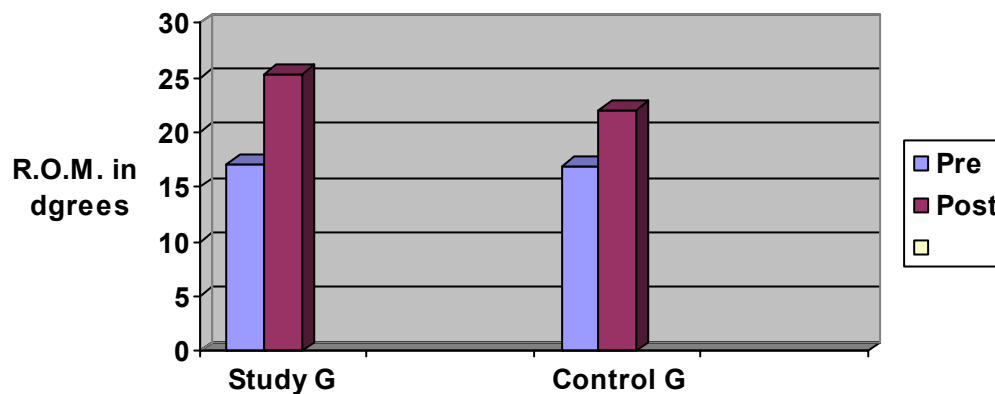


Fig. (2): Shows mean values of Ankle dorsi-flexion ROM (in degrees) In both study and control groups before and after treatment.

From table (3) and fig. (3), it can be shown that in the study group, the mean values of the grades of functional ambulation before and after treatment were 2.67 ± 0.488 and 3.53 ± 0.516 , respectively. The mean difference was 0.87, which was statistically highly significant. Meanwhile, the mean values of these grades in the control group before and after treatment were 2.73 ± 0.458 and 3.00 ± 0.535 , respectively, showing a mean difference of 0.27 which was also statistically significant ($p < 0.05$).

Table (3): Shows mean values of grades of functional ambulation in both study and control groups before and after treatment

Control		Study		Comparison
Post	Pre	Post	Pre	
3.00	2.73	3.53	2.67	Mean
± 0.535	± 0.458	± 0.516	± 0.488	SD
0.27		0.87		MD
9%		32%		% of change
2.2823		4.5313		t
< 0.05		< 0.001		p

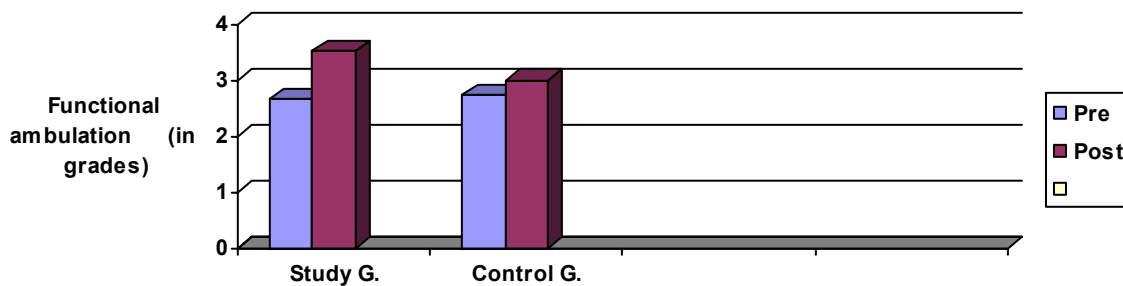


Fig. (3): Shows mean values of grade of functional ambulation in both study and control groups before and after treatment.

As observed from Tables (4) and Fig.(4), the mean value of Ankle equines angles in the study group before treatment was $14.68 \pm 3.112^\circ$, which decreased to $11.5 \pm 1.89^\circ$ after 16 weeks of the combined treatment. The mean difference was 3.18° , which represented a highly significant difference ($p < 0.001$). In the control group, the mean value of Ankle equines angles underwent an decrease from $15.00 \pm 3.262^\circ$ before treatment to be $14.78 \pm 1.982^\circ$ after application of the traditional physical therapy program, with a mean difference of 0.22° , which was statistically non significant ($p < 0.05$).

Table (4): Mean values of equinus angles in both control and study groups before and after 16 weeks of treatment.

Control		Study		Comparison
After	Before	After	Before	
14.78	15.00	11.50	14.68	Mean
± 1.982	± 3.262	± 1.890	± 3.112	SD
0.22		3.18		MD
1.4%		21.6%		% of change
1.1311		2.6959		T
< 0.05 N.S.		> 0.0125		p

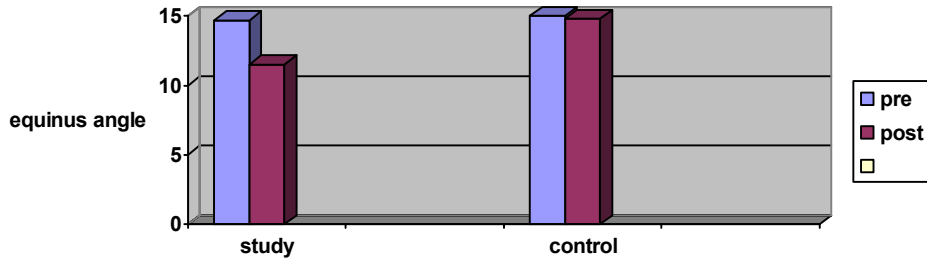


Fig (4): Mean values of equinus angles in both control and study groups before and after 16 weeks of treatment.

From table (5) and fig. (5), it can be shown that in the study group, the mean values of the grades of strength deficits of ankle planter flexor muscles before and after treatment were 2.4 ± 0.84 and 1.1 ± 0.74 , respectively. The mean difference was 1.3, which was statistically highly significant. Meanwhile, the mean values of these grades in the control group before and after treatment were 2.1 ± 0.88 and 1.2 ± 0.97 , respectively, showing a mean difference of 0.9 which was also statistically significant ($p < 0.01$).

Table (5): Mean values of strength deficits of ankle planter flexor muscles In the study and control groups before and after 16 weeks of treatment.

Control		Study		Comparison
after	before	after	before	
1.2	2.1	1.1	2.4	<i>Mean</i>
± 0.97	± 0.88	± 0.74	± 0.84	<i>SD</i>
0.9		1.3		<i>MD</i>
3.91		6.19		<i>T</i>
> 0.01 S.		< 0.001 S.		<i>P</i>

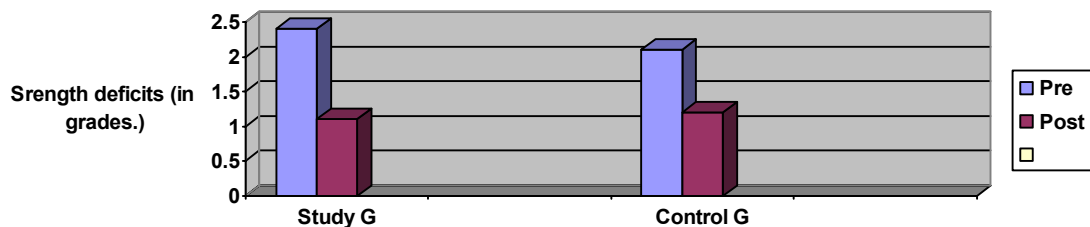


Fig. (5): Mean values of strength deficits of ankle planter flexor muscles in both study and control groups before and after 16 weeks of treatment

Discussion

The results of the present study showed clearly the beneficial effects of using Biofeedback training on increasing tibialis anterior muscle torque, range of ankle joint dorsi-flexion and efficiency of ambulation in hemiplegic cerebral palsied children. Before the start of treatment, there was a considerable reduction of all the measured parameters in all patients. These results came with an agreement with **Dursun et al (2004)**⁽¹³⁾, who stated that lack of smooth coordinated movement causes functional problems in the integration of sensori-motor functions in hemiplegic cerebral palsied children.

The results at the end of the suggested period of treatment exhibited an increase in the mean values of tibialis anterior Ankle dorsi-flexion torque, range of ankle joint dorsi-flexion and efficiency of ambulation in both groups. Patients belonging to the study group demonstrated greater values in all measured parameters. Furthermore, highly significant differences were also noted, at the end of the treatment period, between the mean values of the measured parameters, in the favor of the study group. Such significant differences reflect the great influence of Biofeedback training, when combined with the traditional physical therapy modalities in treatment of hemiplegic cerebral palsied children.

These results agreed with those of **Mc Culloch and Nelson. (1995)**⁽²²⁾, who attributed the effect of Biofeedback training to the increased sensory feedback mechanism, resulting in enhancement of voluntary motor control. In **1996, Woolacott**⁽²⁹⁾ reported that the improvement in muscle torque may be attributed to an improved reciprocal inhibition relationship, which in turn results in significant changes in joint range of motion, with the resulting improvement in functional ambulation. **Cozean et al (1988)**⁽¹⁰⁾ observed that the Biofeedback training -produced movements activate pattern recognition areas of both sensory and cerebellar cortexes. This leads to development of pattern engrams in the sensori-motor cortex, related to the movements. **Basmajian (1992)**⁽⁵⁾ attributed the Biofeedback training -induced improvement in muscle performance to the selective recruitment of type II muscle fibers, responsible for fast twitch motor units, leading to more strength gains.

According to the results of the present study, the improvement of Ankle dorsi-flexor torque was concomitant with similar increase in ankle dorsi-flexion range of motion. These results supported those of **E Dursun (1983)**⁽¹³⁾, who stated that adding Biofeedback training to the traditional physical therapy modalities in strengthening the anti-gravity muscles might develop postural stability and alignment over the involved lower extremity. They reported that the combined use of Biofeedback training and therapeutic exercises could be used effectively for increasing isometric muscle force and range of motion.

Fetters(1996)⁽¹⁴⁾ also confirmed that the use of a proper strengthening program could usually improve strength, flexibility and function.

The results of the present piece of work coincide also with the findings of **E.Dursun (2005)⁽¹³⁾**, who utilized Biofeedback training to stimulate muscles in order to improve function in spastic patients. **Intiso et al (1994)⁽¹⁹⁾** suggested also the utilization of Biofeedback training, applied 3 times per week for at least 6 weeks, in increasing tibialis anterior muscle torque. He added that this increment in muscle torque might result in increasing Ankle range of motion and improvement in walking abilities. The results also came in agreement with the findings of **Damiano et al (1998)⁽¹²⁾**, who emphasized the use of physical therapy exercises in restoring muscle strength in spastic cerebral palsied children. **Fetters et al (1996)⁽¹⁴⁾** added that the functional improvement might be achieved through careful strengthening for weak muscles.

The results of this study indicated that Biofeedback training can help CP children in controlling dynamic equines deformity. This statement is made with the understanding that subjects who probably can be helped most with this technique are those who meet pre-determined criteria, such as those described previously. Results of the radiological examination of all patients in both groups before starting treatment indicated significant ankle planter flexion, however, none of those patients demonstrated bony changes. Dynamic equines deformity attributed to hemiplegia, affects significantly both posture and gait of the patients. The results of the present study at the end of the suggested period of treatment indicated that application of Biofeedback training was effective in reducing spasticity with subsequent controlling of Dynamic equines deformity. **E.Dursun (2005)⁽¹³⁾** It was reported that application of Biofeedback training increases cutaneous inputs to the motoneuron pool, which resulted in a decrease in motoneuron excitability. The findings of the present study agree with **Cozean et.al (1988)⁽¹⁰⁾**, who reported that subcutaneous nerve stimulation may be a tool in the management of spasticity. The results of this study come in agreement with **Burnside et al (1985)⁽⁸⁾**, who stated that Biofeedback training is capable for producing a significant decrease in spasticity.

The inhibitory mechanisms which have been reported to be decreased in spasticity are reciprocal inhibition, Renshaw cells inhibition, Ib inhibition and secondary afferent inhibition (group I). Thus, Biofeedback training could be effective in improving the cutaneous muscular afferent signals, which promote such inhibitory mechanisms, hence reducing spasticity **Cozean et.al (1988)⁽¹⁰⁾** The results of the present study also confirm those of **Heller et al (1993)**, as they stated that using Biofeedback training can control spasticity via reduction of motoneuron excitability.

CONCLUSION:

The results of the present study lend a favorable outlook to use biofeedback training in treatment of hemiplegic CP children, to decrease spasticity with the subsequent improvement of dynamic equines deformity.

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تأثير التغذية الحيوية الرجعية على التحكم في حركة مفصل الكاحل لدى الأطفال المصابين بالشلل المخي التصليبي

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قسم العلاج الطبيعي
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جامعة الملك عبد العزيز

ملخص البحث:

الهدف من الدراسة هو تقييم تأثير التغذية الحيوية الرجعية على حركة مفصل الكاحل وعلى كفاءة المشي لدى الأطفال المصابين بالشلل النصفي التصليبي. اشتمل البحث على ستة عشر طفلا من المصابين بالشلل النصفي التصليبي من الجنسين ممن تراوحت أعمارهم بين ٧ و ٩ أعوام، وقد تم اختيارهم طبقا لبعض المعايير الأساسية، تم تقسيم المرضى عشوائيا إلى مجموعتين (المجموعة محل البحث والمجموعة الضابطة)، عولجت المجموعة الضابطة بواسطة العلاج التقليدي بينما عولجت المجموعة محل البحث باستخدام التغذية الحيوية الرجعية بالإضافة إلى العلاج التقليدي، استمر علاج المجموعتين لمدة عشرين أسبوعا بواقع ثلاثة جلسات أسبوعيا، وقد تم قياس عزم عضلة فرد مفصل الكاحل ومدى حركة فرد مفصل الكاحل بالإضافة إلى كفاءة المشي لجميع المرضى في كلتا المجموعتين قبل وبعد فترة العلاج. أظهرت نتائج البحث وجود فروق ذات دلالة إحصائية بين القياس قبل وبعد العلاج في المجموعتين، بالإضافة إلى وجود فروق ذات دلالة إحصائية بين نتائج المجموعتين بعد انتهاء فترة العلاج لصالح المجموعة محل البحث، وطبقا لهذه النتائج فإنه يوصى باستخدام التغذية الحيوية الرجعية في علاج مرض الشلل النصفي التصليبي إلى جانب وسائل العلاج التقليدية.