Effect of Biofeedback Training on Abnormal Co-contraction in Stroke Hemiparetic Arm

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ABSTRACT

The study was conducted to investigate the effect of electromyographic biofeedback training in conjunction with selected program of therapeutic exercises on co-contraction ratio between biceps and triceps muscles and active range of motion of the elbow joint. Twenty stroke hemiparetic patients were selected for the study. Their ages ranged between 53 and 65 years, with a mean value of 58.7 years. The patients were divided randomly into two equal groups: study and control. The study group received EMG biofeedback plus a specific program of therapeutic exercises. The control group received the same program without biofeedback training for six weeks. Significant decrease in the co-contraction ratio between biceps and triceps muscles was detected during flexion and extension of the elbow joint. The active range of motion in the study group also increased significantly.

INTRODUCTION

Hemiplegia caused by cerebrovascular accident (CVA), is frequently called stroke[5]. It is one of the common causes of severe physical disability, and impairment in voluntary movement[14]. Approximately 5% of people older than "65" years will sustain a stroke making (CVA) a leading cause of disability as well as a major health and economic problems[22]. One of the most devastating and common consequences of stroke is loss of use of the arm and hand[8].

The motor impairment which is manifested by abnormal performance of voluntary movement is due to alteration of normal agonist and antagonist relationship (abnormal co-contraction), in presence of hypertonicity and / or inadequate recruitment of agonist muscles. The abnormal co-contraction is a clinical phenomenon after (CVA), in which the patients are often slow or unable to activate a weak muscle , while simultaneously inhibiting its antagonist[9].

Biofeedback technology was introduced in the late 1960s for therapy in stroke rehabilitation[18].This technique allows subjects to gain conscious control over a voluntary but, latent neurofunction by alerting them, with an auditory or visual clue, that their efforts have activated a targeted neuromuscular pathway. The theoretical premise is that undamaged,yet subliminimal pathways, can be recruied and assume the function of pathways that were irreversibly damaged[12]. The biofeedback may be used to facilitate, or reduce muscle activity to restore motor control. A traditional training strategy of relaxation of spastic musculature (downtraining) followed by facilitation of weak or paretic musculature (uptraining) has been advocated in some studies[21].

The purpose of the present study was to determine the effect of biofeedback training on decreasing abnormal co-contraction and increasing active range of motion of elbow joint in stroke hemiparetic patients.

SUBJECTS, MATERIALS AND METHODS

Subject selection

- Twenty medically stable stroke (hemiparetic patients) selected from Neurolgy Department of Kasr El Aini Hospital, participated in this study.
- Each patient met the following criteria: Diagnosis of hemiparisis secondry to (CVA). The diagnosis was confirmed by CT Scan to determine the exact cause and site of the lesion, with duration of illness of one year or longer. The involved upper extermity was graded in stage 4,5 according to Brunnstrom[4]. Patients were selected with moderate degree of spasticity that allow range of motion of shoulder flexion and abduction about 60 degrees. Absence of receptive aphasia, visual field deficit, and proprioceptive deficits in the involved elbow. Subjects were free from any structural deformities which may affect the process of evaluation and treatment.
- The patients were divided randomly into two groups of equal number (the study and the control groups).
- Informed consent was received from all subjects indicating their voluntary participation in the study.
- Summary of patients characteristics is summarized in table (1).

Table (1): General characteristics of the subjects

	Study group	Control group
Sex		
male	6	5
female	4	5
Age		
Range	53- 65	55 - 63
Mean ±SD	58 ± 8.9	59.2 ± 9.1
Side of paresis		
Right	4	3
Left	6	7
Duration of illness		
Range	12-23 months	12-20 months
Mean ±S D	14.1 ± 6.1	14 .9 ± 6.7

The examinations of the patient included :-

- Quantified measurement of active range of motion (R.O.M) for elbow joint.
- Peak "EMG" of biceps brachii and triceps muscles during isotonic contraction of both muscles, then the co-contraction ratio was calculated.
- All measurements were repeated three times. The means of all measurement were calculated.

Materials

A-For assessment:

a) Polygraph appartus "360 NEC" connected with a computer system Physteach "4" version 1.1, which contains A / D to convert the EMG interference pattern to digital form.. EMG signals from biceps and triceps were recorded simultaneously.

b) Electrogoniometer: The potentiometer is connected to digital multimeter to record continuosly the change of resistance during movement. This changes in resistance is calibrated to degrees of angular displacement.

B- For treatment :

Two EMG feedback devices were

utilized in the study. The use of the two EMG feedback devices allowed simultaneous monitoring of agonistic and antagonistic muscle groups. This was a major importance for treatment of hemiparesis because intension activation of agonistics always causes an unintentional co.activation of the antagonistics[20].

Method

A- Assessment

a- For recording the EMG activites of bicepes and triceps before and after the treatment and to calculate the co-contraction ratio the following steps were followed :-

- Skin impedance was reduced by scrubbing the skin with alcohol and spraytrode. Self adhesive pregelled electrodes with inter electrode distances of less than two cm were secured on the bellies of the biceps and triceps muscles.

- The biceps muscle electrodes were placed at the midpoint between the anterior acromial surface of the scapula and the bicipital fossa. The triceps muscle electrodes were placed at the midpoint between the posterior acromial surface and the olecranon.

- The ground electrode for each of the biceps and triceps muscle electrodes pairs, was placed laterally over the deltoid muscle between the biceps and triceps muscles. The common ground electrode was placed around the wrist joint of the unaffected upper limb of the patient.

- The EMG signals of both muscles were displayed simultaneously on the screen of the polygraph and the computer system was connected to it. The signals were saved on floppy disk for integration by using a complexprogram called **(PEAK)** Which perform the following steps:-

- Rectify and calculate the integral of EMG signals and repeat it over the whole record of 4096 msec.

- Display the peak amplitude of each muscle in ml vol./sec and the corresponding state of the second muscle.

- The integrated EMG were used for calculating the co-contraction ratio between agonist and antagonist during flexion and extenstion by this equation[9]:

$$\text{Co-contraction ratio} = \frac{\text{Antagonist activity}}{\text{Agonist activity + Antagonist activity}}$$

- During flexion of the elbow joint the integrated EMG amplitude of the biceps brachii was the agonist, and the triceps was the antagonist, during extension the agonist muscle was the triceps and the antagonist was the bicepes.

b- Active ROM of the elbow joint was mesured pre and post treatment.

From sitting position the involved shoulder was abducted and flexed to approximtly 60°, elbow flexed 90°

- The arms of the electrogoniometer were aligned with the acromion, and the mid point between the radial and ulnar styloid processes. The stationary arm was placed along the lateral midline of the upper limb, the movable arm was placed along the lateral midline of the forearm. Both arms were secured in their position by elastic fulcrostraps. The changes in degree of elbow movement corresponded to the change in (millimeters) of amplitude of recording pen.

B-For treatment

A pretest - post test, two group design was used in this study. The study group received EMG biofeedback training for biceps and triceps muscles in conjunction with physiotherapeutic program (PT) of exercises. The control group received the same therapeutic exercises program without EMG biofeedback. Treatment duration was six weeks, three times a week. Each session lasted for one hour.

Each patient was seated comfortably on a back chair infront of the biofeedback devices. The affected forearm was supported on a table. The shoulder joint was supported at approximately 30° flexion, the feet were supported on the ground. Surface electrodes were placed over the belly of the biceps and triceps muscles of the affected limb, and fixed with adhesive strap. Myoelectric potentials were converted into a visual display and or an auditory signals, which enable the patient to monitor relaxation or tension in particular muscle.

The patients in the study group began the treatment session in which therapeutic exercises of the affected upper arm was undertaken in conjun-ction with audiovisual biofeedback. In order to have better control of the interdependency between muscular activity and feedback signals, one EMG device was always placed on top of the other in a fixed arrangement. The upper one signaled activity of the flexor muscle, and the lower one signaled activity of the extensor muscle. In addition, activity of those muscles intended to be kept relaxed during an exercise (i.e) flexor during extension and vice versa) was indicated by an acoustic signal, such that visual attention was directed only to the activity of the muscles to be activated. According to Twrezyski et al.,[20] the treatment Schedule was as follows:

- Demonstration and short exercise with the technique using the unaffected arm. Changes of EMG feedback signals from antagonistic muscle groups were demonstrated during relaxation and isometric tension as well as during active arm movements.
- Exercises to relax the paretic limb during inactivity and during spastic activity provoked by passively stretching the muscle, There by, maximal intentional muscle relaxation was practiced as well as maintenance of relaxation during passive limb flexion and extension.
- Exercise of active isometric tension of muscle with subsequent relaxation. These exercises were intended to selectively activate the flexor or extensor while maintaining simultaneous relaxation of corresponding antagonistic muscle.
- Exercise of co-ordinated selective tension and relaxation of the antagonistic muscle groups during active (non- isometric) limb flexion and extension. Integrated into these exercises, were simple types of intentional limb movements (e.g.) stretching the arm to reach for an object.
- In all cases an attempt was made to establish differential muscle control through relaxation and contraction.

RESULTS

In the present study the effects of biofeedback training on active (R.O.M), and the co-contraction ratio between agonist and antagonist muscles during flexion and extension of the elbow joint in stroke hemiparetic patients were studied.

Comparison between mean values of all parameters in the study and control groups before treatment were statistically not significant.

As shown in table 2 and figure 1, during flexion the mean value of active R.O.M in the study group before treatment and six weeks after the treatment were 23°±5.21° and 35° ±

3.71° respectively. The mean difference was 12° which was found significant at P≤ 0.001. The corresponding mean values of the control group were 23.4° ± 6.17° and 25° ± 6.46° respectively. The mean difference was 1.6° which was non statistically significant at (P ≥ 0.05). Percentage of improvement in active R.O.M in study and control groups were 52.17% and 6.84% respectively.

Table (2): Comparison between the mean values of Active R.O.M pre and post treatment during flexion of the elbow joint in both groups.

	Study Group		Control group	
	pre	Post	per	post
$\overline{X}$	23 °	35 °	23.4 °	25 °
S D	± 5.21	3.71	± 6.17	± 6.46
$\overline{X}$ Diff.	12 °		1.6 °	
t value	10.810		1.1765	
% of improvement	52.17		6.84	

$\overline{X}$: mean
S.D: standard deviation
$\overline{X}$ Diff.: Mean Difference   t: Paired t-test

As shown in table 3 and figure 1, the mean values of active R.O.M during extension of the elbow joint in the study group before and six weeks after the treatment were 21.4° ± 4.42° and 30.9°±3.11° respectively. The mean difference was 9.5° which was significant at (P ≤ 0.001). The corresponding mean values of control group were 21.7° ± 6.06° and 23.6±6.42 respectively. The mean difference was 2.1° which was non significant (P≥0.05). The percentage of improvement in the study and control groups were 44.39% and 5.07% respectively.

Table (3): Comparison between the mean value of Active R.O.M pre and post treatment during extension of the elbow joint in both groups.

	Study group		Control group	
	Pre	Post	Pre	Post
$\overline{X}$	21.4°	30.9°	21.7°	23.8°
S.D	± 4.42	±3.11	± 6.06	±6.42
$\overline{X}$ Diff.	9.5°		2.1°	
t value	15.74		1.69	
% of improvement	44.39		5.07	

As shown in table 4 and figure 2 the mean difference between co-contraction ratio during flexion of the elbow joint in the study group at the end of treatment was 0.12. Their was a significant reduction in the co-contraction ratio (p ≤ 0.05). The corresponding mean difference in the control group before and after treatment was 0.01 which was non-significant at (p ≥ .05). The percentage of improvement in the study and the control group was 41.84 and 5.74 respectively.

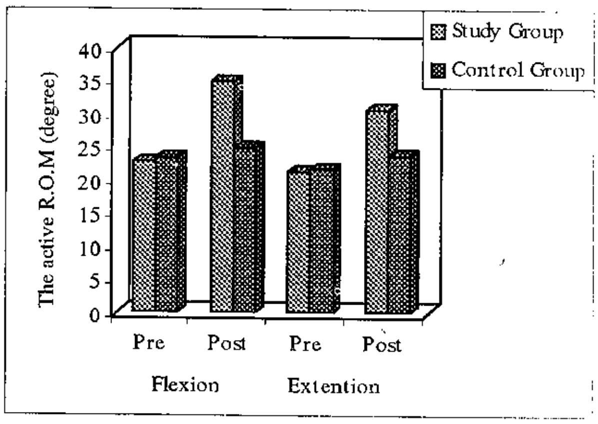

Fig. (1): The mean values of active R.O.M. pre and post treatment during flexion and extension of the elbow joint in both groups.

Table (4) Comparison between co-contraction ratio pre and post treatment during flexion of the elbow joint in the both groups.

	Study group		Control group	
	Pre	Post	Pre	Post
$\overline{X}$	0.28	0.16	.21	0.20
S.D	± 0.156	±0.114	± 0.220	± 0.003
$\overline{X}$Diff.	0.12		.01	
t value	2.07		0.027	
% of improvement	41.84		5.74	

As shown in table 5 which compare the co-contraction ratio during extension of the elbow joint before and at the end of the treatment in both groups, the mean values of the co- contraction ratio in the study group before and after treatment were 0.28 ± 0.16 and 0.19 ± 0.014 respectively. The mean difference was .09. Their was significant decrease in co-contraction ratio ($p \leq 0.001$). The corresponding mean values of the control group before and at the end of the treatment were 0.24 ± 0.05 and 0.22 ± 0.05 respectively. The mean difference was .01, which was non-significant at ($p \geq 0.05$). The percentage of improvement in the study and control groups were 33.45 % and 4.68 % respectively.

Table (5): Comparison between co-contraction ratio pre and post treatment during elbow extension in the both groups.

	Study group		Control group	
	Pre	Post	Pre	Post
$\overline{X}$	0.28	0.19	0.24	0.22
SD	± 0.16	±0.014	± 0.05	±0.05
MD	.09		.01	
t value	6.71		0.04	
% of improvement	33.45		4.68	

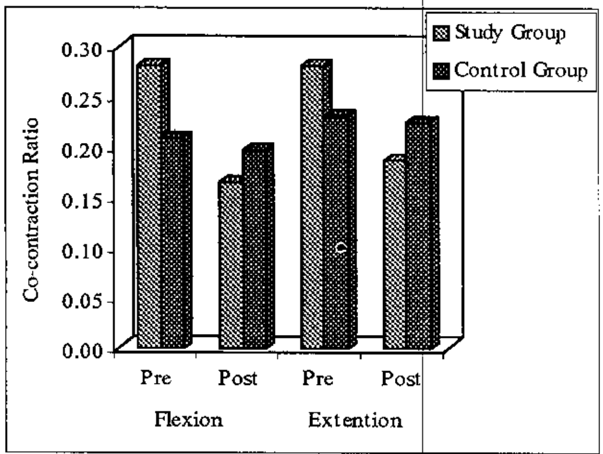

Fig. (2): The mean values of co-contraction ratio pre and post treatment during flexion and extension in both groups.

DISCUSSION

The results of the study showed evidence of greater improvement in R.O.M. Also significant decrease of co-contraction ratio between agonist and antagonist of the study group was recorded.

The effect of co-contraction on movement is controversial. Under normal circumstances it provides the joint greater stability especially when distal limb segment are free to move. After stroke, however, co-contraction about the elbow is often abnormal with biceps muscle contraction while patient attempts elbow extension. A probable mechanism for the dysfunction is the delayed ability to cease muscle activity during reciprocal movement due to impaired reciprocal inhibition[22].

The goal of clinical biofeedback programs is enhancment of conscious awareness of limb muscle contraction.As in this study auditory and visual feedback from the muscle activity is provided to augment proprioception.

Basmajian[1] principles of neuromuscular control to biofeedback state that "activity in the parietal cortex normally results from sensory feed back and occurs after the inital muscle contraction. The sensory system then assists in controlling motion after becoming aware of the movement. Activity in the motor cortex must precede voluntary movement". In absence of sensory feedback the patient is unaware of this neuromotor activity. With improving of awareness of the effect of motor cortex activity, the patient is able to practice and reinforce desired movement patterns. This repetitve practice can result in long term functional gain than an individuals continues to demonstrate without the direct biofeedback. The development of neurologic "engrams" to produce certain movements · results from practicing the movement[5]. Chronic stroke patients were selected in this study to separate the effects of biofeedback from spontaneous neurologic recovery which occurs more rapidly during the first six months post stroke[11].

The improvement of performance in the study group was attributed to motor learning which is in agreement with Schmidt[18] who reported that learning is a process associated with practice and leading to improvement in the ability to produce skilled movement. The results of this study confirmed the previous finding reported by Trombly[19] who found that after practicing tasks in hemiparetic subjects there is decrease in discontinuity of movement. The author attibuted these finding to motor learning than to improve muscle activation.

In the present study the improvement in performance may also be attributed to decrease co-contraction ratio between agonist and antagonist during performing the movement. The finding of this study support the hypothesis of Musa[13] who suggested that afferent input to the spinal cord through movement of the proximal limb joints can reduce spasticity and so facilitate normal movement in stroke patient. These results confirmed the previous study done by Prevo et al.,[15]. They noticed a decrease in co-contraction after treatment by EMG biofeedback. The results of the current study also is in agrrement with Knutsson & Martenson[10] who concluded that abnormal co-contraction is a limiting factor in the stroke patient.

Similar finding were reported by Sahrman & Narton[16] who stated that abnormal co-contraction during voluntary movement may constitute crucial component in impairment of voluntary movement. El Abd et al.,[7] concluded, also that co-contraction may be the cause of inability to perform fractionted elbow movement tasks.

The findings of the present study contradict with those reported by Gowland et al.,[8] who attributed impairement of voluntary control in spastic patients to inadequate recruitment of the agonist which results in its weakness and not due to abnormal co-contraction. Wolf et al.,[22] also concluded that imprvoment in performance of a movement at the elbow joint was due to uptraining of the agonist muscle not due to downtraining hyperactive antagonist muscle.

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الملخص العربي

تأثير التغذية الحيوية العائدة على نسبه الانقباض المتزامن بين العضلات المحركة والمقاومة في مرضى الشلل النصفي

في هذه الدراسة تم دراسة تأثير التغذية الحيوية العائدة بالاشتراك مع برنامج ثابت من التمارين العلاجية على مدى الحركة ونسبة الانقباض المتزامن بين العضلات المحركة والمقاومة في مرضى الشلل النصفي .
تم اختيار (٢٠) مريضا متوسط أعمارهم ٥٨,٧عاما وتم تقسيمهم عشوائيا إلى مجموعتين متساويتين المجموعة الأولى عولجت بالتغذية الحيوية العائدة + برنامج تمارين علاجية معين ,المجموعة الثانية عولجت بنفس برنامج التمارين العلاجية المستخدمة مع المجموعة الأولى وبدون التغذية الحيوية العائدة . وقد استمر العلاج لمده ستة أسابيع وفي نهاية التجربة أظهرت النتائج أن هناك تحسنا في مدى الحركة الذي يمثل تحسن في الأداء الوظيفي ونسبه الانقباض المتزامن بين العضلات المحركة " المقاومة في المجموعتين ولكن التحسن كان إيجابيا في المجموعة الأولى فقط وغير إيجابي في المجموعة الثانية " .