Original article

Physiotherapy and Occupational Therapy Journal
Volume 5 Number 2, April - June 2012

Effects of Electromyographic Biofeedback Training of Triceps Surae Muscle on Functional Performance in Chronic Quadriplegics

Deepti Sharma*, Majumi Mohamad Noohu**

Abstract

Objective: This study was carried out to find the changes in functional status of chronic spinal cord injured patients with treatment of electromyography biofeedback. **Methods:** A sample of 30 subjects randomly allocated into group A and B participated in the study .Group A received electromyographic biofeedback training along with conventional exercise and Group B received conventional exercises only. The subjects were assessed for electromyographic amplitude, quadriplegic index of function and spinal cord independence measure scores. They were assessed before the treatment and after treatment. The total duration of the study was 3 weeks with 5 session of treatment in a week. Results: The study showed significant changes in all variables studied during a intra group analysis as well as intergroup analysis. There was a significant change in EMG amplitude scores of both upper extremities, quadriplegic index of function and spinal cord independence measure scores in both group A and group B after the treatment. There was significant difference in electromyographic amplitude values, quadriplegic index of function and spinal cord independence measure scores after the treatment between the groups. **Conclusion:** The electromyographic biofeedback can be used along with conventional exercises to improve the function in chronic spinal cord injury patients.

Keywords: Quadriplegia; Electromyography biofeedback; Functional performance.

Introduction

Spinal cord injury is one of the most challenging medical conditions for entire rehabilitation team. Transection of the spinal cord will result in loss of motor power, deep and superficial sensation, vasomotor motor , bladder and bowel control, sexual function , finally patient and care givers develop a sense of hopelessness. A spinal cord lesion at the cervical level often results in quadriplegia individuals at the critical functional levels of C_6 and C_7 quadriplegia are on the borderline of achieving total independence in self-care tasks.[1] M.Mizakaumi et al in a study done on 109 quadriplegics found that when triceps brachii muscle begins to function and the deltoid muscle also contributes then effective balance control during push up develops. Thus, transfer in the push up posture becomes much easier.[2] Welch and colleagues surveyed 29 quadriplegic patients 3 months to 4 years post discharge and found that the presence of functional triceps was a significant determinant for functional independence in self-care task. Those subjects having triceps as the lowest functional muscle displayed a significantly greater amount of independence in self care areas than subjects with wrist extensors as the lowest functioning muscle group, both at discharge and follow up.[3]

Biofeedback may be defined as technique of using equipment (usually electronic) to reveal to the human beings some of their internal physiological events, normal and abnormal, in the form of visual and auditory signals in order to teach them to manipulate these otherwise involuntary or unfelt events by manipulating the displayed signals. The application of feedback is often considered as

Author Affilation: *Assistant Professor, Department of Physiotherapy, Manav Rachna International University, Faridabad, Haryana, **Assistant Professor, Centre for Physiotherapy and Rehabilitation Sciences, Jamia Millia Islamia, New Delhi.

Reprint's request: Majumi Mohamad Noohu, Assistant Professor, Centre for, Physiotherapy and Rehabilitation Sciences, Jamia Millia, Islamia, New Delhi.

(Received on 13.11.2011, accepted on 30.11.2011)

an operant conditioning technique. Mechanism of biofeedback is the process of enhancing awareness and self-regulation.[4] Historically, it was realized that organisms learned by using feedback and that it is possible to control physiology by using the feedback loop. The most commonly used biofeedback modality is surface elecrtomyography (EMG, measured in micro-volts). EMG instruments pick up and detect those electrical impulses and are displayed them on the monitor of EMG biofeedback instrument and in the form of auditory signals so the subjects can modify these signals to get the desired result.[5] Reports on EMG feedback training to spinal cord injury patients are few and they provide scanty information regarding techniques and outcome. Several studies document the effect of EMG biofeedback in stroke patients and other neurological conditions. Procedures incorporating EMG feedback have been reported effective in treating neuromuscular dysfunction, both in obtaining voluntary relaxation of unwanted activity and in improving strength, range of motion and control of paretic muscles. It was found that electromyographic biofeedback with physical therapy is effective in training motor activity in patients with hemiplegia but in some cases it was counterproductive.[6] Brucker treated a C_{5-6} spinal cord injury, in his late 20's suffering for past 11 years with EMG biofeedback to increase triceps function to almost normal, wrist flexors to 70% of normal function and finger extensors and flexors enabling the man to write, type and feed himself.[7] Sarah A. Morrison in a case report discussed the effectiveness of EMG biofeedback in re-educating and strengthening the accessory breathing muscles in an individual with high- level (C1) complete quadriplegia. The study results indicated EMG biofeedback is a helpful modality in training accessory breathing muscles to enable an individual with high-level quadriplegia to become independent of mechanical ventilation for varying amounts of time.[8] Klose et al tested the efficacy of biofeedback when administered in conjunction with physical therapy to chronic C_{5-7} quadriplegics. The result showed an increase in function of triceps brachii, biceps brachii, wrist extensors and wrist flexors.[9] Evaluation of disability is important in documenting improvement in clinical and research settings and measurement of functional outcome is an integral part of any goal-oriented, multidisciplinary rehabilitation program .[1,10] So it becomes imperative to study the outcome of treatment procedures in terms of function and there are scales developed to assess the effect of treatment .Short form of quadriplegic index of function (QIF) provides a more specific and sensitive instrument to document the functional improvements achieved during the rehabilitation of tetraplegics patient. The index is composed of 7 variables: transfers, grooming, bathing, feeding, dressing, wheelchair mobility and bed activities. The items are scored on a five point scale (0-4) in order of increasing independence. They were scored on a 5- point scale and total score of QIF ranges from 0-132.[11] Spinal cord independence measure (SCIM) was developed by Catz et al in 1997. This disability scale was developed specifically for spinal cord injured persons in order to make the functional assessments of persons with paraplegia or tetraplegia more sensitive . The SCIM covers three areas of function: self- care (0-20), respiration and sphincter management (0-40) and mobility(0-40). 16 items are scored on ordinal scale varying from three to nine classes. The final score ranges between 0 to100.[12]

Application of EMG biofeedback to the spinal cord injury has resulted in mixed results with some studies documenting the use of EMG biofeedback in spinal cord injury while other contradicting the use of spinal cord injury and there is a paucity of data exists on the impact of EMG biofeedback in functional performance in spinal cord injury. So this study was under taken to characterize the effect of EMG biofeedback in quadriplegic index of function scale scores and spinal cord independence measure scores and to see changes in EMG amplitude. It was hypothesized that there will be significant effect of EMG biofeedback and on EMG amplitude in chronic spinal cord injury patients.

Methods

The study was a quasi-experimental design. A sample of convenience of 30 subjects with spinal cord injury who were being treated in Indian Spinal Injuries Center New Delhi was included. Subjects were randomly assigned to one of the two groups, group A (Biofeedback and conventional exercises) and group B(Conventional exercises).Subjects were included in the study based on the following criteria stable incomplete spinal cord injury, as determined by clinical examination with American spinal injury association scale (Grade B,C and D),12 months post injury , neurological level C_6 and above, triceps muscle strength grade 2 as measured in medical research council grading system, vision and hearing intact, and patients who are able to follow commands. Patients with following problems were excluded such as spinal shock, peripheral nervous system injury of upper extremity, upper extremity fracture, upper limb amputation and upper limb spasticity more than grade 1 as determined by modified Ashworth scale, contracture or deformity of upper limb and altered sensorium .The variables studied were EMG amplitude, quadriplegic index of function(QIF) scores and spinal cord independence measure(SCIM) scores.

Equipment used in the study was Myomed 932, which is a complete unit for EMG biofeedback, pressure feedback and electrotherapy and electro diagnosis. Myomed 932, analysis and provide feedback of EMG signal. It consists of 2 independent channels EMG feedback unit. EMG activity could be displayed either in the form of bar or curve or bar and curve. Threshold value can be adjusted between 0-100% with audio feedback dependent on threshold, proportional or rough EMG. It has adjustable volume and can be switched off. Treatment time could be adjusted between 0-60 minutes.

Following procedure was followed in the study. Subjects were briefly explained about the procedure and purpose of study and informed consent was duly signed. Demographic data, neurological details , muscle power of triceps , EMG amplitude (highest averaged), QIF scale and SCIM scale scores were collected from the subjects and the subjects underwent assessment on all the parameters after 3 weeks also. For measuring EMG amplitude, subject was seated in his or her wheelchair in front of the color monitor of the EMG biofeedback instrument and two pregelled Ag-AgCl surface electrodes were placed over the triceps of one extremity with a third electrode used as ground electrode placed on the ulnar styloid process of the opposite extremity. Electrodes were centered within a small oval area whose center is located 50% of the distance between the angle of the acromion and the olecranon spaced 3 cm. apart .[7] The electrodes were connected to the EMG biofeedback instrument. Then the subjects were asked to extend the elbow and when a favorable EMG response was achieved, the specific placement was recorded and used during subsequent sessions.[13] For the purpose of pretest, the subjects were instructed to extend their right elbow, with the shoulder held in 90^0 flexion and elbow at a starting position of 90^0 flexion. The monitor was configured to display the amplitude of the integrated EMG. The integrated EMG calibrated in microvolts during the attempted elbow extension was recorded. The pretest data were obtained from the highest voluntary EMG amplitude from the triceps during elbow extension. An identical procedure was used for the left arm. The pretest was followed by biofeedback treatment procedure. The highest averaged recorded EMG responses from the triceps during the pretest was placed as criterion line.[14] The subject was advised that the moving line, which he or she was about was about to see on the monitor, was a reflection of the EMG signal of the triceps. The subject was then instructed to attempt an elbow extension while watching the monitor and told them not to be concerned about the actual extension of the elbow. The task was to increase the level of the moving line to a level higher than the criterion line.[15] Audio feedback was chosen to complement the reinforcement of the visual feedback. [8] The auditory display provided rising and falling intensity of sound. All the displays were proportional to the integrated EMG activity, over a selected time period .[16] On subsequent days, the threshold setting was changed. Criterion line was adjusted each time depending upon the patient's previous level of achievement. In each session, 20 seconds were given to complete one contraction and between subsequent contractions 16 second inter-trial interval was given. A total of 10 repetitions were given in a set. Thus in each session there was 20 contractions (2 sets) intervened by rest periods of 10 minutes. The subjects were verbally reinforced every time during elbow extension to raise the amplitude of the EMG higher than the criterion line.[17] The patient received 5 sessions per week for three weeks.[18] This was followed by therapeutic exercises. The session lasted 1 hour . The subjects in the control group also followed the same procedure as of group A barring that subjects in group B were not provide with any EMG biofeedback treatment. Data was analyzed using SPSS software. Paired't' test was used for analysis within the group changes and unpaired 't' test was used for inter group changes in the values of variables studied.Significance level of p d" 0.05 was fixed.

Results

The mean+ S.D of subjects in group A were 34.06 +9.79 years while in group B it was 34.03+ 9.01years and the mean + S.D for time post injury was 17. 4+ 3.56 months in group A and for group B it was 17.6 + 3.45 months. There was a significant change in EMG amplitude scores of both upper extremities (table 1,figure 1), QIF scores (table 2,figure 2)and SCIM scores (table 2,figure 3)in both group A and group B after the treatment.There was no significant difference between EMG amplitude values (table3, figure 4) , QIF (table 4,figure 5)scores and SCIM scores(table 4,figure 6) between the groups before the treatment but there was significant difference in EMG amplitude values (table 3 ,figure 4), QIF score((table 4,figure 5)and SCIM scores (table 4, figure 6) after the treatment between the groups.

Discussion

EMG feedback along with conventional exercise and conventional exercise has shown highly significant increments in the electromyographic activity , it was noticed that mean difference for groupA was higher than the group B (table 1) and there was highly significant difference in EMG amplitude values between two groups after the treatment. The results of this study is similar to the results of previous studies.[19,20] Possible neuronal mechanisms that can be suggested for increased surface EMG generated in the muscles through the use of biofeedback are increased firing rates motor units that were less activate before biofeedback ,increased number of motor units recruited to fire, increased synchronization of motor unit firing so that less cancellation occurs in the surface

Table 1. Intra group comparison of changes in EMG amplitude (micro volt)

Group	Side	EMG scores (micro volt)		p-value	Mean difference
		Pre treatment Mean ± S D	Post treatment Mean ± S D		
Group A N=15	Left	193.2 ± 79.06	231.8 ± 77.42	0.001*	38.6
	Right	180.0 ± 46.83	221.26 ± 39.24	0.001*	41.2
Group B N=15	Left	151.2 ± 42.87	177.26 ± 43.47	0.001*	26.06
	Right	163.2± 34.32	189.33 ± 393.01	0.001*	26.13

*Significant at 0.05 level, EMG-Electromyography

Table 2. Intra group comparison of changes in Quadriplegic Index of Function Scores (QIF)

Name of the Scale	Group	Pre treatment Mean ± S D	Post treatment Mean ± S D	p-value	Mean difference
QIF	Group A N=15	10.46 ±1.59	11.26 ± 1.53	0.001*	0.8
	Group B N=15	9.86 ± .99	10.13 ± 1.12	0.041*	0.267
SCIM	Group A N=15	19.93 ± 2.18	21.06 ± 2.25	0.011*	1.1333
	Group B N=15	19.8 ± 2.077	20.06 ± 2.28	0.041*	0.2667

*Significant at 0.05

Table 3. Comparison of changes in EMG amplitude (micro volt) between two groups

Side	Time	Group A [N=15] Mean± S D	Group B [N=15] Mean ±S D	p-value
Left	Pre treatment	193.2 ± 79.06	151.2 ± 42.87	0.081
	Post treatment	231.8 ± 77.42	177.2 ± 43.47	0.024 *
Right	Pre treatment	180 ± 46.83	163.20 ±34.32	0.272
	Post treatmen	221.26 ±39.24	189.33 ± 33.01	0.023*

*Significant at 0.05 level, EMG-Electromyography

Table 4. Comparison of changes in Quadriplegic Index of Function Scores(QIF)

Functional Test	Time	Group A [N=15] Mean ± S D	Group B [N=15] Mean ± S D	p-value
QIF	Pre treatment	10.46 ± 1.59	9.86 ± .99	0.227
	Post treatment	11.26 ± 1.53	10.13 ± 1.12	0.029 *
SCIM	Pre treatment	19.93 ± 2.18	19.8 ± 2.07	0.865
	Post treatment	21.06 ± 2.25	20.06 ± 2.28	0.023 *

*Significant at 0.05 level

Fig 1. Intra group comparison of changes in EMG amplitude (micro volts)

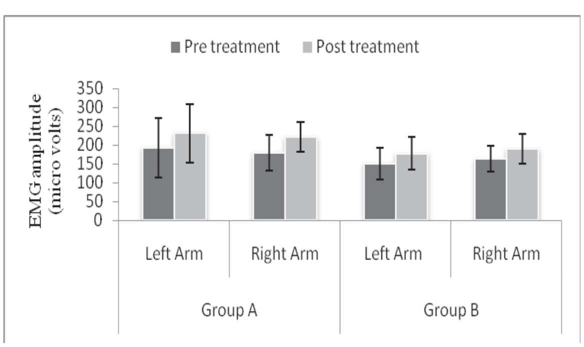


Fig 2. Comparison of changes in quadriplegic index of function scores(QIF) within groups

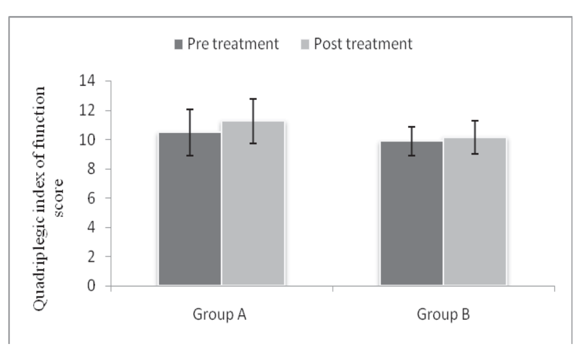


Fig 3. Comparison of changes in spinal cord independence measure score (SCIM) within groups

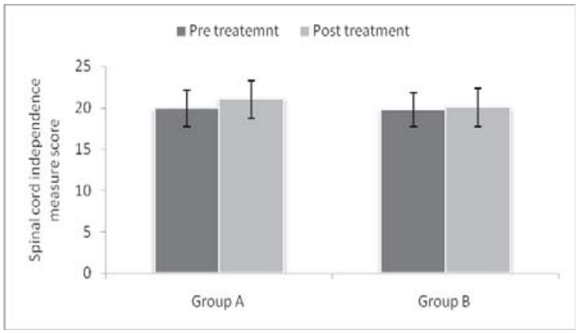


Fig 4. Comparison of changes in EMG amplitude (micro volt) between two groups

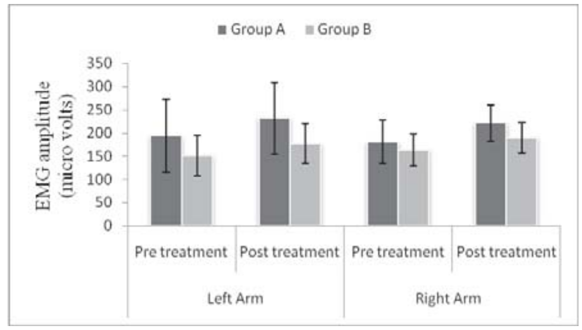


Fig 5. Comparison of changes in quadriplegic index of function scores(QIF) between groups

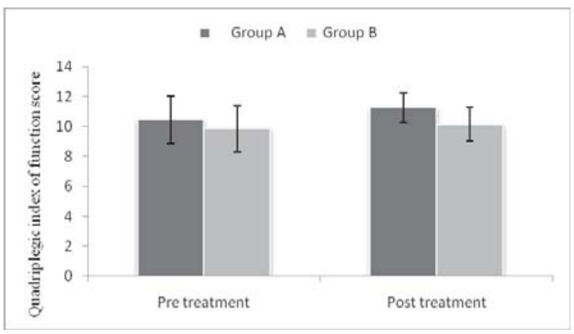
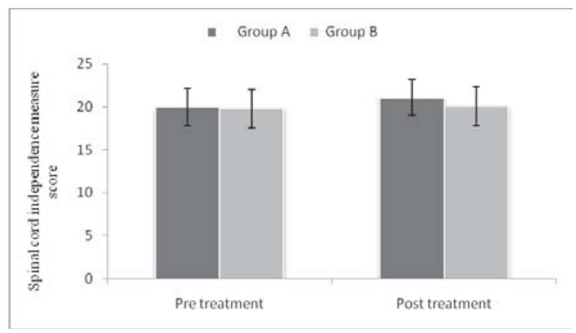


Fig 6. Comparison of changes in spinal cord independence measure scores (SCIM) between groups



*Significant at 0.05 level

EMG and sprouting of motor nerve terminals to innervate additional muscle fibers.[12] The increase may be the result of some 'masked' neural recovery that has taken place but the subject was unaware of or unable to exploit was developed into full potential with biofeedback.[20] The fact that Klose and colleagues did not find biofeedback interventions to effective in increasing EMG or function in spinal cord injury patients is most likely because of procedures for biofeedback used in those studies. It consisted of visual display without specific operant conditioning paradigms for increasing voluntary control of physiological responses. There was significant increase in QIF and SCIM scores, in both groups but the mean difference (table 2) for both the scores was higher for group A than group B. Also there was highly significant difference in QIF scores and SCIM scores in between two groups after the treatment The gains made by the biofeedback groups may be the result of learning, while the gains demonstrated by the other groups may be merely the result of muscle strengthening . There are some unused neurons in the spinal cord which is not utilized under normal circumstances. During the therapy a specific task is assigned to them. As the patient learns to follow instructions in a specific learning paradigm and learns to separate signals, after a few days of application of biofeedback the patient relates EMG signals with function.[6,21] Thus biofeedback adds on to the improvement by providing the patient with immediate, direct information concerning the use of muscle. Such information serves the purpose of reinforcing only positive behavior and motivating the patient. So findings of the study confirms that the increases in EMG amplitude obtained with the biofeedback procedures could translate into functional gains.Future research would include the application of biofeedback protocol to a longer duration with appropriate functional training. Thus, it can be concluded that EMG biofeedback can be used as an adjunct to physical therapy in chronic spinal cord injured patients for improving the motor unit activity and improvement of functional activity.

References

1. Van Tuijl JH, Janssen-Potten YJ, Seelen HA. Evaluation of upper extremity motor function tests in tetraplegics *Spinal Cord* 2002; 40: 51-64.
2. Mizukami M, Kawai N, Iwabaki Y, Yamamoto Y, Yoshido Y, Koyama N, et al. Relationship between functional levels and movement in tetraplegic patients. A retrospective study. *Paraplegia* 1995; 33: 189-194.
3. Welch RD, Lobley SJ, O'Sullivan SB, Freed MM.Functional Independence in Quadriplegia: Critical levels. *Archives of Physical . Medicine and Rehabilitation* 1986; 67: 235-240.
4. Blanchag, EB,Young LD. Clinical application of biofeedback training. A review of evidence. *Archives of General Psychiatry* 1974; 30: 573-589.
5. Basmajian JV. *Biofeedback- Priciples and practice for clinicians*. 3rd ed. Baltimore; Williams and Wilkins, 1989.
6. Mroczek N, Halpren D, McHugh R. Electromyographic feedback and physical therapy for neuromuscular retraining in hemiplegia. *Archives of Physical Medicine and Rehabilitation* 1978; 59: 258-267.
7. Goldsmith MF. Computerized biofeedback training aids in spinal injury rehabilitation. *JAMA 1985*; 253: 1097-1099.
8. Morrison SA. Biofeedback to facilitate unassisted ventilation in individuals with high level Quadriplegia. *Physical Therapy* 1988; 68: 1378-1380.
9. Klose KJ, Needham BM, Schmidt D, Broton JG, Green BA. An assessment of the contribution of electromyographic biofeedback as an adjunct therapy in the physical training of spinal cord injured persons. *Archives of Physical Medicine and Rehabilitation* 1993; 74: 453-456.
10. Middleton JW, Truman G, Geraghty TJ. Neurological Level Effect on the Discharge functional status of Spinal Cord Injured Persons after Rehabilitation. *Archives of Physical Medicine and Rehabilitation* 1998; 79: 1428-1432.
11. Gresham GE, Labi ML, Dittmar SS, Hicks JT, Joyce ZJ, Stehlik MA. The Quadriplegia Index of Function (QIF): sensitivity and reliability demonstrated in a study of thirty quadriplegic patients. *Paraplegia* 1986; 24: 38-44.
12. Catz A, Itzkovich M, Agranov E, Ring H, Tamir A. SCIM- spinal cord Independence measure: a new disability scale for patients with spinal cord lesions: *Spinal Cord* 1997; 35: 850-856.
13. Nacht MB, Wolf SL, Coogler CE. Use of electromyographic biofeedback during the acute phase of spinal cord injury. *Physical Therapy* 1982; 62: 290-294.
14. Stein RB, Brucker DS, Ayyar DR. Motor units in incomplete spinal cord injury; electrical activity, contractive properties and effects of biofeedback. *Journal of Neurolology Neurosurgery and Psychiatry* 1990; 53: 880-885.
15. Ince LP, Leon MS. Biofeedback treatment of upper extremity dysfunction in Guillain-Barré syndrome syndrome. *Archives of Physical Medicine and Rehabilitation* 1986; 67: 30-33.
16. BrudnyJ, KoreinJ, Levidow L, Grynbaum BB, Lieberman A, Friedmann LW. Sensory feedback therapy as a modality of treatment in central nervous system disorders of voluntary movement. *Neurology* 1974; 24: 925-932.
17. Mange KC, Ditunno JF Jr, Herbison GJ, Jaweed MM. Recovery of strength at the zone of injury in motor complete and motor incomplete cervical cord injured patients. *Archives of Physical Medicine and Rehabilitation* 1990; 71: 562-565.
18. Ditunno JF Jr, Stover SL, Freed MM, Ahn JH. Motor recovery of the upper extremities in traumatic quadriplegia: a multicenter study. *Archives of Physical Medicine and Rehabilitation* 1992; 73: 431-436.
19. Klose KJ, Schmidt DL, Needham BM, Brucker BS, Green BA, Ayyar DR. Rehabilitation therapy for patients with long term spinal –cord injuries. *Archives of Physical Medicine and Rehabilitation* 1990; 71: 659-662.
20. Middaugh SJ, Miller C .Electromyographic feedback: effect on voluntary muscle contractions in paretic subjects. *Archives of Physical Medicine and Rehabilitation* 1980; 61: 24-29.
21. Hurrell M . Electromyographic feedback in rehabilitation. *Physiotherapy* 1980; 66: 293-298.