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ORIGINAL ARTICLE

EFFECTIVENESS OF ELECTROMYOGRAPHIC BIOFEEDBACK AND NEUROMUSCULAR ELECTRICAL STIMULATION ON IMPROVING STRENGTH AND FUNCTIONS OF WRIST AND HAND COMPLEX IN SUBJECTS WITH SUBACUTE MCA STROKE

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ABSTRACT

Introduction: stroke rehabilitation mainly emphasize on improving upper limb function especially on wrist and hand. Even mild improvement to wrist and hand function will reflects on patient outcome and reduces disability. **Objective** of the study is to determine the effect of Emg biofeedback and NMES on improving the strength and function of wrist and hand muscles in Sub acute MCA stroke patients. **Methodology:** it is a Pre Vs post experimental design. This study was conducted at Outpatient department of Bethany Navajeevan College of physiotherapy, hospitals in and around Trivandrum 30 subjects with poor hand and wrist function and strength after sub acute MCA stroke whose satisfying inclusion criteria were included in the study. Group a included 15 subjects, was treated with EMG biofeedback, NMES (15hz, pulse width 200ms) and conventional exercises, group b included 15 subjects, was treated with conventional exercises for 6 weeks, 5 days per week. Pre and post tests were conducted on ARAT and MMT. **Results:** based on statistical analysis, the result of the study shows statistically significant difference in pre-test and post-test values in the ARAT and MMT of the experimental group. **Conclusion:** the study concludes that the Emg biofeedback and NMES shows significant improvement in strength and function of wrist and hand complex in Sub acute MCA stroke patients.

Keywords: MCA stroke, Electromyographic biofeedback, neuromuscular electrical stimulation, action research arm test, manual muscle testing.

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INTRODUCTION

Stroke rehabilitation mainly focuses on improving upper limb function. Even after standard neurological rehabilitation, approximately 80% of these patients suffer from hand dysfunction. The increased tension of the wrist dorsal extensors in stroke patients severely affects the active range of motion (AROM) and the wrist dorsal extension. Wrist joint dysfunction leads to impaired motor control function of the upper limb.

Biofeedback improves the awareness of movement or function, by improving voluntary control of that movement or function. Electromyographic (EMG) biofeedback provides information about muscle activity, which is detected through surface electrodes placed on the skin, or through needle or fine wire electrodes inserted into the muscle, and are fed back to the patient via electrical activity displayed on a visual display unit or by an auditory signal[1].

Neuromuscular electrical stimulation (NMES), consists of the application of high-intensity and intermittent electrical stimuli to generate relatively strong muscle contractions, this modality is mainly used for neuromuscular rehabilitation/strength training. The hemiplegic limb is passively moved while applying NMES. Between 1 week and 6 months post-stroke (subacute period of stroke) is a critical time for neural plasticity; most behavioural recovery and rapid changes occur in the first weeks and months post-stroke for the majority of people[2].

The ARAT, developed by Lyle in 1981, is a performance test to assess upper extremity function and dexterity after stroke. The test consists of 19 items and a test kit. The person's performance at every item is assessed using 4-level ordinal scale. The ARAT is divided into 4 subgroups; grasp, grip, pinch and gross movement. Score ranging from 0-57 points, Subtest scores are added to calculate a total score for each side. The subtests in the ARAT are arranged in a hierarchical order, in which the most difficult item is tested first, followed by the easiest item, then items with gradually increasing difficulty. ARAT is a reliable observational rating scale for assessing function and activity of the arm and hand in persons with stroke[3].

The classical MMT scoring system, otherwise known as the Oxford Scale or Medical Research Council Manual Muscle Testing scale. It is a six-point ordinal scale. It was developed Wright and Lovett. The MRC scale for muscle strength uses manual muscle testing to grade muscle strength, ranging from 0 to 5, according to the maximum force expected for a certain muscle.

The aim of the study was to find out the effectiveness Electromyographic Biofeedback and Neuromuscular Electrical Stimulation on improving strength and functions of wrist and hand complex in subjects with subacute MCA stroke.

METHODOLOGY

The study used Pre vs post experimental design. Hospitals in and around Trivandrum and outpatient department of Bethany Navajeevan college of Physiotherapy were used as study setting.

Participants: 30 samples who met inclusion criteria were selected through purposive sampling method.Inclusion criteria were(1)Age group 40-65 years, (2) Both gender, (3)First haemorrhagic or non-haemorrhagic stroke, (4) Lesions located in the territory of the middle cerebral artery (MCA), including the subcortical regions of the corona radiata, internal capsule, and the basal ganglia (mainly the putamen and the globus pallidus, as well as the overlying cortex, diagnosed using either computed tomography (CT) or magnetic resonance imaging (MRI), (5) Brunnstrom's stage between 1-4,(6)Spasticity not higher than 3 in the modified Ashworth scale.

Other neurological disorders, such as Parkinson's disease, epilepsy, multiple sclerosis, etc., Individuals with visual or hearing impairments, Individuals with peripheral nerve injury, an unstable medical condition or uncontrolled systemic diseases, Subjects with cardiac pacemaker, Impaired ability to understand the protocol because of severe aphasia, and severe cognitive disorders (Mini-Mental State Examination score ≤24) were excluded from the study.

Procedure: Based on the inclusion criteria, 30 subjects with poor hand and wrist function and strength after sub acute MCA stroke were included in the study. A brief explanation was given to the participants. After obtaining an informed consent, subjects were allocated into two groups i.e., group A- experimental group and group B – control group with 15 subjects in each group. Subjects Pre-tests was conducted on using Action research arm test and Manual muscle testing (MMT).

Intervention: Intervention program was briefly explained to patients. Group A was treated with Electromyographic Biofeedback, Neuromuscular electrical stimulation and conventional exercises for 6 weeks, 5 days per week. EMG Biofeedback was given in comfortable sitting position next to the device in a quiet room with the wrist on a pillow at 90-degree flexion. Electrodes were applied to the wrist extensor motor points on the forearm. The patient was instructed to try to extend the wrist and perform the finger flexion and extension movements. The patient's muscle activity was shown on a computer monitor as graphical representation. The patient was instructed to try to maintain the muscle activity on the isoelectric line. The patient's motor unit potentials were monitored, and periodic verbal feedback was provided. Treatment duration was 20 minutes.

Neuromuscular Electrical Stimulation was also given in the seated position same as mentioned in EMG biofeedback treatment. Electrodes were placed over the wrist extensor motor points of forearm. Intensity was given to visible muscle contraction. Treatment duration was 20 minutes with frequency of 15 Hz and pulse duration of 200µs. Conventional Exercises were also given as active, active assisted or resisted exercises- Wrist flexion and extension, Ulnar and radial deviation, Finger flexion and extension, Finger opposition, Thumb extension, flexion, adduction, abduction, Thumb press, Ball grip and release, Pinch, Scissor spread, Finger scissor, Side squeeze.

Total duration of treatment was 1 hour in which 15 minutes for EMG biofeedback, 15 minutes for NMES, 15 minutes for conventional exercises, given for 5 days a week for 6 weeks. Group B was treated only with conventional exercises. Treatment session was 30 minutes, given for 5 days a week for 6 weeks.

Post-test was conducted on using Action Research Arm Test and Manual Muscle Testing (MMT).

The results were recorded and analysed statistically recorded using the software SPSS version 29.

Comparison of Pre-Test Vs Post- Test Score of ARAT In Experimental Group

ARAT	No. of Samples	Median	Inter Quartile Range (IQR)	Mean Rank	Sum of Ranks	Z value	*P* value*
Pre test	15	16	15-17	8.00	120.00	-3.415	<.001
Post test	15	33	32-35				

*Analyzed by Wilcoxon signed ranks test, ARAT = Action Research Arm Test

Table No.1 shows the pre vs post-test values of ARAT in experimental group

Comparison of Pre-Test Vs Post- Test Score Of ARAT In Control Group

AART`	No. of Samples	Median	Inter Quartile Range (IQR)	Mean Rank	Sum of Ranks	Z value	*P* value*
Pre test	15	17	16-18	8.00	120.00	-3.426	<.001
Post test	15	25	23-27				

*Analyzed by Wilcoxon signed ranks test, ARAT- Action Research Arm Test

Table No. 2. Shows the pre vs post-test values of ARAT in Control group.

Comparison of Pre-Test Vs Post-Test Score Of ARAT In Between Experimental Group And Control Group

ARAT		No. ofSamples	Median (Inter Quartile Range)	Mean Rank	Sum of Ranks	*U* value	*Z* value	*P* value*
Time Point	Group							
Pre	Exp	15	16(15-17)	13.27	199.00	79.000	-1.421	.155
	Cont	15	17(16-18)	17.73	266.00			
Post	Exp	15	33(32-35)	21.80	327.00	18.000	-3.929	<.001
	Cont	15	25(23-27)	9.20	138.00			

*Analyzed by Mann-Whitney U test, Exp=Experimental group, Cont.=Control group, ARAT – Action Research Arm Test

Table 3. Shows the comparison of pre- and post- test values of ARAT between experimental group and control group

Comparison of Pre-Test Vs Post- Test Score Of MMT In Experimental Group

MMT	No. of Samples	Median	Inter Quartile Range (IQR)	Mean Rank	Sum of Ranks	Z value	*P* value*
Pre test	15	2.00	1-2	8.00	120.00	-3.690	<.001
Post test	15	4.00	3-4				

*Analyzed by Wilcoxon signed ranks test, MMT- Manual Muscle Testing

Table 4. Shows the pre vs post-test values of MMT in experimental group

COMPARISON OF PRE-TEST VS POST- TEST SCORE OF MMT IN CONTROL GROUP

MMT`	No. of Samples	Median	Inter Quartile Range (IQR)	Mean Rank	Sum of Ranks	Z value	*P* value*
Pre test	15	2	2-2	6.00	66.00	-3.317	<.001
Post test	15	3	2-3				

*Analyzed by Wilcoxon signed ranks test, MMT- Manual Muscle Testing

Table No.5. shows the pre vs post-test values of MMT in Control group.

Comparison of Pre-Test Vs Post-Test Score of MMT In Between Experimental Group and Control Group

MMT		No. of Samples	Median (Inter Quartile Range)	Mean Rank	Sum of Ranks	*U* value	*Z* value	*P* value*
Time Point	Group							
Pre	Exp	15	2(1-2)	13.90	208.00	88.500	-1.139	.255
	Cont	15	2(2-2)	17.10	256.00			
Post	Exp	15	4(3-4)	20.67	310.00	35.000	-3.519	<.001
	Cont	15	3(2-3)	10.33	155.00			

*Analyzed by Mann-Whitney U test, Exp=Experimental group, Cont=Control group, MMT- Manual Muscle Testing

Table 6. Shows the comparison of pre- and post- test values of MMT between experimental group and control group

Illustration

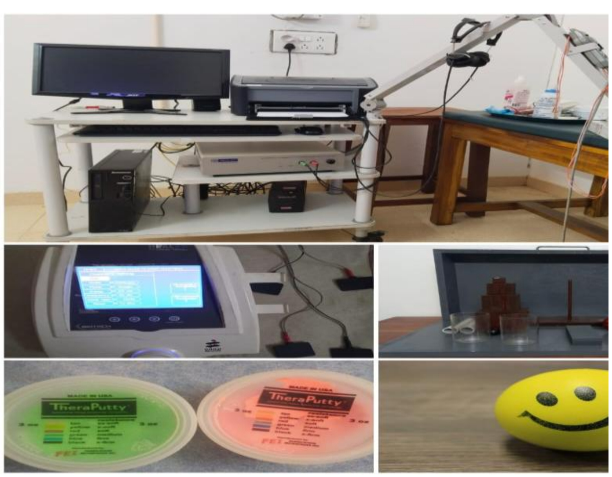

Fig 1. Materials used for the study

Fig.2. a

Fig. 2. b

FIG.2. c

FIG.2. d

FIG. 2. (a, b, c, d) Assessing ARAT

FIG.3 a

Fig. 3. b

FIG. 3. (a, b) subject receiving EMG

FIG.4 a

FIG.4. b (a, b) Subject receiving NMES

FIG. 5. Performing finger exercises using Thera Putty

DISCUSSION

Stroke or brain attack is the sudden neurological functional loss due to any blockage of blood flow to the brain. The most common artery involved in acute stroke is middle cerebral artery. Contra lateral spastic hemi paresis and sensory loss of the face, UE, and LE are the most common characteristics of MCA syndrome.

Cristina Lirio-Romero et al,[11] conducted a study to examine the effects of a 6-week surface electromyographic biofeedback intervention on the re-learning of upper extremity motor function in subjects with paretic upper extremity after stroke. The sEMG-BFB group shows significant increases in upper extremity motor function than the sham BFB group after the intervention. Study concluded that a 6-week sEMG-BFB intervention effectively improved paretic upper limb motor function.

The study conducted by Yea-Ru Yang et al [21], shows that Neuromuscular electrical stimulation (NMES) has been used to improve muscle strength and decrease spasticity of the ankle joint in stroke patients. The results showed that the static and dynamic spasticity of ankle plantarflexors of the control group were significantly decreased after training. Improvement shows on gait performance and ankle control during walking in chronic stroke patients.

Electromyographic biofeedback (EMG-BFB) has been used to improve motor function based on augmented audio and visual feedback information, patient can modify or alter motor unit activity. Training can focus on voluntary inhibition of spastic muscles, or on increasing kinesthetics awareness and recruitment of motor units in weak, hypoactive muscles. Electromyographic (EMG) biofeedback provides information about muscle activity, which is detected through surface electrodes placed on the skin, or through needle or finewire electrodes inserted into the muscle, and is return back to the patient via electrical activity displayed on a visual display unit or by an auditory signal[1].

Neuromuscular electrical stimulation (NMES) is one of the most common techniques for improving the function of paralysed limb. Neuromuscular electrical stimulation (NMES), consists of the application of high-intensity and intermittent electrical stimuli to generate relatively strong muscle contractions. Jayme S Knuston et al[12] found that the NMES provides therapeutic effect by combining both peripheral and central effects.

Peripheral effects of NMES include increase in contractile force and fatigue resistance, increase in muscle mass, reduction of edema, conversion of fast-twitch fast-fatiguing glycolytic type II muscle fibres to slow-twitch fatigue-resistant oxidative type I muscle fibres, and enhanced hyperaemic arterial response and endothelium-dependent cutaneous vasodilation. These peripheral effects can reverse disuse atrophy. Both EMGB and NMES uses the mechanisms motor relearning and neural plasticity.

The purpose of the present study was to find out the effect of Electromyographic biofeedback and Neuromuscular electrical stimulation to improve the strength and function of wrist and hand muscles in subjects with sub acute MCA stroke. Based on inclusion criteria 30 subjects with poor hand and wrist function and strength after sub acute MCA stroke were included in the study. Group A – experimental group and Group B – control group with 15 subjects in each group. Group A was treated with Electromyographic Biofeedback, Neuromuscular electrical stimulation and conventional exercises for 6 weeks, 5 days per week. Group B was treated only with conventional exercises given for 5 days a week for 6 weeks.

Statistical analysis was done using software SPSS 29 version.Wilcoxon signed-rank test and Mann Whitney U test were used as statistical tools to reach a conclusion. Outcome measures, Action research Arm Test for wrist and hand function, Manual Muscle Testing for strength of wrist extensors and flexor muscles. All outcome measure was collected before and after the intervention protocol. In both groups Wilcoxon test was used to compare pre-test and post-test values. The post-test scores and pre-test scores of both groups were analysed using Mann Whitney U Test. The results showed that after 6 weeks of treatment protocol experimental group showed improvement in strength and function of wrist and hand complex. The result of the present study shows that Electromyographic biofeedback and neuromuscular electrical stimulation, along with conventional exercises improves strength and function of wrist and hand in sub acute MCA stroke patients. After 6 weeks of the intervention, there was a significant median difference in the ARAT score and MMT score in experimental group compared with the control group.

By Wilcoxon signed rank test Pre vs post-test values of ARAT in experimental group, pre-test median was 16 and post-test median was 33. The *P* value <.001 which shows that there is a statistically significant difference between the pre and post-test values of ARAT in experimental group. Pre vs post-test values of ARAT in Control group, pre-test median was 17, post-test median was 25. The *P* value <.001 which shows that there is a statistically significant difference between the pre and post-test values of ARAT in control group.

The pre-test Mann-Whitney *U* value was 79.000, *Z* value was -1.421, *P* value was .155, which shows that there is no significant difference in pre-test values of ARAT between experimental and control groups. The post-test Mann-Whitney *U* value was 18.000, *Z* value was -3.929; *P* value was< .001 which shows that there is a statistically significant difference in post-test values of ARAT between experimental and control groups. Also, the result shows that post-test value of ARAT in experimental group is higher than the post-test value of ARAT in control group.

The pre vs post-test values of MMT in experimental group, Pre-test median was 2 and the Post-test median was 4. The value <.001 which shows that there is a statistically significant difference between the pre and post-test values of MMT in experimental group. The pre vs. post-test values of MMT in Control group. Pre-test median was 2 and the Post-test median was 3. The *P* value <.001 which shows that there is a statistically significant difference between the pre and post-test values of MMT in control group.

The comparison of pre and post-test values of MMT between experimental group and control group were done by Mann Whitney U test. The pre-test Mann-Whitney *U* value was 88.500, *Z* value was -1.139, *P* value was .255 which shows that there is no significant difference in pre-test values of MMT between experimental and control groups. The post-test Mann-Whitney *U* value was 35.000, *Z* value was -3.519; *P* value was <.001 which shows that there is a statistically significant difference in post-test values of MMT between experimental and control groups. Also, the result shows that post-test value of MMT in experimental group is higher than the post-test value of MMT in control group.

The statistical findings clearly shows that the EMG Biofeedback and NMES has greater improvement in strength and function of wrist and hand complex in MCA Stroke patients and thereby improves the daily living activities, which is important for their successful social interaction. This improvement is a result of using EMG Biofeedback and NMES along with conventional exercises. Although the study has some limitations, in this study no long term follow up was done, so it is not possible to determine the changes that shown in the study were lasting. The study sample size was small. The study duration was less.

Future recommendations: The study should be conducted to find out whether any gender wise relevance in the interventions. The study could be conducted to find out the effectiveness of intervention in older adult stroke patients. The study could be conducted to find out the effectiveness of intervention in chronic stroke patients. The study could be conducted to find out the long-term effects.

CONCLUSION

Based on the statistical analysis, the result of the present study shows that there is statistically significant difference in the strength and function of wrist and hand in pre-test and post-test values of Group A and Group B. The Group A showed greater improvement in strength and function of wrist and hand in subjects with Sub acute MCA stroke. Thus, the study concludes that EMG Biofeedback and NMES shows significant improvement in strength and functions of wrist and hand complex in subjects with subacute MCA stroke. Therefore, the study rejects the null hypothesis and accepts the alternate hypothesis.

Conflict of Interest: There was no personal or institutional conflict of interest for this study.

Fund for the Study: This was a self-funded study.

Ethical Approval: Institutional ethics committee of Bethany Navajeevan College Ref no: BNCP/N/2021/02

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