Analysis of motor-skill transfer from non-paretic limb to paretic limb and vice-versa in stroke patients

[1]Ms. Apurva Ajay Joshi, [2]Dr. R. M. Singaravelan

[1]BPT Intern, [2]MPT, PhD, Prof and HOD of Dept. of Neuro-Physiotherapy, Dr. A.P.J.A.K.COPT, PIMS (DU), Loni
[1]Department of Neuro Physiotherapy,
[1]Dr. A.P.J. A.K. College of Physiotherapy, PIMS (DU), Loni, Maharashtra, India

Abstract: **BACKGROUND: Stroke is one of the leading causes of death and disability in India. Given the central role upper extremity (UE) plays in all activities of daily living, much attention should be given to its motor recovery. Stroke rehabilitation in UE mainly focuses on the training of paretic limb during motor recovery. Bilateral arm training has proved to be beneficial in improving the paretic limb function. So, the aim of this study was to assess whether the side of motor skill transfer is significant in improving the UE functional performance and myoelectric activity after applying Proprioceptive Neuromuscular Facilitation (PNF) in stroke patients. MATERIALS AND METHOD: 20 participants with ages between 50 to 70 years were selected and were randomly divided into two groups. Group A was given training to the non-paretic UE first whereas Group B was given training to the paretic UE first. Both group A and B received 3 sessions per week, each session lasting for about 20 minutes for 3 days per week for 4 weeks. The outcome measures were assessed before and after intervention by Wolf Motor Function Test (WMFT) assessing UE functional performance and surface electromyography (sEMG) assessing myoelectric activity. RESULT: Statistical analysis (Student's paired and unpaired 't' test) showed no significant difference in WMFT findings but a significant difference in sEMG findings after applying PNF to both UE for 4 weeks, which means that the UE myoelectric activity showed better improvement than UE functional performance in the paretic extremity. Also, Group A (non-paretic side first) showed better improvement as compared to group B (paretic side first). CONCLUSION: Motor skill improvement is better when PNF is applied to the non-paretic UE first, then to the paretic UE as compared to vice-versa in stroke patients for the duration of 4 weeks.**

Index Terms: **Stroke, motor skill transfer, Proprioceptive Neuromuscular Facilitation, Hemiparesis, Upper extremity, Wolf Motor Function Test and Electromyography.**

I. INTRODUCTION

Stroke is defined as the sudden death of brain cells due to lack of oxygen, caused by blockage of blood flow or rupture of an artery to the brain. It is the sudden loss of neurological function caused by an interruption of the blood flow to the brain. It is also known as cerebrovascular accident (abbreviated CVA).[16]

Primary impairments from stroke:

- Motor Function - Rates of motor recovery vary across management categories: patients suffering minor stroke recover rapidly with few or no residual deficits whereas severely impaired individuals demonstrate more limited and prolonged recovery. Motor function often improves after the first few days. In the case of complete paralysis on admission, complete motor recovery occurs in less than 15% of patients.
- Weakness - Weakness (paresis) is found in 80 to 90 percent of all patients after stroke and is a major factor in disability. The degree of weakness is related to the location and size of the brain injury and varies from a complete inability to achieve any visible contraction to measurable impairments in force production. Deficits on the contralateral, side typically include hemiparesis (opposite UE and LE). Owing to the high incidence of MCA strokes, the UE is frequently more affected than the LE.

Given the central role UE plays in all activities of daily living, much attention should be given to its motor recovery.[2] Motor learning has been defined as "a set of internal processes associated with practice or experience leading to relatively permanent changes in the capability for skilled behavior." Studies have shown intense, repetitive movements are of high value in improving the UE motor function as they increase strength, accuracy and functional use when applied to stroke patients with paresis.[2]

Neurophysiological approaches are based on the knowledge of understanding the physiology that helps CNS function and these approaches utilize plasticity. It contributes to the adaptation and reorganization of the CNS function. Correct and repeated stimulation through this approach can lead to the non-affected area of the brain functionally compensating for the affected area.[xvi]

Proprioceptive Neuromuscular Facilitation (PNF):

Motor function can be improved using Proprioceptive Neuromuscular Facilitation (PNF), an approach initially developed by Dr. Herman Kabat and Maggie Knott. Hence, assisted PNF can be applied to the paretic upper extremity while resisted PNF can be applied to the non-paretic upper extremity in a non-paretic to paretic side fashion, or paretic to non-paretic side fashion, as the training is to be given bilaterally.

Purpose of the study:

Bimanual upper limb training is more beneficial and improves performance of the affected limb. Bilateral transfer of a motor skill is a phenomenon according to which, one hand can "teach" a skill to the other hand. However, there is limited research on the concept of direction of transfer of motor training.

The transfer of motor skill learning can occur in two ways:

- Paretic limb to non-paretic limb
- Non-paretic limb to paretic limb

Limited research suggests that the transfer from non-paretic limb to paretic limb would prove more beneficial. This study will support the above mentioned research and assess the beneficial side of motor skill transfer.

Hence, investigating which side of transfer would prove more beneficial in the upper limb recovery of stroke patients is essential.

Aim of the study:

To assess the effectiveness of motor skill transfer when applying Proprioceptive Neuromuscular Facilitation (PNF) from one side of UE to another side on UE functional performance and myoelectric activity in stroke patients.

Objectives of the study:

- To assess if the motor skill transfer from the non-paretic to the paretic UE will show significant improvement in the functional performance and myoelectric activity of the paretic UE after applying PNF.
- To assess if the motor skill transfer from the paretic to the non-paretic UE will show significant improvement in the functional performance and myoelectric activity of the paretic UE after applying PNF.

II. MATERIALS AND METHODOLOGY

- Ethical clearance was obtained from the Institutional Ethical Committee of PIMS (DU), Loni.
- The study design was a Non-randomized or informal Experimental study (pre-test post-test design) which involved convenient sampling. The samples were collected from the In-Patient Department (IPD) of Medicine, Pravara Rural Hospital, Loni and Out-Patient Department of Neuro Physiotherapy, Dr. APJ Abdul Kalam College of Physiotherapy, PIMS, Loni, Maharashtra, India. A sample size of 20 MCA stroke patients with ages between 50- 70 years and who had atleast grade 2 voluntary control according to VCG scale were included. They were randomly divided into 2 groups with each group consisting of 10 patients.
- OUTCOME MEASURES: The paretic and non-paretic UE were assessed for their myoelectric activity by measuring the motor unit action potential (MUAP) of biceps brachii with the help of surface electromyography (sEMG) pre and post-training. The UE functional ability and performance time was also assessed with the help of Wolf Motor Function Test (WMFT) pre and post-training.
- INTERVENTION: Both UE of all patients were trained by applying D1 and D2 diagonal patterns of PNF. The paretic UE was trained by assisted PNF whereas the non-paretic UE was trained by resisted PNF. Group A patients were trained in the sequence – non-paretic UE first followed by paretic UE whereas Group B patients were trained vice-versa.

Treatment duration: 20 minutes per session, 3 days per week for 4 weeks

STATISTICAL ANALYSIS

Data analysis was done using statistical measures like mean, standard deviation and test of significance like Student's paired and unpaired't' test.

DEMOGRAPHICS: A total of 20 patients were screened and considered eligible for the study according to the inclusion and exclusion criteria.

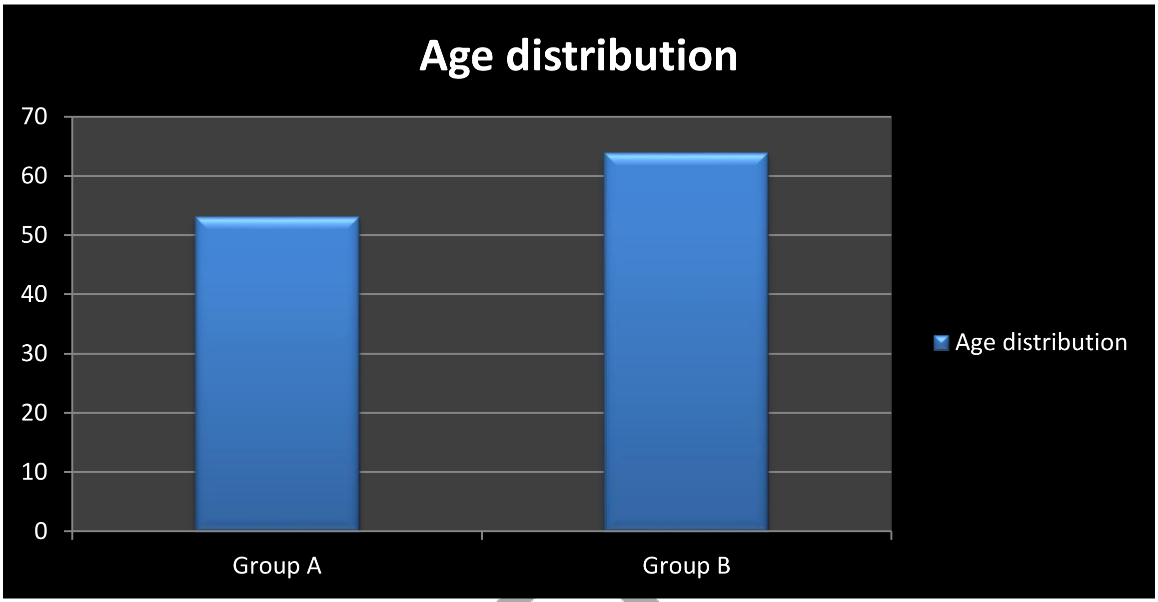
The mean age of patients in Group A was 53.1±16.58 years whereas in Group B it was 63.9±10.87

The gender ratio in Group A was 4:6 (4 men and 6 women) whereas in Group B it was 6:4 (6 men and 4 women)

The total gender ratio was 10:10 (10 men and 10 women)

Table 1: Demographic profile in Group A and B

Groups	Age (years)	Gender (M/F)
Group A	53.1±16.58	4(40%):6(60%)
Group B	63.9±10.87	6(60%):4(40%)
Total	58.5±14.73	10(50%):10(50%)



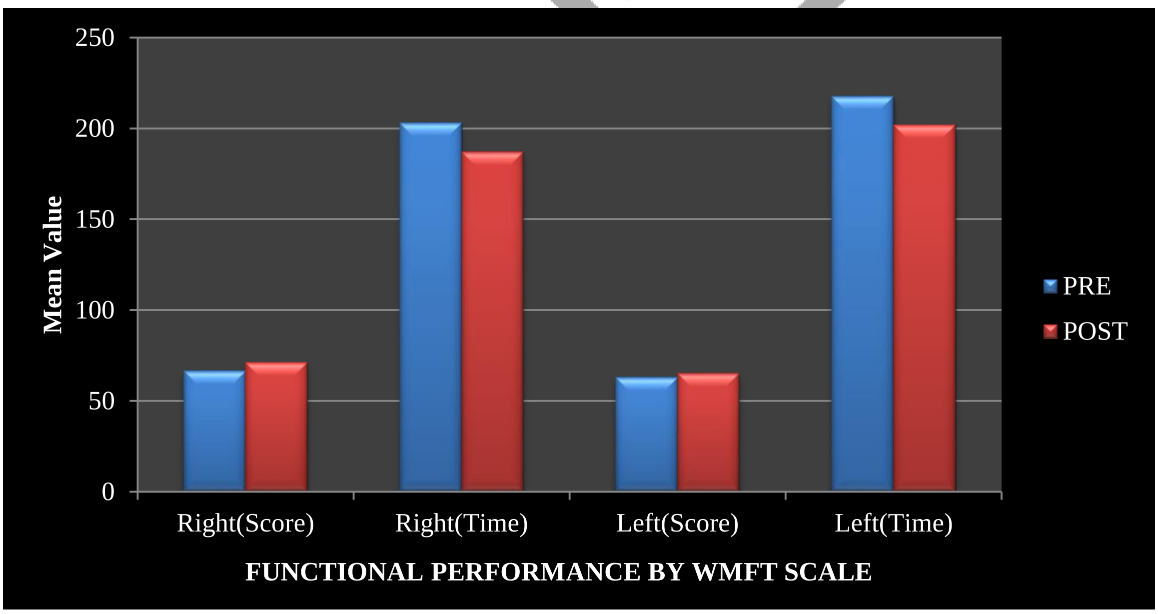
Graph 1: Demographic profile in Group A and B

Comparison of pre and post-intervention values of UE functional performance by WMFT in Group A

The mean pre and post-intervention values of WMFT of Group A were 63.9±14.86, 0.19±0.0, 71±13.83, 0.17±0.04 and 70.9±11.79, 0.13±0.06, 66.6±16.50, 0.14±0.06. The results were calculated by Student's paired 't' test and showed no significant difference pre and post intervention.

Table 2: Comparison of pre and post-intervention values of UE functional performance by WMFT in Group A

WMFT	Pre Mean±SD	Post Mean±SD	Students Paired 't' test value	p values and result
Right UE functional performance	66.4±15.21	71.2±12.46	0.41	p>0.05, not significant
Right UE performance time	201.8±95.23	187±92.30	0.19	p>0.05, not significant
Left UE functional performance	62.8±19.37	65.1±16.78	0.48	p>0.05, not significant
Left UE performance time	217.6±84.47	201.9±89.83	0.35	p>0.05, not significant



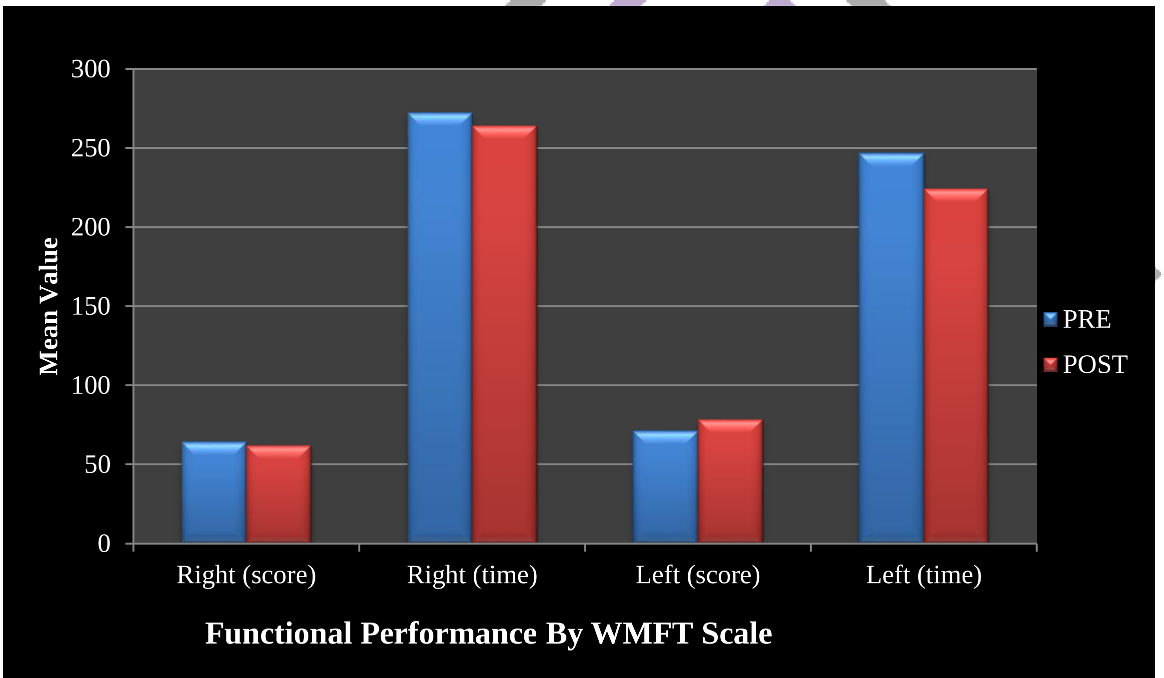
Graph 2: Comparison of pre and post-intervention values of UE functional performance by WMFT in Group A

Comparison of pre and post-intervention values of UE functional performance by WMFT in Group B

The mean pre and post-intervention values of WMFT of Group B were 63.9±14.860, 19±0.05, 71±13.83, 0.17±0.04 and 63.8±12.38, 0.18±0.05, 76.1±8.14, 0.16±0.04. The results were calculated by Student's paired 't' test and showed no significant difference pre and post intervention.

Table 3: Comparison of pre and post-intervention values of UE functional performance by WMFT in Group B

WMFT	Pre Mean±SD	Post Mean±SD	Students Paired 't' test value	p values and result
Right UE functional performance	63.9±14.86	62±11.67	0.07	p>0.05, not significant
Right UE performance time	272.3±86.56	264.2±91.8	0.43	p>0.05, not significant
Left UE functional performance	71±13.83	78.3±4.30	0.45	p>0.05, not significant
Left UE performance time	246.6±64.23	224.2±63.41	0.23	p>0.05, not significant



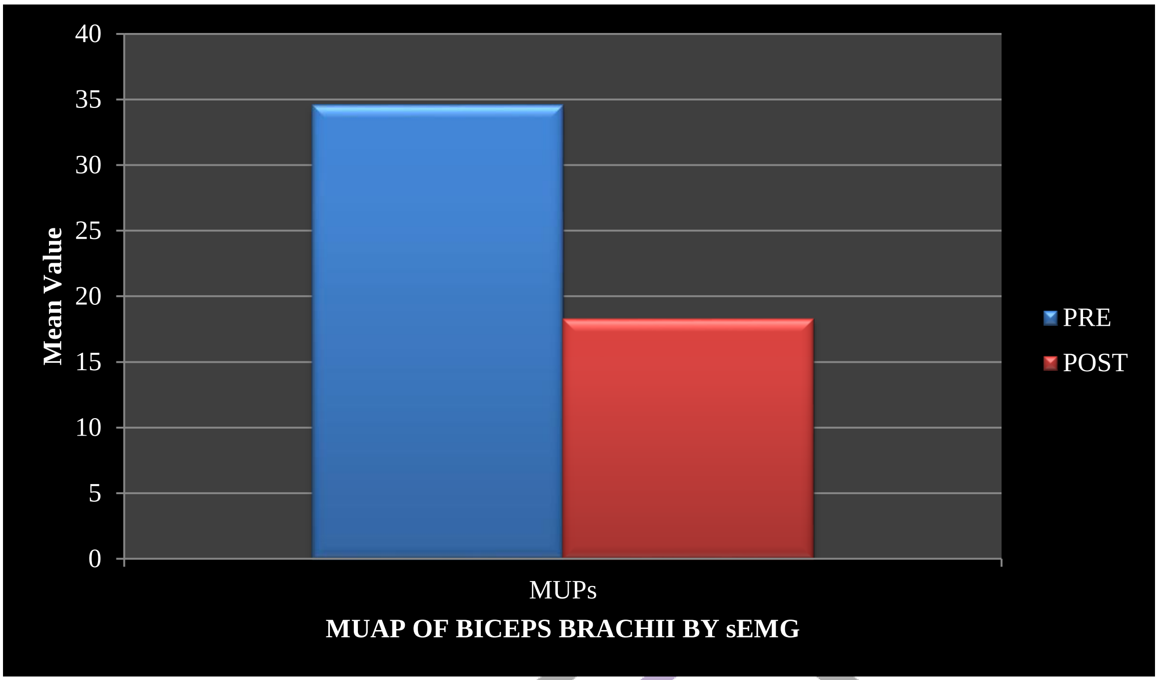
Graph 3: Comparison of pre and post-intervention values of UE functional performance by WMFT in Group B

Comparison of pre and post-intervention values of myoelectric activity by sEMG in Group A

The pre and post-intervention mean values of sEMG findings of Group A were 34.62±7.17 and 18.37±4.80 (p=0.001). The results were calculated by Student's paired 't' test and showed significant difference in pre and post-intervention.

Table 4: Comparison of pre-intervention and post-intervention values of myoelectric activity by sEMG in Group A

EMG	Pre Mean±SD	Post Mean±SD	Students Paired 't' test value	p values and result
MUPs	34.6±7.17	18.3±4.80	0.20	p>0.05, not significant



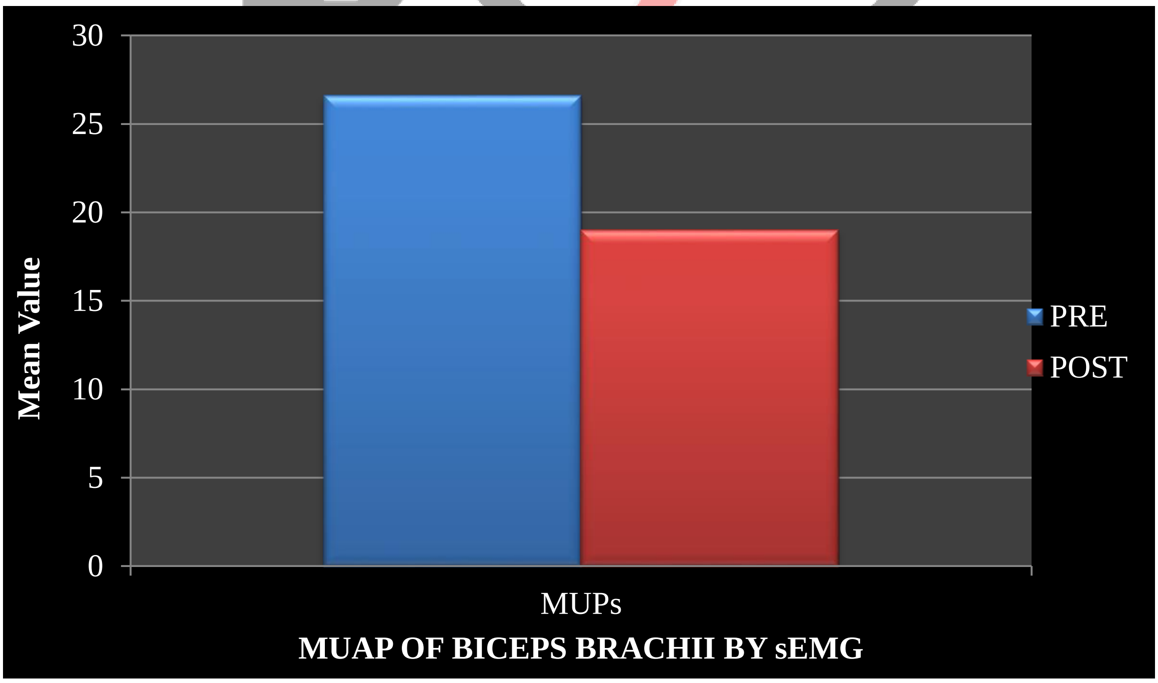
Graph 4: Comparison of pre-intervention and post-intervention values of myoelectric activity of sEMG in Group A

Comparison of pre-intervention and post-intervention values of myoelectric activity by sEMG in Group B

The Pre and Post-intervention mean values of sEMG findings of Group B were 26.68±9.63 and 19.02±7.77 (p=0.001). The results were calculated by Student's paired 't' test and showed significant difference in pre-intervention and post-intervention in Group B.

Table 5: Comparison of pre-intervention and post-intervention values of myoelectric activity by sEMG in Group B

EMG	Pre Mean±SD	Post Mean±SD	Students Paired 't' test value	p values and result
MUPs	26.6±9.63	19.0±7.77	0.17	p>0.05, not significant



Graph 5: Comparison of pre and post-intervention values of myoelectric activity by sEMG in Group B

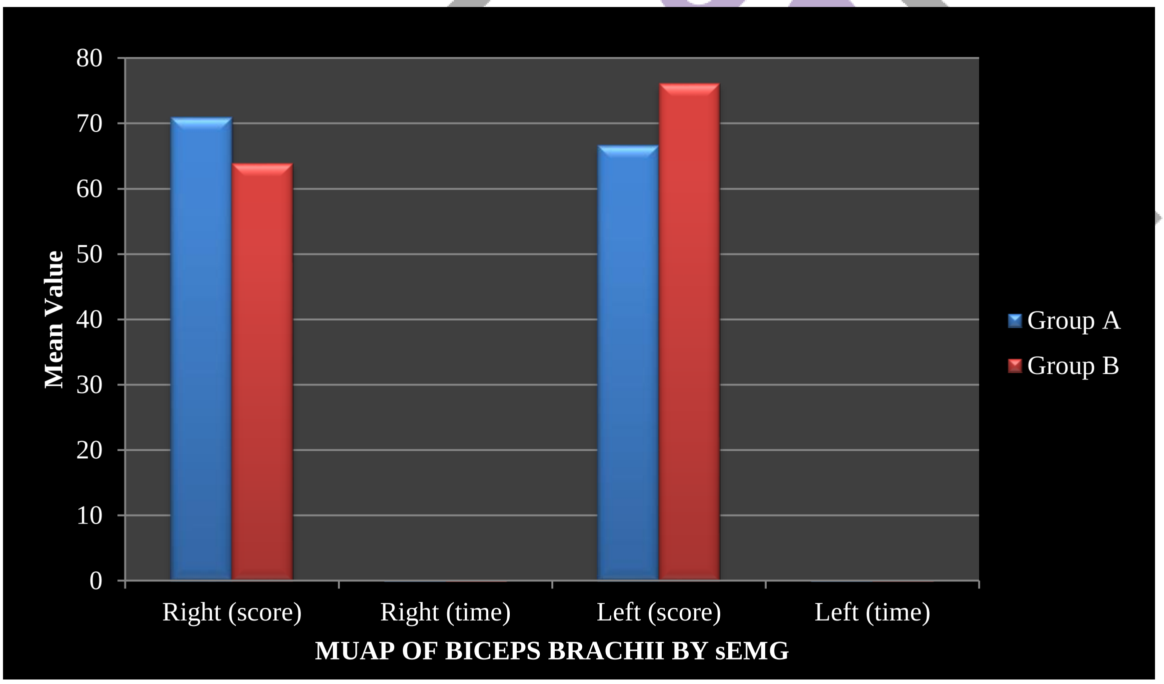
Comparison of post-intervention values of UE functional performance by WMFT of Group A and B

The post-intervention mean values of WMFT of Group A and B were 70.9±11.79, 0.13±0.06, 66.6±16.50, 0.14±0.06 and 63.8±12.38, 0.18±0.05, 76.1±8.14, 0.16±0.04.

The results were calculated by Student's unpaired 't' test and showed significant difference post-intervention.

Table 6: Comparison of post-intervention values of UE functional performance by WMFT of Group A and B

WMFT	Group A Post Mean±SD	Group B Post Mean±SD	Student's unpaired 't' test value	p values and result
Right UE functional performance	70.9±11.79	63.8±12.38	1.62	p= 0.05, Significant
Right UE performance time	0.13±0.06	0.18±0.05	1.73	p= 0.062, Significant
Left UE functional performance	66.6±16.50	76.1±8.14	2.01	p= 0.0713, Significant
Left UE performance time	0.14±0.06	0.16±0.04	1.83	p= 0.0642, Significant



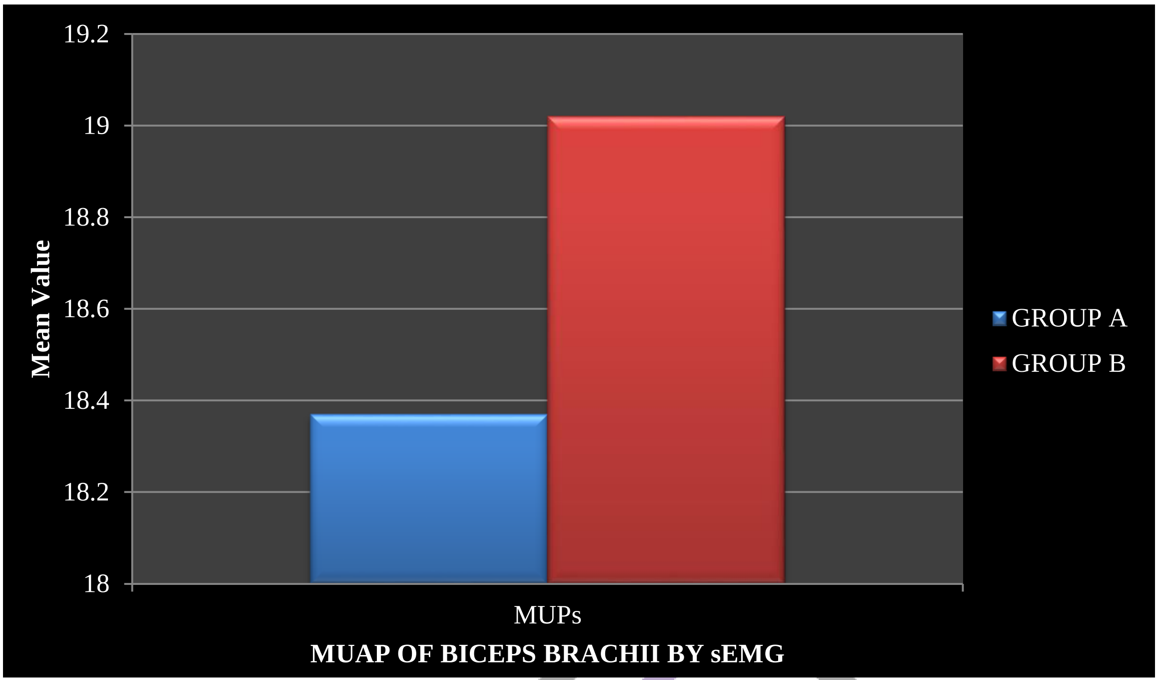
Graph 6: Comparison of Post-intervention values of UE functional performance by WMFT of Group A and B

Comparison of Post-intervention values of myoelectric activity by sEMG of Group A and B

The post-intervention mean values of sEMG findings of Group A and B were 18.37±4.80 and 19.02±7.77. The results were calculated by using Student's unpaired 't' test and showed significant difference in group A and B.

Table 7: Comparison of Post-intervention values of SEMG findings of Group A and B

EMG	Group A Post Mean±SD	Group B Post Mean±SD	Students Unpaired 't' test value	p values and result
MUPs	18.37±4.80	19.02±7.77	4.12	p=0.001, Significant



Graph 7: Comparison of Post-intervention values of myoelectric activity by sEMG of Group A and B

DISCUSSION AND RESULTS

The use of bilateral arm training techniques with the upper limb following stroke has been encouraged recently with the development of new theories regarding neural plasticity. The use of intact limb helps to promote functional recovery of impaired limb through facilitative coupling effects between the damaged and intact cerebral hemispheres through neural networks linked via the corpus callosum.[2]

In general, there is a controversy about the scientific evidence of the preferred direction for bilateral transfer. These results are in accordance with those of Byrd et. al. who found greater transfer from non-paretic to paretic UE. But Kumar and Mandal found a greater bilateral transfer from paretic to non-paretic UE. Bhushan et. al. contributed to this debate suggesting that lack of clear pattern of lateralization limits the motor skill transfer from one to another UE.[1]

The present results of the study suggest there is an improvement in motor recovery of the paretic UE after applying PNF to both extremities for 4 weeks. Also, Group A shows better improvement in WMFT and sEMG pre and post-intervention findings as compared to group B. The results showed better improvement in the sEMG findings pre and post-intervention as compared to findings of WMFT. This means that the UE myoelectric activity showed better improvement than UE functional performance in the paretic extremity.

CONCLUSION

This study concluded that motor skill improvement (UE functional ability, performance time and myoelectric activity) is better when PNF is applied from the non-paretic UE first, then to the paretic UE as compared to the paretic UE first, then to the non-paretic UE in stroke patients for the duration of 4 weeks.

LIMITATIONS OF THE STUDY

1. The study was limited to patients with MCA territory of stroke.
2. It was limited only to the upper extremity motor function.
3. It included smaller sample study.
4. The intervention was done only for 4 weeks i.e. a short-term study.
5. It was limited to Pravara Rural Hospital, Loni, Maharashtra.

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