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Effectiveness of Forced Use Therapy on Sensory Disorders and Hemi Neglect on Upper Extremity in Chronic Stroke Patients

[1]Preeti Yadav, [2]Kangkan Talukdar, [3]Sasanka Mahanta

[1]Physiotherapist, Paras Hospital, Biratnagar, Nepal
[2]Lecturer of Physiotherapy, Jorhat Medical College, Assam, India,
[3]Assistant Professor, Regional College of Paramedical Health Sciences, Guwahati, Assam, India
[1]Department of Physiotherapy,
[1]Paras Hospital, Biratnagar, Nepal

Abstract:
Objectives: To find the effectiveness of Forced Use Therapy on sensory disorders and hemi neglect on upper extremity in chronic stroke patients. **Methods:** 30 subjects were assigned following the inclusion and exclusion criteria and divided into 2 groups- experimental (Group A) and control group (Group B), each containing of 15 subjects. Before intervention, both the groups were tested for Sensory disorder (by Nottingham Sensory Assessment Scale), Hemi neglect (by Letter Cancellation Test), Arm function (by Action Research Arm Test). Patients in the experimental group performed Forced use therapy by immobilizing the healthy arm with a resting splint or a closed arm sling. Patients were encouraged to wear the splint at home during the 10 days of treatment, whereas the sling was only used during treatment hours. Patients in the control group were treated with Neuro-Developmental Therapy method. All activities were performed bilaterally and when necessary, the affected arm was supported with the unaffected hand. Both the groups were treated for 2 consecutive weeks, 5 days a week and 2 hours a day. After the treatment of 2 weeks, the patients were assessed again with the same outcome measures. **Results:** The baseline data of the demographic and outcome variables did not show any statistically significant difference between the patient population in the two groups. In the Group A, scores of all the outcome measures improved after the intervention which was statistically significant. Results did not show any statistically significant difference when we compared the difference between the results of group A and group B. **Conclusions:** So, this study result concluded that there is significant effect of Forced Use Therapy on sensory disorders and hemi neglect on arm functions in chronic stroke patients.

Index Terms: Stroke, Forced Use Therapy, Sensation, Unilateral, Hemi Neglect, Upper Extremity, Cerebrovascular Accident

Address for correspondence: Preeti Yadav, Physiotherapist, Paras Hospital, Biratnagar, Nepal. Email: preeti.manj87@gmail.com

I. INTRODUCTION

Stroke is often referred to as a cerebrovascular accident (CVA). It is defined as a sudden, non- convulsive loss of neurologic function due to an ischemic or hemorrhagic intracranial vascular event.[1] It is considered as one of the leading causes of long-term disability in India.[2] American Stroke Association (2016) considered stroke as the 5th leading cause of death.[3] Approximately 80% of stroke patients survive the acute phase, and although most patients regain their walking ability, 30% to 66% of the survivors are no longer able to use the affected arm.[4] Paralysis of the upper extremity is a severe motor impairment that can occur after stroke.[5] Approximately two thirds of stroke survivors have residual neurological deficits that persistently impair function.[6] Specifically, dysfunction from upper extremity hemiparesis impairs performance of many daily activities such as dressing, bathing, self-care, and writing, thus reducing functional independence.[6] Prediction of recovery from paralysis is difficult and is primarily based on subjective clinical evaluation.[6] In fact, only 5% of adults regain full arm function after stroke, and 20% regain no functional use.[7] Rehabilitation methods have been developed in which patients were either forced to use the affected arm by means of immobilization of the unaffected arm (forced use)[7] or strongly encouraged to do so by a physiotherapist who constantly corrected the patient when he/she tried to use the unaffected arm (constraint induction).[7,8] Stroke patients also suffer from sensory disorders, hemi neglect as well as motor defecits.[7] Literature suggest that forced use therapy helps to improve function in stroke survivors.[9,10] But it is not clear which aspect it improves the function. On the basis of this "forced-use" paradigm, Taub, Wolf, and colleagues constrained the non-paretic arm of chronic stroke patients and forced the patients to use the paretic arm in task-specific activities in an intensive 2-week protocol.[11] In general, patients made significant functional gains as measured by tests of functional ability and daily use. These findings support a hypothesis that patients have "learned nonuse" of their paretic limb and that the forced use particularly with intensive training techniques, unmasks the dormant neuromuscular pathways.[11] Clearly, forced-use or "constraint induced" training, in general, has

major implications for stroke rehabilitation. Indeed, principles of forced use and "task specificity" combined with repetition have supported a rationale for treadmill training studies in chronic hemi paretic stroke patients that demonstrate improvements in functional mobility and motor strength.[12] The principles of forced use and task specificity are retained, but the concept of constraining the non-paretic arm is not. Specifically, we force the use of rhythmic reaching and retrieving actions using a metronome to cue the patients. Auditory cueing has been used successfully to promote immediate and post training gait changes over and above those produced by gait training alone in sub-acute stroke patients. So, this study is intended to evaluate the effectiveness of Forced use therapy on sensory disorder and hemi-neglect on arm function in chronic stroke patients.

II. MATERIALS AND METHODS

Design: This study was an experimental design to find the effectiveness of Forced Use Therapy on sensory disorders and hemi neglect on upper extremity in chronic stroke patients. Convenient sampling was adopted.

Study Setting: The study was conducted on various hospitals and clinics in and around Bangalore, India with institutional ethical clearance.

Inclusion Criteria: Subjects diagnosed by a neurophysician by CT or MRI for stroke, subjects with both genders, subjects of age between 45-65 years, either left or right arm with hemiplegia, subjects with sensory disorders and hemi neglect.

Exclusion criteria: Subject using walking aid, subjects with any musculoskeletal condition that could potentially affect the ability to perform the motor tasks, subjects with Mini-Mental State Examination (MMSE) score <22 and uncooperative subjects were excluded from the study.

Data collection and procedure: Total 30 subjects diagnosed with stroke were selected on the basis of inclusion and exclusion criteria. The study procedure was explained to the subjects and their attendants. An informed written consent was taken from all subjects or attendants on the first day prior to the intervention. 30 subjects were divided into 2 groups- experimental and control group, each containing of 15 subjects. Both the groups were treated for 2 consecutive weeks, 5 days a week and 2 hours a day. Before intervention, both the groups were tested for Sensory disorder (by Nottingham Sensory Assessment Scale), Hemi neglect (by Letter Cancellation Test), Arm function (by Action Research Arm Test).

Experimental Group: All the patients in the experimental groups had their healthy arm immobilized by a resting splint or a closed arm sling. Subjects were encouraged to wear the splint at home during the 10 days of treatment, whereas the sling was only used during treatment hours. Every day, the use of the splint at home was registered by the subjects or their family members in a logbook. Subjects were instructed not to wear the splint when sleeping, dressing, or during toilet activities. Exercises that were given are described below:

Peg board exercises
Grasping exercise: holding objects of different sizes and shapes, squeezing of clay or rubber ball
Reaching activities
Overhead pulley exercises
Resisted exercises for major muscle groups of Arm

Control Group: Subjects in the control group were treated according to the Neuro-Developmental Therapy method. All activities were performed bilaterally and when necessary, the affected arm was supported with the unaffected hand. Subjects were treated using facilitation and inhibition technique. After the treatment of 2 weeks, the subjects were assessed again with the following measures- Sensory disorder (by Nottingham Sensory Assessment Scale), Hemi neglect (by Letter Cancellation Test), Arm function (by Action Research Arm Test).

III. DATA ANALYSIS: Data analysis was performed by SPSS (version 24.0) software for MacBook. Level of significance was set at 5% ($P < 0.05$). Descriptive statistics was performed to find out mean & standard deviation for the demographic variable and outcome variables. Chi-Square test was performed to find out gender differences and side affected between both groups. Similarly, Unpaired T-test was used to find significant differences among demographic variables such as age & duration. Unpaired T-test was also used to find significant differences among baseline variable such as LCT (Letter Cancellation Test). Likewise, Mann Whitney U test was used to find out significant differences among baseline variables such as NSAS (Nottingham Sensory Assessment Scale) & ARAT (Action Research Arm Test). Mann Whitney U test was also used to find out significant differences between groups for NSAS & ARAT. Furthermore, Mann Whitney U test was used to find out significant differences between groups for LCT. Paired T-test was used to find out significant difference within groups for LCT. Wilcoxon signed rank sum test was used to find out significant difference within groups for NSAS & ARAT. Besides, Microsoft Excel and Word were used to generate graphs and tables.

IV. RESULTS

Table 1: Descriptive statistics for demographic variables

Variables	Group A	Group B	P-value
Age	57.13±6.19	58.73±4.65	P=0.430
Gender (M/F)	10/5	9/6	P=0.705
Side (Rt/Lt)	6/9	7/8	P=0.713
Duration(day)	9.93±2.31	10.40±2.38	P=0.591

. Table 1 showing the analysis of demographic variables. In Group A, the mean age was 57.13 and SD was 6.19 and in Group B, the mean age was 58.73 and SD was 4.65 (Figure 5). The age difference between the two groups was statistically insignificant (P >0.05). Similarly, in Group A there were 10 males and 5 females (Figure 6), in Group B there were 9 males and 6 females (Figure 7) and the gender difference was statistically insignificant (P > 0.05). Further, in Group A, there were 6 right sided lesions and 9 left sided lesions (Figure 8), in Group B, there were 7 right sided lesions and 8 left sided lesions (Figure 9). and the side of lesion difference between the groups was not significant (P > 0.05). Likewise, in the Group A the mean duration was 9.93 days and SD was 2.31 and in Group B the mean duration is 10.40 days and SD was 2.38 (Figure 10). The duration difference between the groups was again statistically insignificant (P >0.05). In summary, demographic variables were homogenous between the two groups.

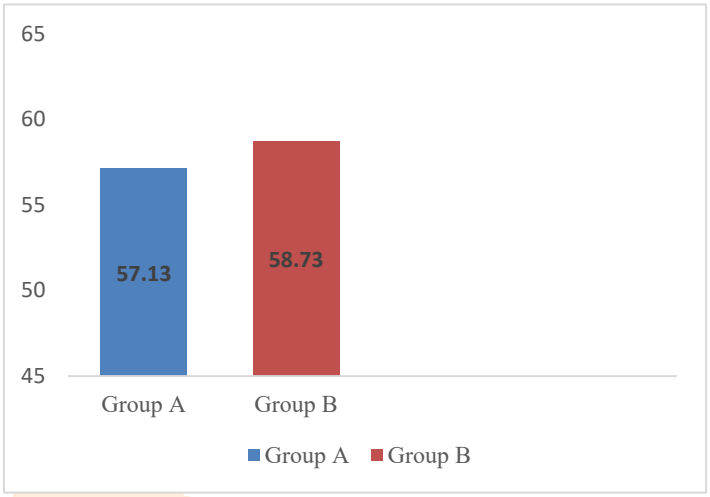

Fig 5: Graphical presentation of mean age of two both groups

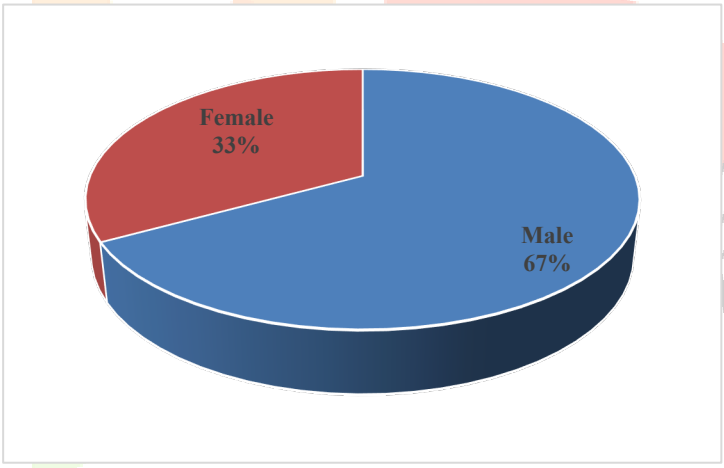

Fig 6: Graphical presentation of gender distribution in Group A

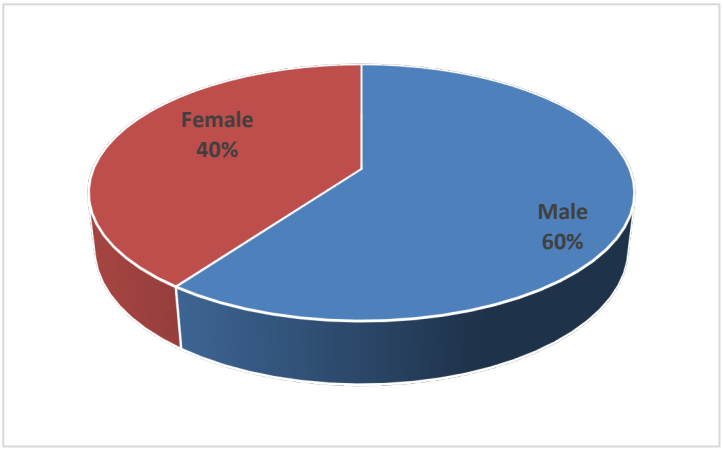

Fig 7: Graphical presentation of gender distribution in Group B

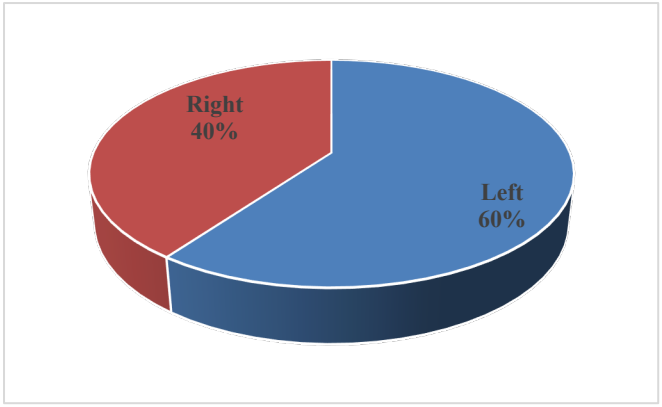

Fig 8: Graphical presentation of side affected distribution in Group A

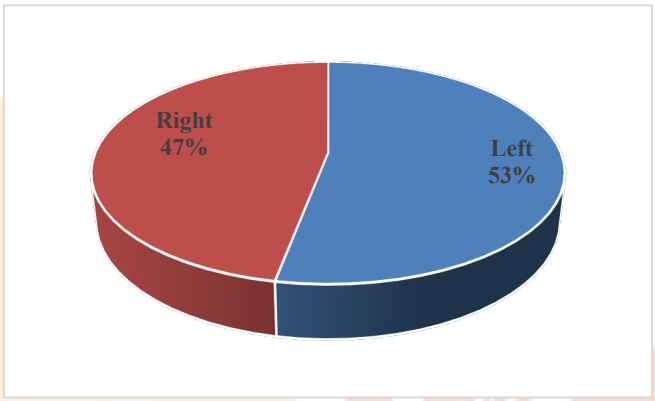

Fig 9: Graphical presentation of side affected distribution in Group B

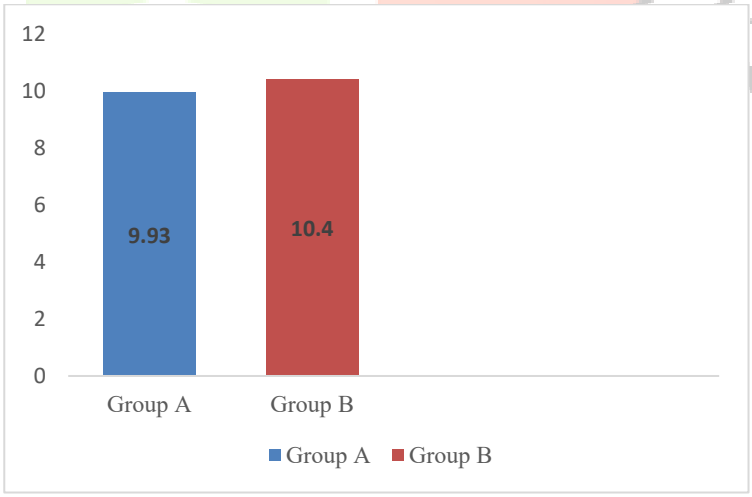

Fig 10: Graphical presentation of mean duration of treatment in both groups

Table 2: Descriptive statistics for the outcome variables

Variables	Group A	Group B	P-value
ARAT	21.40±3.62	22.53±4.88	P=0.512
NSAS	29.13±0.99	29.33±1.11	P=0.461
LCT	4.27±1.16	4.13±1.06	P=0.745

Table 2 showing the mean score for the outcome variables before the intervention for both groups. In Group A, the initial mean ARAT score was 21.40 and SD was 3.62 whereas in Group B the mean ARAT score was 22.53 and SD was 4.88 (Figure 11). The initial mean difference between the groups was statistically insignificant (P > 0.05). Similarly, in Group A, the mean NSAS score was 29.13

and SD was 0.99 whereas in Group B the mean NSAS score was 29.33 and SD was 1.11 (Figure 12) and the difference between them was statistically insignificant (P>0.05). Likewise, in the Group A the initial mean LCT score was 4.27 and SD was 1.16 and in Group B the mean LCT score was 4.13 and SD was 1.06 (Figure 13) and the difference between the groups was statistically insignificant (P >0.05). In summary, the outcome variable measurements were homogenous between the groups before the intervention.

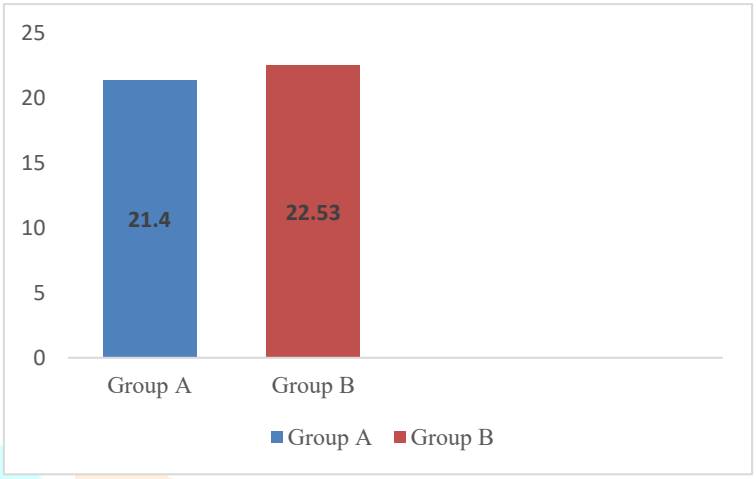

Fig. 11: Graphical presentation of mean ARAT score at baseline

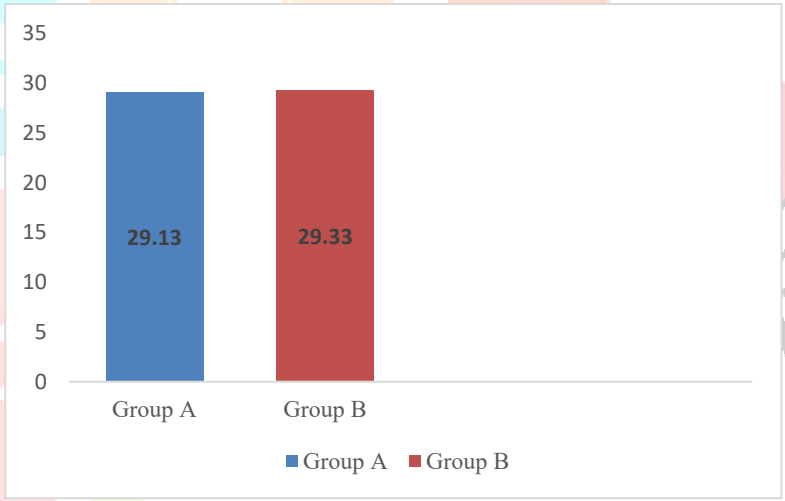

Fig 12: Graphical presentation of mean NSAS score at baseline

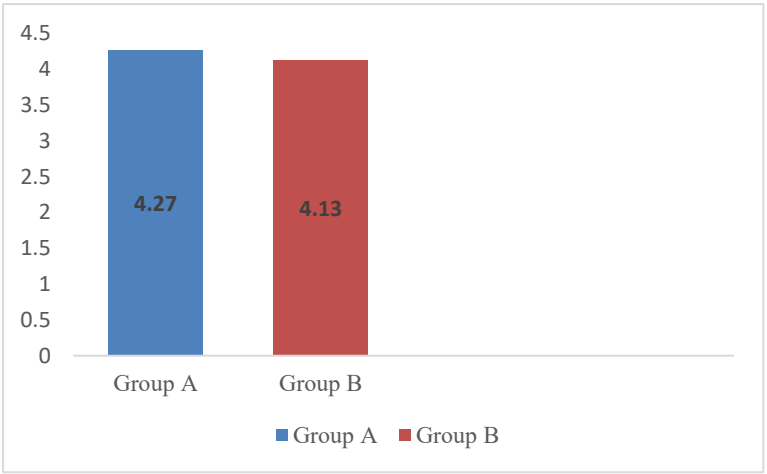

Fig. 13: Graphical presentation of mean LCT score at baseline

The pre and post treatment scores for the outcome variables for both Group A and Group B are presented in Table 3 and 4 respectively.

Table 3: Comparison between different outcome variables within Group A

Variables	Pre	Post	P-value
ARAT	21.40±3.62	24.13±3.46	P=0.001
NSAS	29.13±0.99	29.87±0.35	P=0.009
LCT	4.27±1.16	3.60±0.74	P=0.036

In Group A, the pre ARAT score improved from 21.40 with SD of 3.62 to post ARAT score of 24.13 with SD of 3.46 which was statistically significant ($P < 0.01$). Similarly, the pre NSAS score improved from 29.13 with SD of 0.99 to post score of 29.87 with SD of 0.35, which was statistically significant ($P < 0.05$). Likewise, the pre LCT score of Group A decreased from 4.27 with SD of 1.16 to post score of 3.60 with SD of 0.74, which was also statistically significant ($P<0.05$)

Table 4: Comparison between different outcome variables within Group B

Variables	Pre	Post	p-value
ARAT	22.53±4.88	23.47±4.45	P=0.001
NSAS	29.33±1.11	29.67±0.72	P=0.025
LCT	4.13±1.06	3.80±0.68	P=0.096

In Group B, the pre ARAT score improved from 22.53 with SD of 4.88 to post ARAT score of 23.47 with SD of 4.45 which was statistically significant ($P <0.01$). Similarly, the pre NSAS score improved from 29.33 with SD of 1.11 to post score of 29.67 with SD of 0.72, which was also statistically significant ($P <0.05$). Likewise, the pre LCT score decreased from 4.13 with SD of 1.06 to post score of 3.80 with SD of 0.68 but it was statistically insignificant ($P >0 .05$). The pre and post treatment ARAT, NSAS and LCT scores within groups are also presented graphically in Figure 14, 15 and 16 respectively.

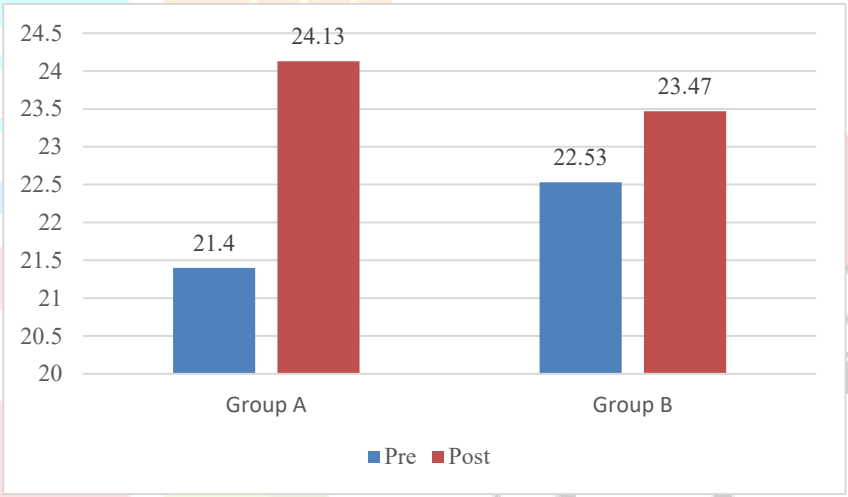

Fig.14: Graphical presentation of Pre- Post difference for ARAT score within groups

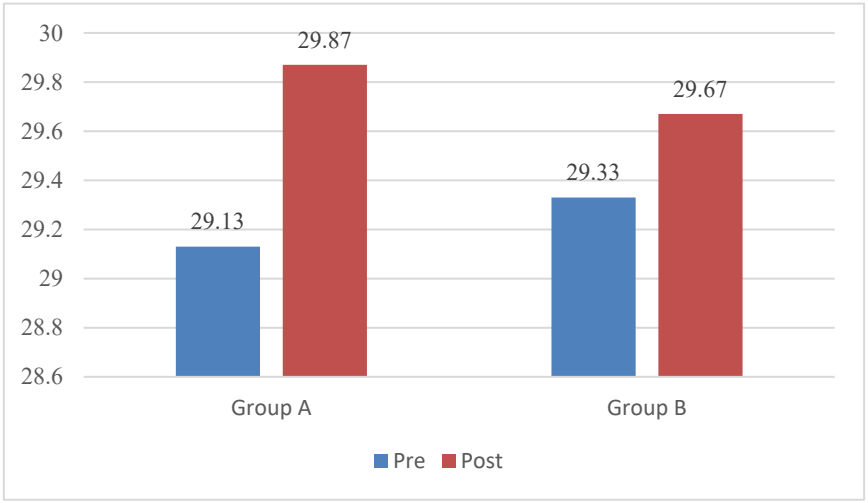

Fig.15: Graphical presentation of Pre- Post difference for NSAS score within groups

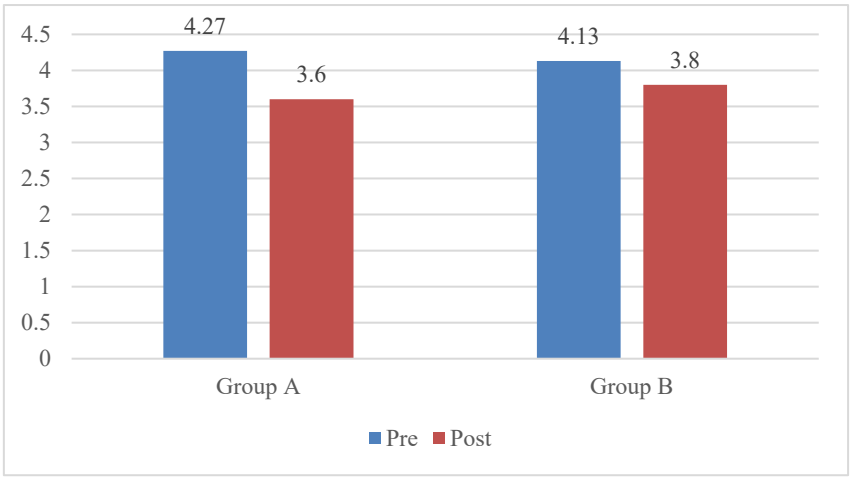

Fig.16: Graphical presentation of Pre- Post difference for LCT scores within groups

The post treatment improvement for different outcome variables between the two groups was also compared which is presented in Table 5.

Table 5: Comparison of improvement post treatment between different outcome variables of two groups

Variables	Group A	Group B	P-value
ARAT	24.13±3.46	23.47±4.45	P=0.461
NSAS	29.87±0.35	29.67±0.72	P=0.713
LCT	3.60±0.74	3.80±0.68	P=0.445

When two groups were compared, the post intervention mean ARAT score for Group A was 24.13 with SD of 3.46 and Group B score was 23.47 with SD of 4.45 and the difference between the scores of two groups was statistically insignificant ($P > 0.05$). Similarly, for Group A the post intervention mean NSAS score was 29.87 with SD of 0.35 and for Group B mean score was 29.67 with SD of 0.72 and the difference was again statistically insignificant ($P > 0.05$). Likewise, the mean LCT score for Group A was 3.60 with SD of 0.74 and for Group B the mean score was 3.80 with SD of 0.68. The difference between the mean LCT score for these two groups was also statistically insignificant ($P > 0.05$). In short, both Group A and Group B were effective in improving ARAT, NSAS and LCT score. The mean differences for different outcome variables between two groups are also presented in Figure 14, 15 and 16 above.

V. DISCUSSION

The purpose of this study was to find the effectiveness of Forced Use Therapy on sensory disorders and hemi neglect on upper extremity in chronic stroke patients. The baseline data of the demographic and outcome variables did not show any statistically significant difference between the patient population in the two groups. All the patients in both the groups were able to complete the study. Group A performed Forced Use Therapy and the result showed that mean pre ARAT of 21.40 increased to post score of 24.13, which was statistically significant ($P<0.001$). In the same group, mean pre NSAS of 29.13 increased to post score of 29.87 which was statistically significant ($P<0.009$) and the mean pre LCT of 4.27 decreased to post score of 3.60 which was also statistically significant ($P <0.036$). This is in accordance with the study done by CIMT and is arguably one of the most promising methods for post-stroke upper limb rehabilitation. The study showed impressive improvements after training in this study. While significant improvements were found in ARAT, Tyson et al. used the Rivermead Assessment of Somatosensory Perception (RASP), which includes two sensory modalities, light touch and proprioception, and two functional assessments, detection and discrimination of objects[13]. They found a higher deficit in tactile sensation than with proprioception in hemiparetic patients during the acute phase and they found a correlation between these methods, suggesting that measuring these abilities may serve as a tool to quantify sensory recovery. Scalha et al. evaluated fine motor skill (grip) of hemiparetics and found a weak correlation with the ability to discriminate textured surfaces and no correlation with recognition of weights with the thumb and forefinger without the aid of visual cues[14]. Studies have indicated that there is substantial variation between patients in recovery from upper limb impairment after stroke than in patients with severe initial impairment. On the other hand, Group B performed Neuro Developmental Therapy (NDT) and the result showed that mean pre ARAT of 22.53 increased to post score of 23.47, which was statistically significant ($P <0.001$). In the same group, mean pre NSAS of 29.33 increased to post score of 29.67, which was also statistically significant ($P<0.025$). Likewise, mean pre LCT of 4.13 decreased to post score of 3.80, which was statistically insignificant ($P <0.096$). These statistical changes could be because in NDT there is a facilitation of sensory awareness through the main somatosensory pathways and it is important to emphasize that these pathways are not parallel. They commonly cross each other, even in areas classically defined as primary and specialized.[13] There is interaction and integration between sensory modalities[15]. The CNS is not hierarchical, but has areas that are activated simultaneously and there is presence of many back-projections.[7] A lesion in the areas involved with the processing of sensory input leads to perceptual impairments, which are less than would be expected from impairment of one component in a hierarchically structured system. A sensory perception may require information from several sensory pathways that are processed separately. Though the majority of the ascending pathways cross over to the

contralateral side of the brain, there are some ipsilateral pathways.[15] Results did not show any statistically significant difference when we compared the difference between the results of group A and group B. In Group A, that is forced arm training ARAT post mean score of 24.13 and group B that is NDT exercise ARAT post mean score of 23.47; the difference between them was statistically insignificant (P > 0.461). Similarly, in Group A that is forced arm training NSAS post mean score of 29.87 and group B that is NDT exercise NSAS post mean score of 29.67 showed no statistically significant difference between them(P>0.713). Furthermore, in Group A that is forced arm training LCT post mean score 3.60 and group B that is NDT exercise LCT post mean score of 3.80 also showed no statistically significant difference between them (P > 0.445). This statistical insignificance could be due to the case of (partial) damage to the motor cortex, residual motor cortex or participation of more distant regions in the recovery process; the larger the damage, the more remote regions recruited to support recovery processes[16]. So far, functional distance or even the order in which regions will be recruited is unclear. One may hypothesize, however, that the suppressive effects of attentional networks hamper spontaneous modulation of interhemispheric competition occurring in the first 10 weeks post-stroke onset, which will normally assist recovery of motor impairments. In this study, both the groups were functionally and statistically effective because both the techniques are equally giving importance to neural plasticity, one in the form of constraining the hemi paretic arm and other in the form of facilitating neuronal action. If we assess forced arm training group, there is more functional gain in the result when compared to NDT group but not statistically. So, this study accepts alternative hypothesis stating that there is significant effect of Forced Use Therapy on sensory disorders and hemi neglect on arm functions in chronic stroke patients. The limitations of the study were Small sample size, Non-paretic arm of the participants is not being constrained; its use might vary across subjects and result in a high variability of the improvement, Patients could not be monitored at their home and thus they were not under continuous supervision during the entire treatment period. Further studies should be carried with larger sample size. Further studies should be carried with longer treatment/experimental duration. Follow up of the patients could be carried out even after the treatment/experimental duration.

VI. CONCLUSION

The outcome of this study with significant statistical changes led us to the conclusion that there is significant effect of Forced Use Therapy on sensory disorders and hemi neglect on upper extremity in chronic stroke patients.

VII. AUTHOR'S CONTRIBUTIONS

All the authors have made considerable contributions in conducting the study and were involved in revising the manuscript critically for important intellectual content. All the authors have given final approval of the paper to be published.

VIII. ACKNOWLEDGEMENTS

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