

## ORIGINAL ARTICLE

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## EFFECT OF STRENGTH TRAINING, FUNCTIONAL TASK RELATED TRAINING AND COMBINED STRENGTH AND FUNCTIONAL TASK RELATED TRAINING ON UPPER EXTREMITY IN POST STROKE PATIENTS

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## ABSTRACT

**Background:** Weakness presents serious compromise to movement function in hemiplegics. Despite the correlation between weakness and impaired function, a clear relationship between strength and function needs more exploration. This study evaluated compared to strength and functional training alone with combined strength and functional training in rehabilitation of upper extremity in stroke patients.

**Methods:** Forty-five patients with history of stroke of duration 3weeks-6months who could initiate shoulder flexion, abduction, elbow flexion and extension, wrist and finger movements were included in the study and randomized into three groups

Group-I - Strength-training

Group-II - Functional-task-related training

Group-III - Combined Strength and Functional-task-related training for the upper extremity

Patients with cognitive impairments, musculoskeletal complications and with the previous history of hemiplegia were excluded.

Outcome Measures used: Fugl-Meyer, Chedoke-Arm and Hand-Inventory, Dynamometer and MMT Interventions were given 3days/week for 6weeks. Subjects were evaluated at 0, 3 and 6weeks.

**Result:** All the three groups showed improvements in Fugl-Meyer ( $p < 0.005$ ). Group, I showed improvements in Dynamometer and MMT ( $p < 0.005$ ), but less functional gain, whereas group II showed improvement in Chedoke ( $p < 0.005$ ), but without adequate strength gain. Group III showed improvements in MMT ( $p < 0.005$ ), Dynamometer ( $p < 0.005$ ) and Chedoke ( $p < 0.005$ ), suggesting increased strength with improved functional performance.

**Conclusion:** Combined strength and functional task related training improved both functional motor performance and strength and led to more effective rehabilitation.

**Keywords:** Stroke, Strength-training, Functional-task related training, Fugl Meyer Assessment of Physical Performance, Dynamometer.

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## INTRODUCTION

Stroke is the third most common cause of death and the leading cause of disability among adults. The prevalence of stroke in India is 203 per 100,000 populations [1]. Over the last decade, the number of stroke survivors has increased to 30% worldwide, and incidence of stroke has dramatically increased in younger individuals [2]. The primary concern of physical rehabilitation is to optimize recovery of function, minimize long-term disability and restoration of requisite motor function to perform daily tasks.

Hemiparesis of the upper limb is the most serious impairment that results from stroke and requires rehabilitation. In spite of the upper limbs having maximum impact on disability and health, rehabilitation of the hand and upper arm is neglected, and functional recovery of arm and hand are limited compared with that of the lower extremity [3].

Weakness is an inability to generate normal levels of force and is a major impairment of motor function [4]. The effects of muscle weakness on function are difficulty in eliciting and sustaining muscle activity, difficulty in generating force and lack of dexterity [5]. It is documented that once spasticity is decreased spastic muscle may reveal great weakness. Considering all these factors the concept of strength training has been introduced for stroke rehabilitation [2].

Strength training after stroke can improve force-generating capacity, the efficiency of the weak muscles and functional motor performance [6]. Strength training has been eliminated from some programs due to beliefs that it increases spasticity, co-contraction, and abnormal movement patterns. Clinical research has shown that strength training does not increase spasticity [7-12]. On the other hand, not only does strength training decrease spasticity but also improves functional performance and strength [7,8,10,11]. The effect of strength training on function needs to be explored.

Previously spasticity was addressed first as it was considered as a limitation to functional recovery. Currently, functional and task specific therapies focusing on activities of daily living are thought to drive the neural plasticity and promote recovery of function at a behavioral level [12]. Therefore, functional task demands are used instead of exercises to provide graded motor challenges. Functional training is a method of retraining the motor system using the repetitive practice of functional tasks in an attempt to re-establish the client's ability to perform activities of daily living [13]. It is thought to produce subtle neuroplastic changes and prevent learned nonuse of the involved segment while stimulating CNS recovery.

The primary aim of rehabilitation is to improve function and to promote the individual participation in activities of daily living. However, it is important for an intervention to reduce disability in addition to alleviating impairments. It is assumed that improved strength will automatically transfer into improved function however this may not be the case always. The body adapts specifically to the demands imposed on it, and the effects of strength training and functional task-oriented training are both specific to

task and context. A study done by Yang Y R (2006) has shown that task-oriented exercises with progressive resisted exercises improved lower extremity strength and muscle performance in stroke patients [14]. Morris et.al (2004) concluded that ability to strengthen to enhance the performance of functional activities or participation in societal role remains unknown [15]. Although the correlation between weakness and impaired movement function is clear, the relationship between strength and function is not established.

Hence a study was carried out to investigate the effect of combining strength training and functional training in rehabilitation of the upper extremity in stroke patients was carried out. The aim of the study is to find the effect of strength training; functional task related training and combination of the two in upper extremity rehabilitation in post-stroke patients.

## MATERIALS AND METHODOLOGY

The study included 45 first time stroke patients due to Anterior & Middle cerebral artery infarcts from Government and Private super specialty hospitals. The onset of stroke ranged between 2 weeks to 6 months. Only patients who were in stage 2 or higher Brunnstrom grading and were able to follow simple commands were included in the study. Patients from the age of 30 years to 75 years were included. Patients with previous history of Hemiplegia or brain injury with cognitive problems, peripheral nerve or orthopedic conditions that interfered with arm movements, a cardiac disease that limited function, severe aphasia, neglect, dementia, depression were excluded from the study. All patients were explained about the study and consent was taken.

Patients selected were randomized into three groups of 15 subjects each using simple random sampling. Group I Strength training, Group II Functional Training, Group III Strength and Functional training. Subjects were evaluated at the start of therapy and reevaluated at three weeks and then at six weeks. The outcome measures used were Upper extremity portion of Fugl Meyer for assessment of motor function, Chedoke Arm, and Hand Inventory to measure the functional ability of hemiplegic arm and hand, Hand-held Dynamometer for isometric force measurement of flexors and extensors of the shoulder, elbow, and wrist. The subjects in all the three groups received physiotherapy interventions four days a week for six weeks during hospitalization and were followed by O.P.D. basis or home-based management program. Each session was for 70 minutes which included Conventional therapy, Strength Training or Functional Training or both. Conventional therapy included stretching, balance training, gait training.

### GROUP I: STRENGTH TRAINING

Strength training used resistance to available arm motion to increase strength. Exercises were performed by using eccentric, isometric or concentric contractions. These patients received physical assistance by the therapist to perform actions followed by active assisted exercises in gravity eliminating the position and then progressively to against gravity exercises and progressive resisted exercises.

Strength Training incorporated open chain exercises for Shoulder flexors, extensors, abductors, adductors, Elbow flexors, extensors, Wrist flexors, extensors. Subject completed two sets of 8 repetitions with proper rest periods (2 minutes after every session). Training load for resisted exercises was determined by 1 R.M. (The maximum load lifted once). Initial load was set up at 50% of 1 R.M. increasing to 80% of 1 R.M. Resistance was provided by weight cuffs.

#### GROUP II: FUNCTIONAL TASK RELATED TRAINING

The functional training exercises were specific to task to be learned. Functional training was given according to the framed protocol. (Annexure1) It consisted of six activity categories which included work related activities, bimanual activities, activities to improve grip and grasp, dressing activities, feeding activities, household chores and personal hygiene activities. The activities were practiced which progressed from proximal to distal recovery patterns and simple tasks to complex tasks. Task performed by the patient, its progression, missing components were all recorded. Four steps in tasks related training included analysis of task, the practice of missing components, the practice of task and transfer of training.

#### GROUP III: STRENGTH TRAINING AND FUNCTIONAL TASK RELATED TRAINING

Subjects in this group received combined interventions of strength training and functional task related training. It consisted of 40 min of strength training and 40 min functional task related training.

#### Outcome Measures:

Fugl Meyer Assessment of Physical Performance [16]:

This is an impairment based test with items organized by sequential recovery stages. A 3 points ordinal scale is used to measure impairments of volitional movement, with grades ranging from 0 - 2. 0 indicates item cannot be performed whereas 2 indicates item can be fully performed. Subtests exist for upper extremity function, lower extremity function, balance, sensation, range of motion and pain. Upper extremity scoring of 66 was only considered for this study. This instrument has good construct validity, high reliability ( $r=0.99$ ) for determining motor function.

Chedoke Arm and Hand Activity Inventory [17]:

The purpose of this measure is to evaluate functional ability of the hemiplegic arm and hand to perform tasks that have been identified as important by stroke survivors. The performance of affected upper limb was scored using 7-point activity scale.

Dynamometer [18]:

It is the measurement of isometric strength using hand-held dynamometer. Hand-held dynamometer provides an objective indication of isometric muscle strength. The instrument (dynamometer) used in this study was custom made. A pilot study on 40 normal subjects was done for comparison of grip strength by grip dynamometer and handheld dynamometer. The instrument was face validated, and criterion validated. Intra-rater reliability of the instrument was significant with co-relation 0.001. General principles of dynamometry were followed.

Spasticity of the muscles was evaluated using the modified Ashworth scale at 0, 3 and 6 weeks.

#### Statistical Analysis:

Kruskal-Wallis and Dunn's multiple comparisons were used for comparison between 3 groups and Friedman's & Dunn's multiple comparisons were used for comparison within the groups.

## RESULTS

Subjects were randomized into three groups consisting of 15 subjects each. Three subjects each from the group I and III and two subjects from group II were lost to follow-up. The results were tabulated and analyzed. Out of the 37 subjects who completed the study, 8 were females, and 29 were males. Group, I consisted of 3 females and 9 males, group II had 3 females, and ten males and group III had two females and ten males. (TABLE 1)

Twenty-nine subjects had left hemiparesis, and 8 had right hemiparesis. Group, I consisted of 10 left and two right hemiparesis, group II had nine left and four right hemipareses, and group III had ten left and two right hemiparesis. (TABLE 1)

The mean age for the group I was 66.92 years, 70.46 years for group II and 69.67 years' group III. (TABLE 1)

The mean duration of stroke was 7.58 weeks for the group I, 8.15 weeks for group II and 7.33 weeks for group III. (Table 1)

All the results were analyzed at 0 weeks, i.e., Baseline, 3weeks, and 6weeks interval.

All the three groups had improved significantly on Fugl Meyer and hence between groups comparisons were not significant. (Table 2&3) Within group comparisons by Friedman and Dunns multiple comparisons showed significant improvements ( $p<0.05$ ) at 3wks and 6wks assessment ( $p>0.05$ ). According to Kruskal-Wallis mean rank, Group III was better than other two groups. (Table 3)

Within group comparisons by Friedman and Dunns multiple comparisons on Chedoke showed significant improvements at 3wks and 6wks assessment in all the three groups ( $p<0.05$ ). However, between-group comparisons showed significant improvements in Group II and Group III only ( $p<0.01$ ). (Table 2 and 3) According to Kruskal-Wallis mean rank, Group III was better than other two groups. (Table3)

On dynamometer findings for shoulder flexors, extensors, abductors and adductors, elbow flexors and extensors, wrist flexors and extensors, within group comparisons by Friedman and Dunns multiple comparison showed significant improvements in all the three groups ( $p<0.05$ ) at 3wks and 6wks, however between group comparisons showed significant improvements in Group I and Group III ( $p<0.01$ ). (Table2 and 3) According to Kruskal-Wallis mean rank, Group III was better than other two groups. (Table 3)

None of the subjects in either of the groups showed an increase in spasticity according to the Modified Ashworth Scale.

**Table 1: Demographics**

		Group I	Group II	Group III
Age (years)	Mean + S.D.	66.92 + 12.38	70.46 + 14.32	69.67 + 14.14
Gender	Male	9	10	10
	Female	3	3	2
Side	Left	10	9	10
	Right	2	4	2
Duration	Mean + S.D.	7.58 + 6.26	8.15 + 6.59	7.33 + 5.48

**Table 2: Mean and Median for Fugl Meyer, Chedoke and Hand-held dynamometer values**

TIME PERIOD (WEEKS)	STRENGTH TRAINING			FUNCTIONAL TRAINING			STRENGTH + FUNCTIONAL TRAINING		
	SD	MEDIAN	MEAN	SD	MEDIAN	MEAN	SD	MEDIAN	MEAN
<b>FUGL MEYER PHYSICAL PERFORMANCE SCALE FOR UPPER EXTREMITY</b>									
0	7.89	26	25.50	11.03	21	23.62	9	21.50	21.33
3	5.35	42	42.75	8.87	41	41.62	8.80	43	44.17
6	3.07	59.50	59.17	6.01	57	57	7.66	63	60.33
<b>CHEDOKE ARM AND HAND INVENTORY FOR HAND FUNCTION</b>									
0	4.44	16	17.42	9.60	25.50	22.62	6.62	15.50	17.67
3	4.94	34.50	34.25	10.65	47	45.31	8.47	44	41.50
6	10.61	49.50	53.08	9.50	83	79.23	14.03	80	77.58
<b>HANDHELD DYNAMOMETER FOR STRENGTH</b>									
<b>SHOULDER FLEXORS</b>									
0	0.42	1.15	1.12	0.29	0.90	0.97	0.37	0.83	0.92
3	0.43	1.55	1.49	0.27	0.79	0.79	0.40	1.25	1.25
6	0.46	1.99	1.93	0.22	1.03	1.03	0.51	1.44	1.53
<b>SHOULDER EXTENSORS</b>									
0	0.32	0.93	0.89	0.22	0.53	0.61	0.32	0.75	0.75
3	0.33	1.26	1.25	0.28	0.55	0.58	0.46	1.22	1.07
6	0.29	1.60	1.65	0.38	0.68	0.78	0.50	1.52	1.43
<b>SHOULDER ABDUCTORS</b>									
0	0.64	1.08	1.10	0.20	0.73	0.81	0.22	0.97	0.92
3	0.59	1.53	1.45	0.36	0.78	0.85	0.23	1.30	1.20
6	0.65	1.97	1.92	0.41	1.08	1.10	0.28	1.63	1.59
<b>SHOULDER ADDUCTORS</b>									
0	0.89	1.11	1.28	0.26	0.70	0.74	0.28	0.67	0.77
3	0.95	1.35	1.60	0.36	0.60	0.63	0.32	1.02	1.11
6	0.90	1.73	1.95	0.45	0.76	0.86	0.44	1.52	1.57
<b>ELBOW FLEXORS</b>									
0	0.41	1.20	1.19	0.25	1.00	0.96	0.40	1.07	1.08
3	0.49	1.56	1.55	0.43	0.80	0.87	0.43	1.43	1.45
6	0.47	1.99	2.05	0.51	0.95	1.06	0.62	1.80	1.94
<b>ELBOW EXTENSORS</b>									
0	0.30	1.00	0.90	0.37	0.78	0.86	0.44	0.95	0.36
3	0.27	1.42	1.37	0.52	0.65	0.77	0.29	1.37	1.31
6	0.27	1.83	1.76	0.60	0.79	0.98	0.58	1.74	1.75
<b>WRIST FLEXORS</b>									
0	0.25	0.63	0.66	0.09	0.50	0.52	0.22	0.58	0.55
3	0.26	0.95	0.96	0.21	0.52	0.53	0.28	0.80	0.86
6	0.23	1.35	1.32	0.34	0.69	0.75	0.27	1.15	1.20

WRIST EXTENSORS									
0	0.46	0.67	0.69	0.12	0.41	0.40	0.24	0.57	0.52
3	0.38	0.99	0.85	0.12	0.46	0.46	0.31	0.78	0.79
6	0.28	1.39	1.34	0.20	0.59	0.63	0.38	1.12	1.06

**Table 3:** Comparison of Fugl Meyer, Chedoke and Hand-held dynamometer values

Period (WEEKS)	MEAN RANK			KRUSKAL WALLIS TEST (df = 2)		
	GROUP I	GROUP II	GROUP III	CHI SQUARE	P value	DIFFERENCE
<b>FUGL MEYER PHYSICAL PERFORMANCE SCALE FOR UPPER EXTREMITY</b>						
0	21.33	19.04	16.63	1.138	0.566	NOT SIGNIFICANT
3	17.96	17.69	21.46	0.924	0.629	NOT SIGNIFICANT
6	18.21	15.35	23.75	3.880	0.143	NOT SIGNIFICANT
<b>CHEDOKE ARM AND HAND INVENTORY FOR HAND FUNCTION</b>						
0	18.63	21.00	17.21	0.811	0.666	NOT SIGNIFICANT
3	11.29	24.19	21.08	9.538	0.008	SIGNIFICANT
6	8.29	24.69	23.54	17.495	0.000	SIGNIFICANT
<b>HANDHELD DYNAMOMETER FOR STRENGTH</b>						
<b>SHOULDER FLEXORS</b>						
0	22.29	18.96	15.75	2.193	0.334	NOT SIGNIFICANT
3	26.33	10.35	21.04	14.254	0.001	SIGNIFICANT
6	27.58	9.81	20.38	17.125	0.001	SIGNIFICANT
<b>SHOULDER EXTENSORS</b>						
0	23.75	13.81	19.88	5.384	0.068	NOT SIGNIFICANT
3	26.04	10.50	21.17	13.588	0.001	SIGNIFICANT
6	26.67	9.92	21.17	15.651	0.0004	SIGNIFICANT
<b>SHOULDER ABDUCTORS</b>						
0	22.83	14.58	19.96	3.774	0.152	NOT SIGNIFICANT
3	25.21	11.04	21.42	11.588	0.003	SIGNIFICANT
6	26.38	10.46	20.88	14.030	0.001	SIGNIFICANT
<b>SHOULDER ADDUCTORS</b>						
0	24.88	15.92	16.46	5.250	0.072	NOT SIGNIFICANT
3	25.96	9.66	22.17	15.685	0.0004	SIGNIFICANT
6	25.54	9.42	22.83	16.076	0.0003	SIGNIFICANT
<b>ELBOW FLEXORS</b>						
0	24.63	14.50	18.25	5.558	0.062	NOT SIGNIFICANT
3	25.33	10.23	22.17	13.684	0.001	SIGNIFICANT
6	26.67	9.27	21.88	17.381	0.000	SIGNIFICANT
<b>ELBOW EXTENSORS</b>						
0	22.50	13.81	21.13	4.712	0.095	NOT SIGNIFICANT
3	24.08	10.69	22.92	1.880	0.002	SIGNIFICANT
6	23.92	10.62	23.17	12.064	0.0024	SIGNIFICANT
<b>WRIST FLEXORS</b>						
0	22.38	16.54	18.29	1.902	0.386	NOT SIGNIFICANT
3	25.75	9.62	22.42	15.663	0.0004	SIGNIFICANT
6	26.13	9.31	22.38	16.811	0.0002	SIGNIFICANT
<b>WRIST EXTENSORS</b>						
0	22.29	14.73	20.33	3.318	0.190	NOT SIGNIFICANT
3	22.63	12.15	22.79	8.022	0.018	SIGNIFICANT
6	27.54	9.58	20.67	17.621	0.0001	SIGNIFICANT

## DISCUSSION

Results showed all the three groups significantly improved in motor performance as evidenced by scores on the Fugl Meyer Assessment. This can be due to the increased strength following Strength training in group I, repetitive practice of the task incorporated in Functional training in group II and combined effects of both in group III.

Group II and group III showed significant improvements in functional performance as seen in Chedoke arm and hand inventory. This might be because of the task specificity and activity-dependent neuroplasticity which helps in improving the motor control and motor learning in the desired activity on the task and specific environment. Our findings corroborate with Blennerhassett J and Dite W, 2004 [19] who reported that additional task-related practice improves mobility and upper limb function early after stroke.

Task-related training may cause the recruitment of the motor units specifically required for the task. Functional Task Related training adds specificity and variability to practice. We would hypothesize that task-related practice of meaningful action might provide the best input conditions for achieving the most effective reorganization. With training and repetition of the task, a motor engram is formed.

According to Katherine J. Sullivan (2007), activity-dependent neuroplasticity is the adaptation that occurs in the brain as an individual learns new motor skills or relearns previously acquired movements that may have been impaired after brain injury such as stroke [13]. It is seen that changes in the nervous system may occur according to the patterns of use. For e.g. sensory-motor cortical representation (map) of the reading finger is expanded in blind Braille readers [20] and fluctuates according to the extent of reading activity [21].

Group I showed less improvements in routine activities as compared to other two groups which suggest that the strength training effect could not be transferred to the function and may require a longer time than 6weeks. However, Strength training group showed significant improvements in strength as evidence by dynamometer reading. It can be due to improvement in force generation and force sustenance. Increase strength was seen in all muscle groups, but antagonist muscles showed more improvements than spastic agonist muscles. This can be due to neural adaptation which occurred early in the antagonist muscles than the agonist muscles as suggested by Carr and Shepherd [6].

Group II which had improved in Chedoke and Fugl Meyer, however, showed less improvements in effective force production and sustenance. This suggests that Functional training alone does not help to increase isometric strength. The positive results of increased strength in group I and group III may be due to neural and structural effects which resulted in enhanced muscle excitation, improvements in the recruitment of motor neuron pool, motor unit activation and synchronization of the firing pattern of the motor unit [6].

There was no increase in spasticity of the muscle groups involved in any of the subjects which corroborate with findings of Ada and Cannign, 2006, who showed that Strengthening interventions increase strength, improve activity, and do not increase spasticity [11]. Group III showed improvements in all outcome measures and had effective force production and improvements in functional motor performance as well. The mechanisms underlying the improvement of muscle strength and motor control following stroke are similar to those after strength training in non-disabled individuals [6]. It is accepted that a large part of any early increase in muscle strength in the able-bodied is due to neural adaptation, including task-specific adaptation to neural drive which is both quantitative (increase neural drive to target muscles) and qualitative (reduced co-contraction and improved coordination among synergists) [22]. Patten C, Dozono et.al, 2006, concluded that there were improvements in strength and positive outcome effects at the physiological, clinical, and functional levels in the subject following the experimental hybrid upper-extremity rehabilitation intervention [12].

Thus upper extremity rehabilitation involving combined strength training and functional task related training have produced significant positive outcome on clinical and neuromuscular indicators of upper extremity motor function.

## CONCLUSION

There was a significant improvement in motor performance in all the three groups. However, neither strength training alone improved function in the subjects nor did functional training alone improve strength significantly. Combined strength and functional task related training” improved both functional motor performance and strength and led to more effective rehabilitation and should be preferred over only strength or functional task-related training alone.

An increased follow-up for a longer period is necessary to evaluate the long-term benefits of these modalities of rehabilitation.

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