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Effect of trunk stabilization exercises on upper limb recovery in chronic stroke

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Abstract

Background: The trunk being the central key point of the body, proximal trunk control may be a prerequisite for distal limb movement control and functional activities. Sitting balance and selective trunk movements remain impaired together with limbs after stroke. Selective trunk muscle exercises are administered for rehabilitation of lower limb in reference to better trunk control, but therewith of upper limb functioning isn't well established in subjects with chronic stroke.

Objective: To test the consequences of trunk stabilization exercises on upper extremity recovery in chronic stroke.

Method: 30 subjects with chronic stroke were randomly divided into two groups (n= 15), group I was administered conventional therapy and group II, conventional therapy together with trunk stabilization exercises for five days per week for 3 weeks. Fugl-Meyer Assessment Scale for upper extremity (FMA-UE), Action Research Arm Test (ARAT) and Wolf Motor Function Test (WMFT) were wont to analyse objective of this study.

Results: Trunk stabilization exercises were showing significantly greater change in upper limb motor recovery and functionality than only conventional therapy intervention. Within the trunk stabilization exercise group, significant change in upper limb motor recovery ($p < 0.05$) and functional status ($p < 0.05$) with 95% confidence interval were found. There was no change found on improvising strength of activity performance in WMFT scale.

Conclusion: Trunk stabilization exercises together with conventional therapy enhance upper limb recovery in subjects with chronic stroke.

Keywords: Stroke, trunk stabilization exercises, upper limb rehabilitation, Fugl-meyer assessment scale, action research arm test, wolf motor function test

Introduction

A centralized brain allows groups of muscles to be co-activated in complex patterns; by allowing various stimuli impinging on one a component of the body to evoke responses in other parts, and prevent different parts of the body from engaging at cross-purposes to each other. The world Health Organization (WHO) definition of stroke, foremost devastating and deteriorating neurological conditions is: “rapidly developing clinical signs of focal (or global) disturbance of cerebral function, with symptoms lasting 24 hours or longer or leading to death, with no apparent cause other than of vascular origin” [1]. It is becoming a significant reason for disability in low-income and middle-income countries like India, driven by demographic changes and enhanced by the increasing prevalence of the key modifiable risk factors between age group 30-60 years [2]. After injury to the pallium, the frontal and parietal cortex and/or subcortical structures within the striatum and thalamus are affected, resulting in deficits in motor function within the contralateral musculature.

Many stroke survivors encounter complex neurologic deficits, leading to poor movement quality, muscle weakness, sensory dysfunction, and cognitive impairments in contralateral upper limbs and lower limbs along with significant affection of trunk [3]. The trunk muscles are impaired on both the sides of the body in subjects with stroke. Selective movements of the upper and so the lower trunk are impaired in chronic stroke [4]. The trunk plays a postural role in functional movement by preparing the body for the movement of the extremities against gravity. It also plays a full of life role in smoothing the movement of the centre of gravity, and it enables simple movement into a novel posture [5].

Supported multivariate analysis analyses, the reported variance of functional outcome after stroke explained by trunk performance ranges from 9% to 71% [6, 7]. Trunk is anatomically and functionally correlated with both limbs. All the muscles which act on the shoulder and enable it to be moved in such plenty of complex ways are dependent upon the proximal anchorage provided by the arch, which itself relies upon thoracic stabilization. Such a fixation requires a relentless and subtle interplay between the flexors and extensors of the trunk. The rotation of the trunk muscle requires static holding of contralateral muscles to stabilize the central aponeurosis, so allowing the antagonist shorten and draws one side the pelvic or thorax forwards. Counter rotation between the upper and lower trunk is that the mobility over stability task which is crucial for all the functional movements.

Though bilateral innervation of trunk is evidenced, it had been found that the weakness of trunk flexor-extensor and bilateral trunk rotator muscles in subjects with chronic stroke [8, 9].

Trunk stabilization exercises showed effects in chronic stroke subjects on both the deep abdominal muscles weakness and balance. Simultaneous application of routine therapy and trunk stabilization exercises can promote the recovery of chronic stroke subjects and be helpful in rehabilitating them and improving their functional outcome [10].

Trunk stabilization exercises have also transfer effect on standing balance and ambulation [11]. It has been estimated that 55% of stroke survivors have a non-functional upper extremity following initial therapy and 30% of stroke survivors have had some partial recovery of upper extremity function, which negatively affects their independence and increase the burden of care [12].

Various tools are present to measure recovery of upper extremities in terms of motor recovery, functionality and quality of life. Some of them are very much reliable and valid as compare to others to show improvement such as Fugl-Myer assessment scale for upper extremity (FMA-UE), Action Research Arm test (ARAT), Wolf Motor Function test (WMFT).

Improvement of upper extremity function is one in every of the foremost important objectives of stroke rehabilitation, because extremity function greatly affects overall function. Many of them don't regain functional use of the paretic arm, which can cause difficulties in activities of daily living (ADLs) and engagement in community life [13].

New therapies are taking advantage of technology like robot-assisted therapy, [14] biofeedback therapy, [15] and computer game training, [16] which have produced positive winds up in terms of clinical scales, like Fugl–Meyer score, motor status scores, and kinematic performance of basic upper extremity movements within the chronic stroke population.

Training the arm and postural control in isolation, won't restore integrated functional use necessary for independent skilled performance of activities of daily living.

Trunk restraint features a moderate effect on reduction of upper extremity impairment in chronic stroke subjects, in terms of FMA-UE score, increased shoulder flexion, and reduction in excessive trunk movement during reaching. There's insufficient evidence to demonstrate that trunk restraint improves upper extremity function and reaching trajectory smoothness and straightness in chronic stroke subjects [17].

There is strong theoretical background showing the relation between trunk and extremities [18]. Many studies are done which shows effects of additional trunk stabilization exercises on trunk performance with its transfer effects on lower extremity after stroke. Increasing trunk stability to spice up the upper extremities has attracted attention, but to the best of my knowledge there's scarcity of literature which determines the effect of additional trunk stabilization exercises in recovery on upper extremity in subjects with chronic stroke.

The study is purposed to judge the results of trunk stabilization exercises on upper extremity recovery in subjects with chronic stroke with clear aim of comparing the results of trunk stabilization exercise plus conventional therapy with conventional therapy alone on upper limb recovery in chronic stroke subjects.

Method

After being issued clearance by the Institutional Committee of Ethics of The Sarvajanik College of Physiotherapy the present study aiming to check the effect of trunk stabilization exercises on upper limb recovery in with subjects' chronic stroke was initiated.

Sample size

Sample size calculation was done using G Power 3.1.9.2 version and the total sample size required was 30. With effect size 0.9, α level 0.05 and power 0.65, total sample size calculated was 30. A total of 30 subjects were purposively selected from different outpatient departments like Physiotherapy department of Ayurvedic College, Meet physiotherapy clinic, Matru physiotherapy clinic from Surat and Dharmik physiotherapy clinic from Navsari. All subjects were screened on the day one of the treatment, based upon the inclusion and exclusion criteria as follow:

Inclusion criteria

Stroke diagnosed with CT/ MRI or ascertained by medical reports by qualified medical professionals.

- Age – 35 to 65 years
- 6 months post stroke
- Mini mental scale examination ≥ 24[19]
- Trunk impairment scale < 16/23 [7]
- Subjects who are able to sit minimum of 10 seconds independently [20]
- Brunnstrom stage of arm recovery of 2 to 4[21]

Exclusion criteria

- Subjects who are not able to understand simple commands
- Subjects who are already receiving trunk stabilization exercises
- Any neurological disease other than stroke.
- Any musculoskeletal disorders like subluxation or dislocation of affected shoulder, fractures in affected limb.
- visual or auditory loss if affects in outcomes
- Sever sensory and perceptual deficits if affects in outcomes

After screening, all subjects were given explanation about the present study in detail and a written consent was signed by each subject as a formality towards their willingness to participate.

Randomization of subjects into groups

The subjects (23 males and 7 females) were randomly allocated in to two groups i.e. Group I- control group and Group II - experimental group, while visiting to the different clinic as per the availability of the subjects.

The allocation was carried out by the following Quasi Randomization Method: First subject who fulfilled the inclusion criteria was allocated under Group I and the consecutive subject under Group II while visiting to the different clinic as per the availability of the subjects.

Same procedure was followed for the rest of the available subjects.

Groups

Group I: subjects belonging to this group were administered conventional therapy.

Group II: subjects belonging to this group were administered trunk stabilization exercises followed by conventional therapy.

Blindedness

The subjects were kept blinded about the effectiveness of intervention given to them in both the groups. The assessor was kept blinded about the intervention given to subjects in both the groups and about the purpose of study.

Outcome measures

Fugl-myer assessment scale (FMA)

The FMA is a performance-based measure. It has five sections to test a specific construct (motor, balance, sensation, range of motion, and pain). Motor recovery subsection is found to be a highly reliable and valid tool to assess the motor recovery of patients post stroke [21, 22, 23].

Action research arm test (ARAT)

ARAT is an observational test used to assess activity limitations of the upper extremity. It consists of nineteen items grouped in four subtests – grasp, grip, pinch, and gross arm movement – focusing on grasping objects of different shapes and sizes and gross movements in the vertical and horizontal planes. ARAT has demonstrated high inter-rater and retest reliability and concurrent validity in studies involving subjects with stroke [21, 24-26].

The wolf motor function test (WMFT)

It is used to quantify motor function in stroke subjects with upper extremity (UE) motor deficits. It contains tasks that are sequenced to progressively use more UE joints and include movements that range from simple movements, such as bringing the hand to a table top, to more complex movements that require control over all UE joints, such as lifting a pen. The WMFT is reported to have high inter-rater and intra-rater reliability for both performance time and functional ability scores. The WMFT demonstrated criterion validity when correlated with the Fugl-Meyer test scores for the more affected extremity of post stroke subjects [27, 28].

Before the study was commenced, the application of all the outcome measures was practised and mastered within a period of three days as per standard guidelines by the assessor who was going to assess all the subjects' pre and post study [29, 30, 31].

Each subject was assessed with Fugl Meyer Assessment Scale for upper extremity, Action Research Arm Test and Wolf Motor Function Test on the 1st day pre-treatment and on the last day post treatment by separate assessor.

Subjects of experimental group were administered trunk stabilization exercises on mat and physio ball [11,32,33,34,35] along with conventional therapy and subjects belonging control group were administered conventional therapy only [36,37,38,39] for 60-75 minutes for 5 sessions per week for 3 weeks [33].

Table 1: Exercise protocol for Conventional therapy for Group I

Sr. No.	Exercises
	Stretching exercise for upper and lower extremity (30 sec hold for 3 times)[38]
	Active assisted training for upper and lower extremity for subjects who were not able to perform full range exercises actively. (apply talcum on table if needed to reduce friction) (10 times for each).
	Active movements for upper and lower extremity for subjects who were able to perform tasks as mentioned above (10 times for each)[36]
	Manual dexterity exercise (10 times for each) Grasping and gripping activities by using jar, spoon, glass, towel, key, coin, pencil[40]
	Balance training - both static and dynamic balance in sitting
	Sit to stand training (10 times for each)
	Weight bearing training including Prone on elbow and hand, Quadruped, kneeling, half kneeling, standing with and without support
	Gait training[41]

Group II: Conventional therapy + trunk stabilization exercises

Table 2: Exercise protocol for Trunk stabilization exercises

Sr No.	Exercise on Static surface:	Dynamic surface (physio ball):
	Starting position: Supine Upper trunk flexion – extension exercises (5 times)	Starting position - Supine: Unilateral bridge (5 times each side)
	Upper trunk flexion – rotation exercise (5 times each side).	Lower trunk flexion (5 times)
	Rotation of upper trunk (5 times each side)	Lower trunk flexion rotation (5 times each side)
	Pelvic bridge (5 times)	Lower trunk rotation (5 times each side)
	Unilateral bridge (5 times)	Perform bridging action; stabilization of the upper trunk by 900 shoulder flexion (5 times)
	Lower trunk flexion (5 times)	Keep both ankles on the ball and perform upper trunk flexion –extension (5 times)
	Lower trunk rotation (5 times each side)	Starting position prone: Upper trunk extension (5 times)
	Lower trunk flexion rotation (5 times each side).	Starting position -Sitting: Anterior – posterior tilting of pelvis (5 times)
	Rolling to affected and non affected side (5 times each side).	Weight shifting by sitting on the ball (5 times each side)
	Reciprocal rotation (5 times each side).	Flexion rotation of upper trunk (5 times each side)
	Starting position - Prone: Upper trunk extension (5 times)	Flexion-rotation of lower trunk (5-5 times each side)
	Starting position sitting: Upper trunk lateral flexion (5 times each side).	Reach outs (forward, lateral, diagonal) (5-5 times)
		Ball throwing (5 times)

All exercises were demonstrated by researcher prior and whenever it was needed.
The intensity of the exercises was increased by introducing one or several of the following changes:

1. Reducing the base of support
2. Increasing the lever arm
3. Advancing the balance limits
4. Increasing the hold time [33].

Rest was given to subjects whenever it was needed.
After completion of intervention for 3 weeks, relevant statistical analysis was done.

Result

The statistical analysis was done for Group – I for the readings taken on Day 1 when the subject had approached the researcher for the treatment of impaired upper extremity due to chronic stroke and on the last day of the 3rd week after the treatment with conventional therapy. The statistical analysis was done for Group – II for readings taken on Day1 when the subject had approached the researcher and then on the last day of the 3rd week after the treatment of conventional therapy along with trunk stabilization exercises. For better understanding the readings that were taken for statistical analysis were assigned the terms PRE for 1st day for both the Groups and POST for last day of 3rd week for Group I and Group II.

Data analysis

Descriptive statistics including mean, standard deviation were analyzed. After analysing the data for its normality, which is Shapirov-Wilk test for subjects less than 100. As the data were found to be normally distributed, further parametric tests were used. Unpaired t-test was used for comparing means between all the two groups. Paired t- test was used to compare the difference within the groups at two time periods –baseline and after 3 weeks. Results were considered to be significant at $p< 0.05$ and confidence interval was set at 95%. All statistical analysis was performed using SPSS version 20.

Table 3: Demographic data

Characteristics	Group I	Group II
Age (mean ± SD)	56.80 ± 6.4	60.20 ± 3.8
Gender (male/female)	11 / 4	12 / 3
Involved side (right/left)	9 / 6	11 / 4
Type of stroke (ischemic/haemorrhagic)	12 / 3	13 / 2
Post stroke duration (in years) (mean ± SD)	2.2 ± 0.7	2.2 ± 0.8
Brunnstrom recovery stage for upper limb (mean ± SD)	2.9 ± 0.7	2.9 ± 0.7
Trunk impairment scale (mean ± SD)	11.60 ± 1.3	10.60 ± 0.9

Table 3 shows the descriptive statistics of age, gender, involved side, type of stroke, duration of stroke, Brunnstorm recovery stage for upper limb and trunk impairment scale distribution among 15 subjects per group for all 30 subjects in both the groups. Group I analysed by using paired t-test to determine the difference pre and post treatment within same group.

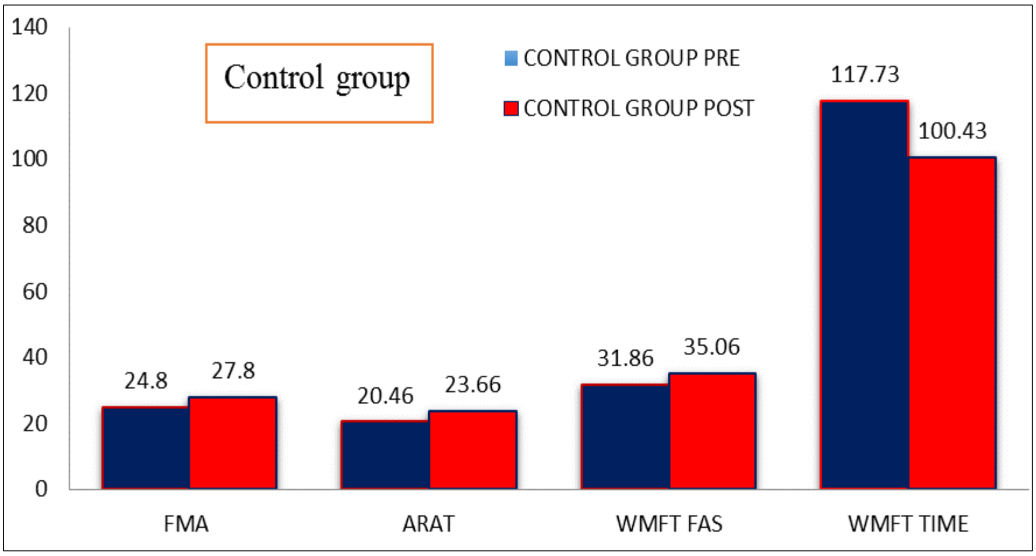

Fig 1: Mean difference comparison within group for group I

Figure 1 shows pre – post comparison for FMA, ARAT, WMFT FAS and WMFT TIME for group I. Mean difference were plotted to determine average improvement within group I. Group II analysed by using paired t-test to determine the difference pre and post treatment within same group.
Figure 2 shows pre – post comparison for FMA, ARAT, WMFT FAS and WMFT TIME for group II. Mean difference is plotted to determine average improvement within experimental group.
Figure 3 shows post comparison for FMA, ARAT, WMFT FAS and WMFT TIME for both group I and group II. Mean difference is plotted to determine average improvement between groups by using unpaired t test.

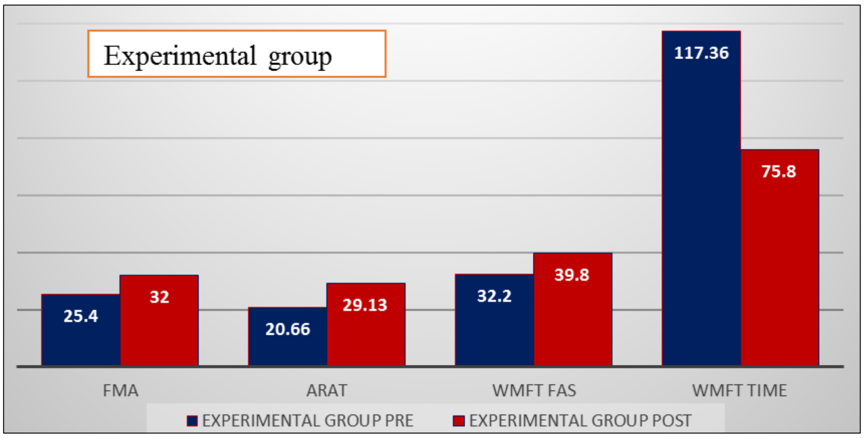

Fig 2: Mean difference comparison within group for group II

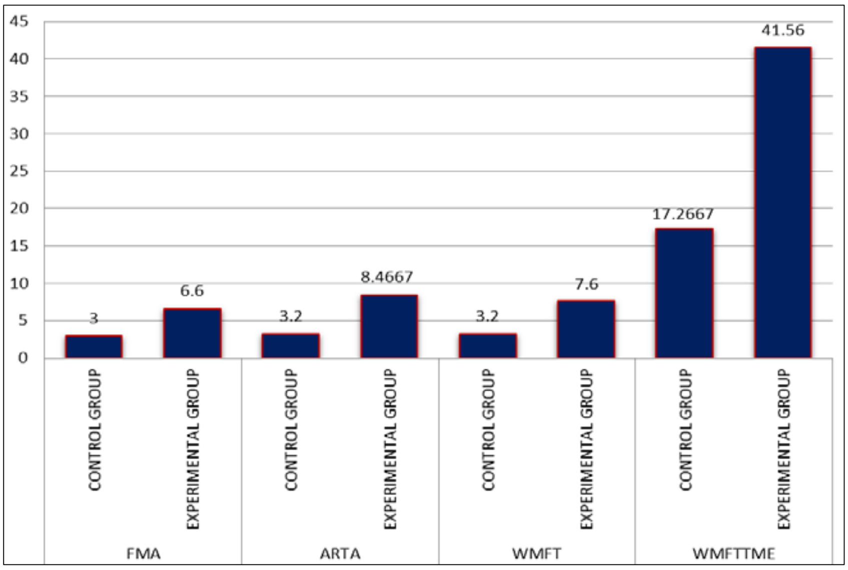

Fig 3: Comparison of mean difference between groups for group I and group II

Discussion

In comparison with limb rehabilitation, trunk recovery could be a rather neglected area of stroke rehabilitation research. This study hypothesized whether improving trunk stability produces distal mobility and improved controlled movement of the upper extremities by about to evaluate the effect of trunk stabilization exercises on upper extremity recovery in chronic stroke subjects which can help to scale back activity limitations and functional disabilities. The first findings of present study were that, 3 weeks of trunk stabilization exercises together with conventional therapy for chronic stroke subjects of outpatient departments enhance upper limb recovery. After mean of 2.2 ± 0.8 years post stroke, performance of trunk was found 11.60 ± 0.3 out of 23 as graded with TIS which shows that the trunk performance was less. Amongst 3 main components of TIS, subjects should show betterment in rating of static sitting balance. Difficulties were found in dynamic sitting balance and coordination activities. These findings are strongly correlated with study performed by Verheyden G *et al*. stated that trunk performance is impaired after stroke mainly in dynamic sitting balance and coordination by using various tools [4,42]. Hence it's understood that proximal stability is yet to be taken care of during rehabilitation protocol for improvement in functional abilities with its carry over effects to extremities as discussed in studies of trunk rehabilitation In study by Verheyden *et al*. 10 hours of additional task specific trunk exercises together with regular rehabilitation had shown improvement within the trunk control in subjects with sub-acute stroke [32]. A study by Mudie *et al*. found that training the patient within the awareness of trunk position could improve symmetry of weight shifting in sitting after the first phase of the stroke [43]. Furthermore, Dong Kwon Seo *et al*. had performed study to see effect of trunk stabilization exercise on thickness of deep abdominal muscles and balance [10] of these studies are supporting the employment of trunk stabilization exercises in stroke subjects. Moorkoth Likhi *et al*. conducted a study to correlate trunk performance with overall functions of upper and lower extremities which showed strong correlation between proximal stability of trunk to attain distal mobility by means of arm hand functions and walking [42]. These studies support the very fact that trunk is that the key component in improvement of upper and lower limbs after stroke.

The present study was distributed with the concept of strong correlation between trunk and extremities including 30 chronic stroke subjects who were randomly divided in to 2 groups. For group I conventional therapy and for group II trunk stabilization exercises together with conventional therapy were administered for five times every week for 3 weeks for determining effects on upper limb recovery by using reliable and valid outcome measures like Fugl-Myer Assessment scale for upper extremity, Action Research Arm Test, Wolf Motor Function Test. Henk T. Hendricks have conducted systematic review by performing a computer-aided search in bibliographic databases of longitudinal cohort studies, original prognostic studies and randomized controlled trials published within the period 1966 to November 2001, which was extended by references from retrieved articles and narrative reviews. In an RCT including 29 interventions for improving motor and functional recovery of the upper extremity, a mean change of the Fugl-Meyer Motor Assessment (FMA) of 12.1 points within the half year and 4.3 points within the half year post stroke was found within the control group (50 subjects). These studies suggest that, in some subjects, late motor recovery may occur even several months after stroke [41]. Identical conclusions were found within the present study which states that effect was also seen in upper limb recovery 1 year post stroke.

The present study involved subjects with severe impairment of upper extremity (Brunnstorm stage 2,3 and 4) who were administered trunk stabilization exercises together with conventional therapy. So it will be hypothesized that this treatment can show its effectiveness in mild or moderate impairment to boost motor recovery and functionality status of subjects too. one amongst the possible reasons behind less improvement by using various approaches like constraint-induced movement therapy, computer aided therapy etc. in severe impairment could be the lacking of proximal stability while performing exercises which results in encouragement of a compensatory mechanism by which the central systema nervosum may extend the reach of the arm by using trunk in abnormal pattern when the control of the active range of arm joints is proscribed [46]. Restriction of compensatory trunk movements during practice for chronic stroke subjects led to reduced trunk displacement, improved shoulder and elbow movements, with straighter reach trajectories, leading to improvements in reach-to-grasp movements [17]. Seng Kwee Wee *et al*. had conducted systematic review and meta-analysis to judge the evidence that trunk restraint limits compensatory trunk movement and/or promotes better upper extremity recovery in stroke subjects. In 6 studies including a complete of 187 participants within the chronic phase (>6 months) of stroke, chest harness to strap the themes were used. They need found moderate effect in recovery of upper limb mainly by using FMA-UE. These are the means to limit compensatory movements of trunk with use of passive devices to stabilize the trunk and by which to expect improvement in upper extremity [17]. In present study, trunk stabilization was trained by administration of varied exercises to arrange the trunk against destabilizing forces imposed by the movement of the limb and to orient the trunk in space so the specified motor output is achieved via the focal movement. During this study, upper extremity improvement is measured by using same scale FMA-UE. In present study, significant improvement was found in both experimental and control group in terms of FMA-UE. In experimental group (group II), major effects were seen in arm, forearm and gross movement with average improvement of 6.60 as compare to wrist and hand components of FMA-UE. In control group (group I), significant improvement was seen with increasing scores of 3.00 mainly of arm region. Significant improvement has been seen in experimental group with scoring of average improvement of 3.6 while comparing it with control group which shows improvement in recovery in upper extremity with help of trunk stabilization exercises. In previous mentioned study, distal component of FMA-UE also showed beneficial effects as they may have included both acute and chronic stroke subjects. The study performed by Stella Maris Michaelsen *et al*., A randomized controlled study to determine effects of task oriented training with trunk restrain in chronic stroke subjects to see upper limb recovery showed identical results with the results of present study by means of improvement in FMA-UE in chronic stroke subjects [47]. Furthermore, present study also supports statements resulted by Michaelsen SM *et al*., that moderately to severely affect subjects show more benefits than milder affected subjects through trunk restraint [48]. Present study shows positive findings in functional scales like ARAT and WMFT for improvement in functionality by administering active trunk stabilization exercises. In present study, significant improvement was found in functional ability scale of WMFT mainly in the actions without resistance and also in gross movements. In experimental group, average improvement of 7.60 was seen which is statistically significant. In control group, average improvement of 3.20 was seen. The average improvement of 4.4 between both groups was found which shows statistically significant results. There was no difference in strength component of WMFT which states that the possibly it might be difficult for subjects with Brunnstorm recovery stage 2,3 and 4 in chronic stage to be improvement of strength in 3 weeks of trunk stabilization protocol. The time component also showed significant improvement in experimental group with average improvement of reducing 41.56 seconds and for control group by reducing 17.26 seconds. The statistical significance was found in WMFT FAS and WMFT TIME by average improvement 4.4 and 24 seconds respectively while comparing both groups. The experimental group showed minimally clinically important difference which means for subjects with chronic stroke, trunk stabilization exercises are clinically significant for both functional ability and for time consumed per activity. Woodbury *et al*. performed study on chronic stroke subjects with trunk restraint along with CIMT which supports positivity of present study by using WMFT scale [49]. Wu CY *et al*. had conducted study Pilot trial of distributed constraint-induced therapy with trunk restraint to improve post stroke reach to grasp and trunk kinematics by using ARAT as functional outcome measure. This study showed significant over all higher improvement in functional status of stroke subjects in improving grasping movements and reversing compensatory strategy of trunk [50]. The present study supports strongly to this study by showing statistically significant results in ARAT. In experimental group, average improvement of 8.46 with statistical significance was found whereas in control group, 3.20 with statistical significance were found. The experimental group shows 5.46 average improvements with statistical significance while comparing with control group. Subscales of ARAT, Gross movement and grasping show better improvement than pinching tasks in both groups. The possible reason for this might be the presence of difficulties in achieving improvement in hand functions in chronic stroke subjects with 3 weeks of trunk stabilization exercises. These results also near about the minimally clinically important difference. So, results of ARAT show beneficial improvement for chronic stroke subjects.

The results from present study suggest that Trunk stabilization restrict compensatory shoulder girdle and trunk movements and minimizes the components of the scapular protraction and elevation synergy. This reduces the opportunity for the individual to perform reaching tasks using abnormal movement synergies. Thus, trunk stabilization may encourage more normal upper extremity synergies, that is, shoulder flexion and elbow extension, during reaching. Trial and error is a key component of motor learning and involves using sensory feedback to correct “errors” that compromise goal achievement. Trunk stabilization removes the “error” of abnormal trunk movement, “forcing” utilization of available upper extremity joint range. Initially, this may be a cognitive decision but with practice may become an automatic response and with high intensity, repetition and task-specificity may facilitate cortical reorganization and hence neuroplasticity. Therefore, learning how to control and stabilize the trunk during training may explain reduction in compensatory trunk movement. It can be summarized from the above discussion that trunk stabilization exercises can improve upper limb recovery by means of: • Improving motor performance after stroke • Improving ability to perform gross movements of upper extremity, grasping, gripping etc. • Reducing time to perform activities of daily living • Improving functionality of stroke subjects.

Limitations of the study

1. The duration of the study was short, three weeks, not satisfactory for chronic stroke subjects.
2. There was no follow up of the subjects.
3. Subjects with Brunnstorm recovery stage 2, 3 and 4 dysfunctions were taken into the study. The results of the study can't be made applicable to any respective population of Stroke with at specific Brunnstorm stage.

Conclusion

The results of the present study on 30 chronic stroke subjects have rejected the null hypothesis of this study. Hence, it is concluded that there is a significant difference between conventional therapy alone and conventional therapy along with trunk stabilization exercises in upper limb recovery of chronic stroke subjects.

After 3 weeks of treatment, significant improvement was noted in terms of FAM-UE, ARAT and WMFT in subjects receiving conventional therapy and in all outcome measures FAM-UE, ARAT and WMFT in conventional therapy along with trunk stabilization exercises. But improvement was much better in the experimental group who received conventional therapy in form of stretching, strengthening exercises and functional task specific exercises plus trunk stabilization exercise. So, combination of theses gives greater functional independence to stroke subjects.

Thus, it can be concluded that conventional therapy along with trunk stabilization exercises is more effective than conventional therapy alone in improving upper extremity recovery in chronic stroke subjects.

Future recommendation

- The study was done on a small sample size, so to generalize the effectiveness of the intervention large sample size is recommended
- The study should have a follow up in order to evaluate the effectiveness that is maintained or not and for what period of time.
- The study was done on Brunnstorm stage 2, 3 and 4, so further study can be done on specific Brunnstorm stage for generalisability at a particular stage.
- The study was done on chronic stroke subjects, so further study can be done on different population such as acute or sub-acute stroke.
- The study was done to see effect of trunk stabilization on upper limb recovery. So in future any approach for upper limb rehabilitation can be compared with the present approach to see if there is a better effect on upper limb recovery.

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