

Effectiveness of Reach to Grasp Training Using Trunk-Restraint on Trunk Arm Control after Stroke

Madiha Hassan Nabih Mohamed^{1,*}, Shereen Abd El-Moniem Ahmed²

¹Lecturer of Medical Surgical Nursing, Faculty of Nursing, Mansoura University

²Lecturer of Medical Surgical Nursing, Faculty of Nursing, Suez Canal University

*Corresponding author: medicin483@yahoo.com

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Abstract Background: Rehabilitation of upper limb is a challenge; constraint of compensatory trunk movement by trunk-restraint may be a crucial element to take in throughout training of reach to grasp for stroke patients with upper arm impairment. **Aim:** Evaluate the effectiveness of reach to grasp training using trunk-restraint on trunk arm control after stroke. **Method:** Experimental design was used on randomized control sample of eighty stroke patients in this study chosen by simple randomization. The study was conducted from the 1st of January, 2017 to the 1st of January, 2018. Three tools were used to conduct this study: Interviewing questionnaire, Fugl-Meyer Upper Extremity (FMUE) Scale, and Modified Ashworth Scale. **Results:** The majority of the studied groups (95.0% and 90.0%) were an ischemic stroke for the study and control group respectively. Statistical significant increase in elbow extension score at the study group compared with the control group that registers just 2.20° increase in elbow extension ($P: 0.000$). **Conclusion:** Use of trunk restraint is an effective therapy for the training of reaching and grasping, which reduce the upper extremity impairment, increased elbow extension, and reduce the excessive trunk movement during reaching. **Recommendations:** The current study recommended the conduction of additional studies at a variety of health institutions in Egypt, with a large sample size and long-term follow-up.

Keywords: stroke, reach to grasp training, trunk-restraint, trunk arm control

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1. Introduction

Stroke often causes significant disability induced by the brain lesions and leads to a neuromuscular dysfunction, immobility, and limitation of daily activities [1]. Upper extremity (UE) dysfunction is one of the most persistent and significant stroke-related physical impairments that affects more than 80% of stroke survivors and weakens the ability to range using the impaired arm. Muscular weakness with other motor problems is recognized as a limiting factor for rehabilitation [2,3,4,5].

In order to compensate the upper limb impairment, patients with hemiparesis can use alternative strategies to improve arm and hand function. Several researches have confirmed that post-stroke patients suffering excessive trunk displacement and abnormal shoulder-elbow coordination. The increased trunk recruitment is a neural regulation by central nervous system (neural plasticity mechanisms) that can control arm movement when their normal function is limited [6,7]. It begins while the brain is also undergoing widespread repair, in addition to regrowth and re-modelling of the connectivity patterns of surviving neurons after stroke [8].

The compensatory movement patterns that develop after stroke can be self-taught or encouraged by interventions. Stroke rehabilitation is focused on improving functional abilities, and this improvement can be achieved through either the development of new compensatory strategies or the recovery of more-normal function. The relative contribution of the two varies with impairment level, and compensation making a larger contribution in those with more severe impairment [9].

Reaching and grasping freely without restraining to the trunk maximizing motor compensation that provides central nervous system with non-optimal sensory information from the trunk and limb. The rehabilitation strategies can perpetuate the functional compensation. Using structured training program help to restricting compensatory trunk movements and promote shoulder flexion—elbow extension coordination and reinforce development of "normal" reaching pattern with additional typical joints motion during reaching activities [10, 11].

On the other hand, task-related activities provided to the patient using trunk restraint will be significant to limit trunk movement with repetitive meaningful unimanual and bimanual reaching, grasping tasks; moreover, it recovers patient's functional abilities than those unrestrained [12,13].

1.1. Aim

This study aimed to evaluate the effectiveness of reach to grasp training using trunk-restraint on trunk arm control after stroke.

1.2. Research Hypothesis

H₁: Trunk restraint training will improve arm reaching in neurological rehabilitation for stroke patients.

1.3. Significance of the Study

Prior research supports the efficacy of structured, specific, and intensive training protocols to increase the use of hemiparetic limb, but less attention has been given to normalizing movement strategies post-stroke. With high number of researches on stroke rehabilitation, there is a need to determine the potential use of trunk restraint training in improving arm reaching in neurological rehabilitation particularly for stroke patients.

Therefore, the current study was designed to determine the influence of trunk restraint on recovery of reaching movements and improvement of upper extremity function post stroke. It increases knowledge base of clinical practitioner and aid therapists in establishing comprehensive upper extremity rehabilitation programs for post stroke patients.

2. Subject and Methods

2.1. Design

This study was designed as an experimental research design.

2.2. Participants and Settings

Eighty (80) stroke patients were recruited in the present study using simple randomized control (Study and control) sampling from the rehabilitation departments affiliated to Mansoura University hospitals and Suez-Canal University hospitals, Egypt, from January, 2017 to January, 2018.

The inclusion criteria were (a) stroke patients aged 20 to 60 years, (b) six months to one year since the onset of a unilateral stroke, (c) cognitive ability to understand simple instructions, (d) no pain; contractures; or severe weakness in arm muscles (<3 in Manual Muscle tone Testing of affected upper limb based on Modified Ashworth Scale (MAS) for muscle tone grading from [14], and (e) have moderate arm motor impairment (30 to 49 scores) on the Fugl-Meyer (FM) arm section scale according to [15].

After informed consent was obtained, participants were divided into two equal groups (40 each) using simple randomization. Experimental group (Group I) submitted to a program of reach to grasp training with trunk restraint and control group (Group II) submitted to the same program without trunk restraint.

Sample size was calculated using epidemiological information (EPI info.) program version 6.02 after taking into consideration the total number of stroke patients

admitted to rehabilitation department, alpha error 5% (= confidence level=95%) Beta error 20% (=study power=80%).

$$\text{Sample Size} = \frac{Z^2 * (p) * (1 - p)}{C^2}$$

Where: Z = Z value (e.g. 1.96 for 95% confidence level), p = percentage picking a choice, expressed as decimal, (.5 used for sample size needed), C = confidence interval, expressed as decimal

2.3. Tools for Data Collection

2.3.1. Tool I: Interview questionnaire: designed by the researchers and Divided into two parts

Part (1): A demographic data included four questions as each study participant provided data on their age, sex, marital status, and education.

Part (2): Clinical characteristics included four questions as type of stroke, affected side, dominant side, and time since onset.

2.3.2. Tool II: Modified Ashworth Scale referenced from Bohannon & Smith [14] and Michaelsen, et al., [15] to assess the participants' contractures and weakness in the shoulder flexion muscles by measuring resistance during passive soft-tissue stretching. It is used as a simple measure of spasticity for assessment of muscle tone and upper extremity impairment.

Scoring of the Modified Ashworth Scale:

0: No increase in muscle tone

1: Slight increase in muscle tone, manifested by a catch and release or by minimal resistance at the end of the range of motion when the affected part(s) is moved in flexion or extension

1+: Slight increase in muscle tone, manifested by a catch, followed by minimal resistance throughout the remainder (less than half) of the ROM

2: More marked increase in muscle tone through most of the ROM, but affected part(s) easily moved

3: Considerable increase in muscle tone, passive movement difficult

4: Affected part(s) rigid in flexion or extension

2.3.3. Tool III: The Fugl-Meyer Upper Extremity (FMUE) Scale referenced from [16]: It is a performance-based measure of impairment that designed to assess reflex activity, movement control, and muscle strength in the upper extremity of people with post-stroke hemiplegia. All studied sample was evaluated by (FMUE) Scale at the pre-treatment period.

The **FMUE Scale** comprises 33 items, each scored on a scale of 0 to 2, where 0 = cannot perform, 1 = performs partially and 2 = performs fully for a 66-point maximum. It takes up to 30 minutes to administer. All studied sample was evaluated by (FMUE) Scale at the pre-treatment period.

2.4. Validity and Reliability

Fugl-Meyer Upper Extremity (FMUE) Scale show Excellent internal consistency (alpha = 0.94 to 0.98 across four administrations over 6 months). Regarding validity; Intra-rater (ICC 0.99, 95% CI 0.99 to 1.00) and inter-rater (ICC 0.96, 95% CI 0.92 to 0.98) agreement were shown to be excellent.

Modified Ashworth Scale is an excellent instrument with weight Kappa values of 0.868 and 0.892 and have very good inter-rater reliability.

The three tools used in this study were reviewed by a panel of 7 experts in the medical surgical nursing specialty before introducing them to the participants to ensure its validity and their comments were considered.

2.5. Pilot Study

The purpose of the pilot study was to test content clarity and applicability of implementing the designed tools. The pilot study was carried on 10% of the study sample. The pilot was excluded from the study sample.

2.6. Intervention

2.6.1. Patients' Assessment

Patients' assessment was done two times during the study as the patients were assessed first before application of the Trunk-Restraint to test patients' reach and grasp abilities, then the second assessment was done to assess the patients' improvement after 6 weeks (recommended training period).

To assess the patients' progress, patient instructed to reaching and grasp an object (cubes, Blocks or can) (5.3 cm in diameter and 10.5 cm in height; along the participants' mid-sagittal plan [17]. The researchers measured the arm's length as the distance from the acromion to the third fingertip to explore the trunk compensation in different task demands before and after application of the Trunk-Restraint

2.6.2. Implementation

- Standard instruction comprised demonstration of activities by the researchers accompanied by explanations for the patient. Patients then practiced reaching activities and receiving assistance and feedback by the researchers
- Participants received a 1-hour program with object-related reach-to-grasp training 3 times per week for 6 weeks with total (18) sessions.
- Intervention assured recurrent practice of meaningful tasks with increasing difficulty. It included repetitive functional uni and bimanual reach-to-grasp tasks using objects varying in size, weight, and shape, using whole-hand, and finger-tip.
- The researchers consider progression criteria that were established by increasing within block repetitions, increasing object size and weight, as well as increasing the height and distance at which objects were manipulated in addition to rest periods of 1 to 2 minutes were permitted when necessary to avoid fatigue.
- Both groups (study and control) practiced the same tasks except that in trunk restraints (TR), trunk movements were prevented by body and shoulder belts attached to the chair back.

2.6.3. Evaluation

The evaluation was done after application of the training with six weeks for both the study and the control

groups; to evaluate the mean values of elbow extension (ROM). The prelisted tools were used by the two groups throughout the study phases, as the researchers fill them on the participants during the assessment and the evaluation phases.

2.7. Ethical Considerations

Certificate of approval was obtained to carry out the study, the researchers introduced themselves to all the studied patients and the aim of the study was explained prior their participation to obtain their cooperation and their written consent. Confidentiality of data was assured to all the participants. The researchers assured that participation in the study was voluntary and they have the right to withdraw at any time.

2.8. Data Analysis

The study data analyzed using SPSS version 21. Descriptive statistics used for the analysis of nominal data as demographic and clinical characteristics of the participants. Differences between variables through the study analyzed using One Way ANOVA. The statistical significance and associations were assessed using, the arithmetic means, the standard deviation (*SD*), (X^2), and (*t-test*) utilized to explore correlation between variables. Significance level was identified at $P < 0.05$.

Reach to Grasp Training (contents and objectives)	
Objectives	Content
Improve motor movement of the affected arm	<ul style="list-style-type: none"> • Repetitive functional reach-to-grasp tasks • Using objects varying in size, weight, and shape, using whole-hand, and finger-tip. • Increasing arm reach repetitions • Increasing object size and weight, as well as increasing the height and distance at which objects were manipulated • Provide rest periods of 1 to 2 minutes were permitted when necessary to avoid fatigue
Restriction of trunk motor compensations	<ul style="list-style-type: none"> • Restraining the trunk by shoulder belts fixed to the back of the chair.

3. Results

Table 1 shows a total of 80 patients (40 for control and 40 for study) group with mean age (51.8 ± 9.1 and 52.3 ± 7.1) years old in study and control group respectively, males more prevalent in study group (60.0%) where females are more prevalent in control group (52.5%), most of both groups were married (62.5%, 67.5%) at the study and control group respectively. Concerning level of education illiteracy was prevailing among 50.0% of the study group and 72.5% for the control group.

Table 2 explained clinical characteristics of the studied groups and observed that the majority of the studied groups (95.0% and 90.0%) are ischemic stroke, and more than half in study and control group patients (60.0% and 62.0% respectively) are left side hemiplegia. Mean time since onset was 8 ± 1.5 month previously in study group and 7.7 ± 1.3 month previously in control group.

Table 1. Distribution of studied groups according to demographic characteristics (N=80)

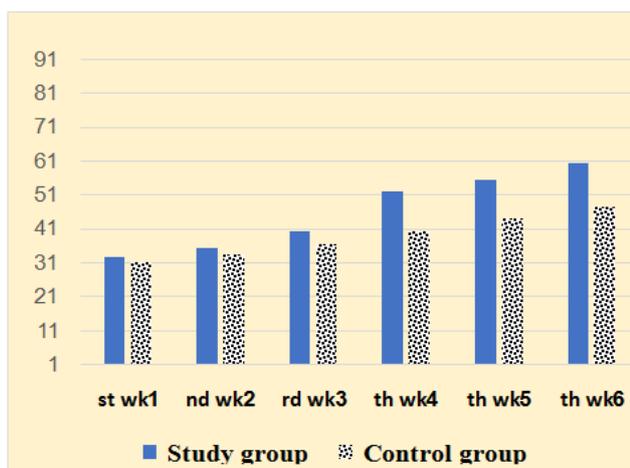
Demographic characteristics	Groups				Test (P-Value)
	(study) (N = 40)		(control) (N = 40)		
	No	%	No	%	
Age	20 – 60 Years old				$T = 0.35 (0.731)$
Mean \pm SD	51.8 \pm 9.1		52.3 \pm 7.1		
Sex					
Male	24	60.0%	19	47.5%	$X^2 = 0.16 (0.687)$
Female	16	40.0%	21	52.5%	
Marital status					
Married	25	62.5%	27	67.5%	$X^2 = 6.0 (0.049^{*\wedge})$
Widow	15	37.5%	13	32.5%	
Education					
Illiterate	20	50.0%	29	72.5%	$X^2 = 3.4 (0.338^\wedge)$
Primary	3	7.50%	3	7.5%	
Secondary	7	17.5%	3	7.5%	
High education	10	25.0%	5	12.5%	

X^2 : Chi-square test, P value based on Mont Carlo exact probability, * $P < 0.05$ (significant).

Table 2. Distribution of studied groups according to clinical characteristics (N=80)

Clinical characteristics	Groups				Test (P-Value)
	Study (N = 40)		Control (N = 40)		
	No	%	No	%	
Diagnosis					
• Ischemic	38	95.0	36	90.0	$X^2 = 0.44 (0.505)$
• Hemorrhagic	2	5.0	4	10.0	
Affected Side					
• Right side	16	40.0	15	37.5	$X^2 = 0.04 (0.839)$
• Left side	24	60.0	25	62.5	
Dominant Side before stroke					
• Right	40	100.0	40	100.0	NA
• Time since onset/previous months,	<u>mean (SD)</u>				
	8 \pm 1.5		7.7 \pm 1.3		

X^2 : Chi-square test, $^\wedge$ P value based on Mont Carlo exact probability, * $P < 0.05$ (significant), NA: Not Applicable, t: independent samples t-test.



$X^2 (5.35)$, ($P=0.000^*$); P : Friedman test for related samples; P-value based on Mann-Whitney test

Figure 1. Functional improvement after 6 wks. Among the studied group

Figure 1 reflects a comparison between the studied groups according to their functional improvement after six weeks using Fugl-Meyer Upper Extremity (FMUE) Scale. It can be noticed that training with (TR) led to greater decreases in trunk displacement, and normal reaching pattern ($P=0.001$) with apparent increase in mean FMUE score in study group (60.5 ± 8.3) than control group (47.3 ± 8.7) by the end of the study (6th wks.).

Table 3 reflects a comparison between the studied groups according to pre and post treatments mean values of elbow extension in studied participants. It can be noticed that a statistical significant increase in elbow extension score post treatment in study group (trunk restrain group) compared to control group ($P=0.001$ and 0.0074 respectively), with apparent improvement in shoulder flexion—elbow extension coordination in study group, as TR increased elbow extension by 7.29° at post-test in study group compared with control group, that register just 2.20° increase in elbow extension.

Table 3. Pre and post-training mean values of elbow extension (ROM) among the studied groups

Groups				
Elbow extension (ROM)	Pre-treatment	post-treatment	T-test	P-value
	X± SD	X ± SD		
Study group	50.40±3.83	58.20±6.52	5.954	.0001*
Control group	52.38±7.79	54.53±4.99	3.129	.0074*

4. Discussion

Research on the effectiveness of rehabilitation techniques for patients with stroke is important not only for stroke survivors but also for care givers, treatment providers and society [18].

The upper limbs have an energetic part in the performance of more than 50% of daily activities, in form of reach and grasp activities. Enhanced upper extremity recovery will have a positive effect on ADLs by decreasing a compensatory movements when extending arm to reach objects when shoulder and elbow movement is impaired [19,20,21].

Secondary complications occurs as a result of unnecessary use of compensatory movements including muscle contractures, joint misalignment, pain, limb disuse, and increased energy expenditure, can impede the longer-term functional recovery of the upper extremity [21,22,23].

The ability to reach and grasp post-stroke differed according to therapeutic intervention. Additionally, compensatory mechanism used for reaching movements enables the patients to sufficiently reach the object located within the extent of the arm accompanied with inadequate shoulder flexion and elbow extension [18].

Trunk restraint should be used in all stroke patients even those with chronic hemiparesis to encourage maximal joint range of motion and to promote maximal arm motor recovery, which is likely to reduce independence and increase burden of care [7]. This study aimed to investigate the effectiveness of reach to grasp training using trunk-restraint on trunk arm control after stroke.

The current study included a total of 80 patients with mean age 51.8 ± 9.1 and 52.3 ± 7.1 years old in study and control group respectively, more than half of the study group are males and the control group are females, most of both groups were married, and illiteracy was prevailing among half of the study group and most of the control group. The majority of this sample is ischemic stroke, has left side hemiplegia, and with mean time post-onset was 8 ± 1.5 month previously in study group and 7.7±1.3 month previously in control group. These results could be related to high incidence of stroke with age. Also Ischemic stroke is the most common type of stroke.

A functional analysis of the upper limb movement during arm reaching has illustrated that patients with hemiparesis were used more trunk flexion and shoulder abduction to compensate for reduced elbow extension, demonstrated abnormal shoulder abductor power to compensate for the reduced shoulder flexor power. These compensatory movement strategies are evident during unilateral upper limb tasks [24].

The key results of the current study presented that, training with trunk restraint led to greater decreases in trunk displacement and normal reaching pattern with

apparent increase in mean FMUE score in study group than control group by the end of the study (6th wks.) with statistically significant difference.

This may be attributed to additional related somatosensory input from the arm joints that can control the reaching abilities, as compensatory mechanism counter improvements in the function of the paretic side. Moreover, the repeated participation by patients in therapeutic programs of active physical activity directly influences functional reorganization in the brain and enhances neurological recovery.

This result is steady with other studies [18,25] who revealed that compensatory behaviors are also self-taught. As they are developed early and are well practiced, these self-taught behaviors may be normally a main power in shaping post-stroke brain reorganization; however, they may do so in suboptimal or even maladaptive ways. During trunk restraint, patients improved active elbow extension; shoulder ranges and inter joint coordination when reaching.

Other studies by [11,26] clarified that, new treatments for injury-induced impairments may lie within the neural mechanisms and influences of compensatory behavior, thus the trunk restraint allowed patients to use the joint ranges that were present but not recruited during unrestrained reaching. Reports from other studies indicated that, restraining the trunk during reaching exercises would force individuals to use the arm's unexploited capacity, support the hypothesis that training with trunk restraint (TR) can help to improve functional abilities [12,27].

Within this context [21] showed that reach-to-grasp training with TR has a moderate significant effect on reduction of upper extremity impairment measured by the Fugl-Meyer Assessment/Upper Limb Section (FMA/ULS) and on improvements in shoulder flexion. Hence, ADL positively affected by improved upper extremity recovery a compensatory response to help increase arm reach when shoulder and elbow movement and control are impaired.

Also, study carried out by [29] emphasizes that uncoordinated arm joint movement in stroke patients mainly resulting from compensatory trunk displacement. using trunk restraint throughout reaching practice for patients with chronic stroke limiting trunk displacement, enhance shoulder and elbow movements, with straighter reach trajectories, resulting in improvements in reach-to-grasp movements.

Impaired elbow extension post stroke is commonly observed complication and considered a part of a flexor synergy pattern that produces coexisting flexion motions, which also weakens the patient's ability to move joints [7].

The current study and Shaikh et al., [28] have shown increase in elbow extension score post treatment in trunk restraint group compared to control group. This may

attributed to increased performance of upper-limb activities with trunk restraint that promote return of upper limb active range of motion.

Consistent with the results of the current study [11] reported that the trunk restraint group showed less trunk compensation during reaching and more arm recruitment than control groups. Also, Sawan et al., [7] stated that trunk restraint group significantly increase elbow extension ROM compared to non-restraint group. On the other hand, the uniqueness of the present study is that it demonstrated that participants' improvements after trunk restraint occurred not only in motor control and compensatory movement but also in functional gains and patient's reported outcomes of functional performance.

To address the limitations of the present study regarding small sample size and lack of follow-up, future research to confirm this study findings through application of trunk restraint with a large sample size and follow-up will be of value.

5. Conclusion / Recommendations

Use of trunk restraint as a treatment paradigm aimed at decreasing compensatory strategies has the potential of becoming an effective therapy to include in post stroke rehabilitation. The use of trunk restraints led to benefits in reduction of upper extremity impairment, in terms of FMA-UE score, increased shoulder flexion—elbow extension coordination, and reduction in excessive trunk movement.

The current study recommended the conduction of additional studies at a variety of health institutions in Egypt, with a large sample size and long-term follow-up.

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Author Contributions

Ahmed, S.A and Nabih, M.H. developed the Study conception and design, collected data of the study, performed data analysis and interpretation, formulated drafting of the article and completed the critical revision of the article.

Conflict of Interest

The researchers have no conflict of interest.

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