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Short-term effectiveness of trunk and bimanual hand training on upper limb motor recovery and function in stroke patients

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***Abstract*---**Background*:* Stroke is a leading cause of motor impairment in adults and the elderly, necessitating appropriate therapies that might aid upper-limb rehabilitation. Upper-limb rehabilitation is difficult limiting the anticipatory core action using trunk-restraints could be an important factor to consider during Physiotherapy for stroke individuals with upper-arm disability. Different approaches, such as the use of exergames in motor rehabilitation and balance, are being used because they work as motivators, making therapy more enjoyable. Aim: To assess the effects of trunk-restraint reach-to-grasp therapy on trunk arm control following a stroke. The goal of this research was to see how trunk and bimanual hand training affected patients' balance and upper-limb motor function following a stroke. Method: In this work, an experimental design was employed on a randomised control group of 62 stroke patients selected by simple randomization. The research was carried out from September 2020, to august 2021. The Fugl-Meyer Upper Extremity (FMUE) Scale, Modified Ashworth Scale, and the interviewing questionnaire were all employed in this investigation. Results: For the study and control groups, most of the groups that were examined (95.0 percent and 90.0 percent, respectively) had an ischemic stroke. In comparison with the control group, the experimental stroke showed a substantial rise in elbow extension ($P \leq 0.000$), which only has an increase of 2.20° in elbow extension. Conclusion: Trunk restraint is an excellent treatment for reaching and grasping training, as it reduces the impairment of the upper extremity, excessive trunk movement, and increased elbow extension when reaching.

***Keywords*---**Bilateral movement training, stroke, Rehabilitation, bimanual hand training, upper limb motor recovery.

Introduction

After cancer and heart disease, stroke is becoming the top cause of mortality, causing sufferers all over the globe to feel hopeless. Stroke is a major public health problem since it is one of the most well recognised causes of disability and death. The cerebral impedances are the most unavoidable of all the deficits evident in stroke. The link between cranial nerves, muscular control, and tone, coordination, walk, apraxia, and reflexes are mixed in motor loss. Paralysis of the upper extremity is a common and annoying side effect of paraplegia, which increases activity restrictions. A paraplegic's recovery is often slower than the loss approach of gradual cut-off work. [1] In the 16th century, "stroke" was elegantly formalised as a medical diagnostic. Paresis, manual loss of smoothness, and improvement variations from the standard are all symptoms of upper limb brokenness in stroke, and they may have a significant impact on the execution of everyday tasks. [2,3] Understanding, holding, and regulating articles are step-by-step tasks that 45 percent–65 percent of patients 2–6 months after a stroke still lack. Different intercessions look at have been ringed in physiotherapy, examining the influence of various recuperation tactics in redesigning furthest point engine control and operating. The most often used approach for retraining hemiplegic patients is coordinated preparation. [4]

Strokes may have a substantial influence on people’s standard of living, especially when it comes to doing everyday tasks independently. As a result, rehabilitation is required for all post-stroke patients, it is critical to functional recovery, and it necessitates a dynamic training programme to maintain patient engagement, which is a prerequisite for a positive rehabilitation outcome, and the use of interactive games in stroke rehabilitation treatments is now widely accepted.

Upper limb (UL) dysfunction occurs in 50–80% of people who have had a stroke in the acute phase and 40–50% of those who have had a stroke in the chronic phase, and it has a significant impact on everyday activities. [5] People with stroke learn to use the non-affected UL and neglect the affected limb over time, which leads to non-use, atypical posture patterns, and contractures [6,7], and they suffer anxiety, poor quality of life perception, impaired cognitive capacity, and changed mood as a result. This inhibits their capacity to operate and actively participate in the community. [8] An early, intense, repeated, and task-specific exercise programme has been shown to induce neuroplastic changes, improve UL function, and promote neurological recovery. [9] This training will activate the anterior cingulated and supplementary motor regions, resulting in UL motor recovery that is more predictable and consistent than conventional therapy. [10] However, owing to loss of voluntary movement control, diminished muscular strength, and the presence of discomfort, most persons with stroke have inadequate mobility in the afflicted limb to complete the tasks. [11] Even so, robot aided treatment, electro-myogram-triggered electrical stimulation, and other methods may be used to offer repeated task-based training to the afflicted UL. [12] however, because to their exorbitant cost, they are out of reach for most stroke survivors. [13] Upper motor neuron syndrome, sensorimotor deficiency contralateral to the brain abrasion, and cognitive issues are all frequent UL impairments produced by neurological loss following a stroke, all of which impact functional abilities in accomplishing tasks and autonomy, affecting standard of living.

Clinical measurements may be unable to identify discrete movement patterns and motor impairments [14], indicating the requirement of more accurate procedures of compensatory methods or subtle limitations. [15,16] Furthermore, apart from the Wolf Motor Function Test (WMFT), compensatory movement techniques such as lateral flexion and forward displacement of the trunk in grasping layouts don't clearly quantify by most activity-level motor scales. [17] The capacity to identify motor recovery from compensatory methods is improved when kinematic assessments are paired with the medical context linked with levels of ICF. [18-20]

Upper-limb weakness is common in both acute and chronic phases of stroke recovery, with up to 40% of people never recovering functional upper-limb usage in everyday tasks. Maximum voluntary force is diminished after a stroke, the central nervous system is reorganised, and peripheral muscle alterations occur (e.g., muscle weakness). [21]

Meyer et al. previously found that impairments of somatosensory and motor are low to moderately associated ($r = 0.22$ to 0.61) in 122 individuals during the first 6 months after stroke in a cross-sectional investigation. Long-term research is required to better understand the relationship between somatosensory and motor recovery, such as if both could be described by the universal mechanisms of recovery of spontaneous neurobiological or whether somatosensory disability or/and recovery has an impact on motor recovery. Furthermore, the lack of somatosensory input may affect experience-dependent plasticity, which underpins neural circuit remodelling and, as a result, may impede the formation of novel motor programmes after a stroke. In the latter case, one would predict a failure in the recovery of somatosensory impairments to be strongly linked to lower motor recovery of upper paretic limb. [22]

After a stroke, upper limb neuromuscular weakness is common, with muscle weakness and agility having the greatest influence on functional recovery. Motor deficits or muscular strength in the upper extremities are linked to functional capacity and might even lead to functional impairment less than muscle development sensibility, poor dexterity, or discomfort in stroke-related disability. Denervation potentials, motor unit loss, selective atrophy of type II muscle fibres, decreased motor unit activation, and lowered maximum contraction are among the abnormalities Bourbonnais and Giuliani discovered after a stroke. Overall contraction duration has been observed to be longer, and motor unit firing rate has been reported to be lower in certain trials. Muscle weakness may be caused by any of these conditions. Because of the weakness, movement production and control may be impaired, limiting goal-oriented activities, daily independence, and job capacity. [23]

Between 2 and 6 months following a stroke, significant remodelling of motor units may occur. There are three stages to regaining upper limb function: First, cell repair activation; second, functional cell plasticity; and third, neuro anatomical plasticity. Most participants can recover adequate mobility and control of their limbs to accomplish their activities of daily living (ADL) with the help of good therapy. This process could be influenced by treatments aimed at improving muscular strength and, as a result, motor function. [24]

One goal of stroke therapy is to enhance the subject's ADLs by increasing his or her independence in gross motor skills and walking. Strengthening exercises may enhance functional results, according to previous stroke rehabilitation literature and research on the benefits of strength training. Post stroke physical activity and fitness levels are poor, with muscle power, muscular strength, balance, flexibility, and body composition being the most essential components of physical fitness. Most of the physical fitness training is divided into three categories: resistance training (RT), cardio-respiratory, and combined training. RT involves muscular contractions that are resisted by body mass, weight, or elastic devices. It has to do with increasing muscular strength, endurance, and power. RT can increase flexibility and balance while also influencing body composition. Exercise training has been shown to be effective in assisting stroke survivors with improvements in blood cardiovascular risk factors, cardio-respiratory capacity, mobility, body composition, cognition, physical skills, and balance. Some studies believe that RT, which causes muscles to work or hold under an applied weight, plays an important role in stroke recovery.

Materials and Method

To conduct this study, the researchers presented oneself to the patients who were being investigated, and the purpose of the study was described to them prior to their involvement to acquire their cooperation and written permission. All participants were guaranteed that their information would be kept private. Participants in the study are completely free to leave at any moment, according to the researchers.

Design

The experimental study design was used for this investigation. In this research, scrambled pre-test as well as post-test control group layout was adopted. Participants were randomised at random either to BHT or control groups (Figure 1). The outcome measurements were given before and after an eight-week intervention. Training occurred within regularly scheduled vocational counselling sessions, while all other standard stroke rehabilitation programs (such as physical therapy) continued as before.

Participants

We recruited 62 stroke patients (42 males and 20 females; mean age = 47.58 years) from the Department of Physiotherapy, Suyash hospital after the start of an ischemic or haemorrhagic stroke (during September 2020 to August 2021) 12 months. The informed consent forms for all the patients were authorized by the institutional review board. According to self-reported data, all the subjects were right-handed dominant before the stroke.

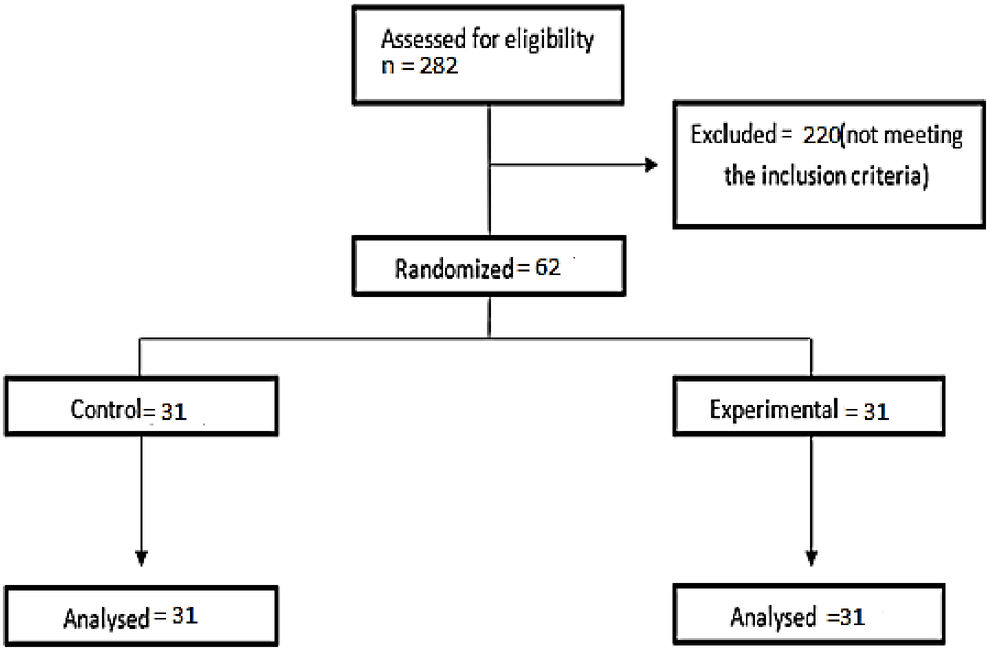

Figure 1. The randomization technique is depicted as a flow diagram

An inclusion criterion for the participants is given below:

- Those who are between the ages of 30 and 60.
- Those who are in the sub-acute phase of a stroke, which lasts between six months and a year, and have had continuous physiotherapy from the start of the stroke.
- Those with significant arm motor impairment on the Fugl-Meyer (FM) arm segment scale (30 to 49).
- The capacity to comprehend basic instructions cognitively.
- Those who obtained a minimum score of 24 on the Mini-Mental State Examination.
- There is no discomfort, contractures, or significant weakening in the arm muscles (<3 in The Modified Ashworth Scale (MAS) is used to grade muscular tone in the affected upper limb).
- Those who have had a sub acute stroke that has been checked through computed tomography or magnetic resonance imaging (MRI). Those who plan to take part in the research.

The exclusion criteria for the participants are as below:

- Those who have had epilepsy or neurosurgery in the past.
- Those who have had a transient ischemic stroke in the past (TIA).
- People with aphasia or significant cognitive disabilities.
- Those who have been diagnosed with organ failure, such as heart, lung, kidney, or liver.
- Those who are unable to undergo an MRI scan.
- Participants who are enrolled in another clinical investigation.

Intervention

The participating hospitals received the intervention, which was overseen by the Physiotherapist. The investigators educated the treating therapists within execution of the BHT guidelines and required them to pass a written competency exam before they could begin treating the subjects. The usual rehabilitation approach includes Hemiplegia side body positioning, position training, bridge activities, self-participation in finger interlocking, body sensory training, tuck exercise, and active &passive training for joint mobility.

The following instructions were added to the manual sensorimotor rigorous training that's been improved from the one aptly known by many others: (1) Pectoral girdle controlling competence training: enhancing the pectoral girdle muscle and improving the pectoral girdle and myodynamia consistency while holding load and even against the resistance. (2) Training for haptic perception: bimanual processing training for observable sensation, discrimination, and perception with the possibility of employing items of various textures, forms, along with sizes. (3) Training for bimanual coordination involves both body parts, like placing on and removing off various types of clothing and dressing manually with various shaped do-up clothes. (4) Hand functional training, including includes penning and sketching with the center line crossed, as well as using cutters and bending paper.

Patients were told to scrunch and start to unravel a piece of paper with both hand until a line emerged in the center; draw a symmetrical/asymmetrical depiction in which the left portion is drawn by left hand and the right portion drawn by right hand; and to aid in this process and to make a template, practice finger and wrist stretch of both the engaged hand while using unengaged hand as a stabilizer, then cut out the template.

Structured practice with raising bimanual complexity of hand and the functional tasks were part of the above-mentioned training. In addition, the obligation to repeat bimanual cooperative activities was highlighted throughout training. By eliminating the requirement for E-game’s, draw poker, and deceitful activities, we seemed able to cut main time of bimanual practice from 6 hours a day to 2 hours a day in children with Hemiplegia, compared to Gordon's HABIT plan. The same competent physical therapist with more than 5 years of experience administered all the therapies. Both HABIT and CRP treatments were given over the course of one hour. More exercises were conducted to fulfill the hour if the activities were completed in less than an hour. Each technique had two treatment sessions per day, 5 days a week for 2 weeks (10 days total), for a total of 20 hours of physiotherapy. If the patients became weary, the training was interrupted and repeated after an hour of rest to complete a one hour of session. The program was adjusted whenever the intensity of the workouts got too high for the participants. Before (i.e., at baseline), after 1 week of treatment, and after 2 weeks of physiotherapy, all evaluations were completed. All cases were assessed and analyzed by the same evaluator and statistician (both blind to categorization).

Bimanual Hand Training Group

For four weeks, the BHT group focused on both damaged and uninjured UEs moving concurrently in cognitive activities in symmetric layouts for two hours each day, five days a week. The participants were supervised one-on-one while they performed a range of functional activities that are often challenging for stroke patients. Lifting two cups, stacking two checkers, picking up two trivial, desiccated beans with such a diameter of 0.5 to 1 cm, folding two rubs, turning two big screws, manipulating two silvers instantaneously with each hand, or holding a sprayer can to water plants with both hands were among the tasks assigned to the participants.

Control Intervention Group

For 8 weeks, 2 hours a day, 5 days a week, the control group received the same intensity and length of therapy. In addition to UE training, this group received standard Physiotherapy treatment, including neuro developmental techniques, trunk–arm control (i.e., performing UE tasks while standing), weight bearing by the affected arm, fine motor task practice, and practice with compensatory strategies for daily activities.

Patients' Assessment

Patients were examined twice throughout the study: first before the Trunk-Restraint was applied to measure their reach and grip skills, and then again after 8 weeks to assess their progress (recommended training period).Patients were asked to reach and grab an item to see how much they had improved. The arm's length was measured from the acromion to the third fingertip before and after the Trunk-Restraint was applied to investigate trunk compensation under various job demands before and after the Trunk-Restraint was applied.

Implementation

As part of the normal training, the researchers would show and explain activities to the patient. Patients then practiced reaching skills while receiving help and comments from the researchers. Three times each week for four weeks, participants were given a one-hour program with object-related reach-to-grasp training. The intervention guaranteed that relevant, increasingly complicated activities were done on a regular basis. It included practical unimanual along with bimanual reach-to-grasp tasks with items of differing sizes, weights, and forms, as well as whole-hand and fingertip use. The researchers examined at escalation factors such as expanding the number of repetitions within a block, increasing item size and weight, and raising the height and distance upon which objects were moved, as well as 1-to-2-minute rest periods as needed to avoid fatigue. The only difference between the two groups (study and control) was that trunk motions were restrained by way of body and shoulder straps tied towards the chair back in trunk restraints (TR).

Evaluation
Primary outcomes

For both the research and control groups, the assessment was done after six weeks of training to determine the mean values of elbow extension (ROM). The researchers filled out the pre-listed instruments on the participants throughout the assessment and evaluation stages, and the two groups utilized them throughout the study phases.

Clinical motor functional efficiency

Fugl-Meyer Motor Evaluation Upper limb reflex activity, extensor synergy motion, flexor synergy motion, activities followed by disengaging movement, normal reflex action, synergy motion, and stability of carpal joints are among the functional groups assessed. The FMA exam consisted of 33 questions on diverse motions, reflexes, and coordination (divided into nine categories). Each was assigned a rating from 0 to 2 (for a total score of 66), with 0 indicating that they couldn't perform, 1 indicating that they can still partly perform, and 2 indicating that they might completely execute. The FMA is a valid and accurate assessment of the efficacy of recovering upper - limb activity in stroke patients, and it focuses on the Body Function/Body Structure domain of the International Classification of Functioning, Disability, and Health framework (ICF B7, Musculoskeletal and Movement Related Functions) (ICF).

Action research arm test

The assessment comprises broad anatomical motions as well as grabbing, gripping, pinching, and clutching. The scoring range for each ordinal scale is 0 to 3. Each object's movement quality was assessed on 4-point scale, ranging from the no movement (0) to moderate movement (1), considerable movement (2), and entirely normal movement (3). With one hand on the table, the patient was instructed to perform mobility exercises. The ARAT is a supplement to the FMA that primarily includes ICF activity components.

Data Analysis

SPSS version 25.0 was used to analyze the research data. Descriptive statistics are used to analyze nominal data such as participant demographics and clinical features. T-test was applied to establish statistical implication and relationships. $P \leq 0.05$ was used as the significance threshold.

Results

Table 1 presents a total of 62 sick people (31 in each group) with mean ages of 44.9 ± 5.98 in control and 50.2 ± 5.15 years in experimental group, men were more prominent in the experimental group (55 percent) and females were more prevalent in the control group (52.5 percent), and most of both groups were married (72.5 percent and 77.5 percent, respectively). In terms of educational attainment, illiteracy was found 77.5 percent in experimental group and 80 percent in control group. In the study group, the mean period from start was 8±1.5 months, whereas in the control group, it was 7.7± 1.3 months.

Table 1
llustrates the demographic features of groups under investigation (N=62).

Characteristics		Control Group (n=31)	Experimental Group (n=31)
Number of Participants	Male	24(14%)	18(11.16%)
	Female	7 (4.39%)	13 (8.5%)
Age	Male	44.68 ± 6.25	50.13 ± 5.83
	Female	45.09 ± 5.39	50.44 ± 4.21
Education	Illiterate	3 (1.86%)	6(3.72%)
	Primary	7 (4.39%)	4 (2.48%)
	Higher secondary	11 (6.82%)	16 (9.92%)
	Graduate	8(4.96%)	4 (2.48%)
	Postgraduate	2 (1.24%)	1 (0.62%)
Marital Status	Married	28 (17.36%)	23 (14.26%)
	Widow	2(1.24%)	7 (4.39%)
	Unmarried	1 (0.62%)	1 (0.62%)

Table 2 shows the pre- and post-test comparison of ROM, FMA and ARAT in between the control and the experimental group (mean ± S.D).

Table 2
Pre- and post-test comparison of rehabilitation in both groups

Groups		Pre-test	Post-test	*P*
ROM	Control	50.41 ± 1.65	51.13 ± 1.27	0.036
	Experimental	49.43 ± 2.23	56.56 ± 1.99	0.000
FMA	Control	31.08 ± 2.28	32.05 ± 2.45	0.000
	Experimental	31.18 ± 2.18	51.10 ± 3.76	0.000
ARAT	Control	30.25 ± 1.91	31.11 ± 2.07	0.000
	Experimental	29.66 ± 2.37	34.43 ± 2.10	0.000

The data indicated that in ROM, statistically a highly significant difference have been observed in control as well as in the experimental groups ($P \leq 0.05$). Similarly, FMA and ARAT also showed statistically a highly substantial variation among the control and experimental group ($P \leq 0.05$).

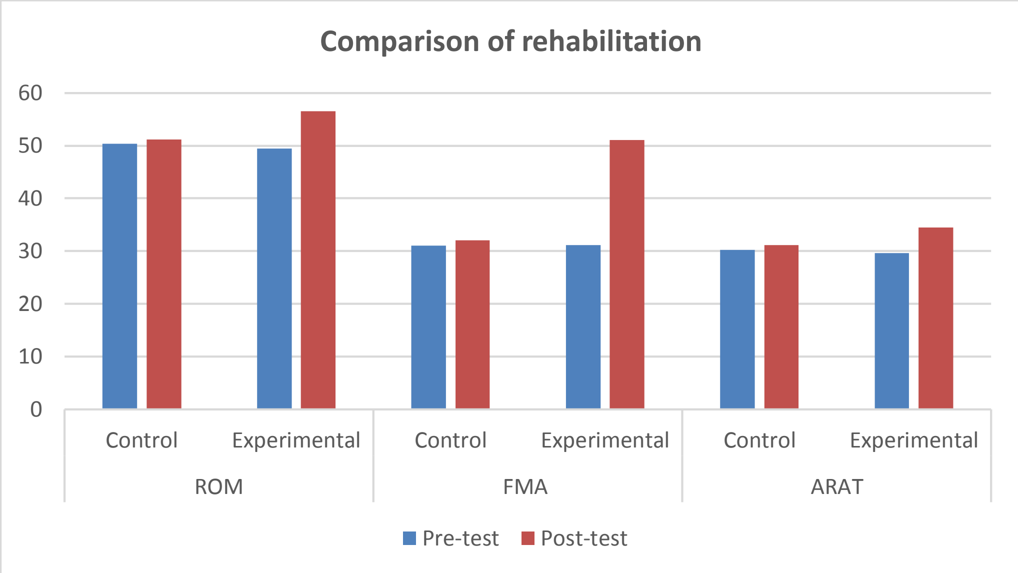

Figure 2. Pre- and post-test comparison of ROM, FMA and ARAT. An increase in the post-test can be observed when compared to the pre-test in the experimental groups. In control groups, minor increase can be observed.

Analysis of grasp motor activities

No differences between the groups were there at the beginning. The mean pre-grasp of the participants in control group was 5.78 ± 3.13, while after one month it was 5.89 ± 3.41, and after two months the mean grasp was 6.2 ± 2.84. The mean pre-grasp of participants in the experimental group was 5.17 ± 2.98, whereas after one month it was 5.77 ± 2.62, and after two months it was 6.56 ± 3.07.

Analysis of pinch motor activities

The pre-pinch mean for the control group was 1.45 ± 1.36, after a month it was 1.76 ± 1.87, and after two months was 2.54 ± 2.15.
The pre-pinch mean for the experimental group was 1.56 ± 1.35, after one-month was 2.79 ± 1.39, and the two-month it was 5.51 ± 1.95.

Discussion

Stroke is still a severely debilitating condition, despite the adoption of a variety of rehabilitation therapies. Researchers are continuing to investigate new ways to improve UL function throughout the acute phase of a stroke when movement is impossible, which incorporate the tenets of motor learning (i.e., practise specificity, intensive repetitive task practise, and feedback) and neuro plasticity (due to motivation, repetition, reward, and increasing movement complexity). [25]

It is hypothesised that in acute stroke the recovery of motor function affected role is the time-sequential method, and that assessing a patient's sense, motor, motion amplitude, balance coordination, and joint function by utilizing FMA at various time interval allows for time-dependent assessment of the patient's recovery. [26] Because of its excellent reliability and validity, FMA is extensively employed as in evaluation of arm functions in the patients who have had an acute stroke.FMA is frequently used in tandem with the ARAT, which estimates the capability to cope with small items as well as upper-extremity gross motor skills. [27] The ARAT is a specialised test for determining upper limb malfunctioning. AMP may successfully forecast the outcome of those who have had an acute stroke.[28] A high ranking amplitude in AMP after an acute stroke is a reliable indicator of advanced motor rehabilitation and effective outcome. [29] Furthermore, improved corticospinal tract conduction is linked to motor recovery, and a shorter CMCT suggests prevalent motor recovery. [30] As a result, ARAT, FMA, RMT, AMP, and CMCT were utilised in this research to evaluate therapy efficacy after HABIT and CRP with the goal of discovering a better method.

In research by Levin and colleagues [31], it was shown that in patients with hemi paresis, trunk movement displacement occurred sooner and was larger than in healthy persons. The current investigation found that the BRT group had fewer torso engagements just at start of achieving than that of the URT group following training. Both BRT and URT reduced corrective torso progression, even though evidenced by higher qualities of slope at the midline of achieving after intervention, and descriptive analysis indicated that BRT and URT both reduced compensatory trunk movement, as evidenced by higher values of the slope at the midline of achieving after intervention.

Kim et al. found no significant changes among the RT group compared to control on physical or mental health component of the SF 36 at the end of the intervention in a small study of 20 stroke patients. [32]. The study by Saunders et al. sought to see whether fitness training after a stroke reduced mortality, dependency, and impairment. They discovered that resistance training was good for stroke patients in terms of improving muscular strength, quality of life, and daily activity performance. [33]

Conclusion

The dispatch, detection, delivery, and door stages of the stroke chain of survival may all be improved with repeated community awareness programs and collaboration with local physicians. The findings of the study show that restraint high standardized treatment might be used to improve upper extremity motor limit as well as tasks of everyday life in stroke patients. The data indicated a significant improvement in the experimental groups of ROM, FMA and ARAT ($P \leq 0.05^*$) as equated to the control group. In the grasp motor activities, the data showed an improvement in the experimental group (B) from 5.17 ± 2.98 to 6.56 ± 3.07 as compared to the control group (A) (from 5.78 ± 3.13 to 6.2 ± 2.84).The data also indicated an improvement in pinch motor activities in the experimental group (from 1.56 ± 1.35 to 5.51 ± 1.95) as compared to the control group. The data imply that the BHT may be a good option in enhancing motor control and motor performance of the damaged UE in stroke patients.

Recommendations

As per the current study, more investigations with larger sample size and long-term follow-up must be undertaken at a range of health institutions in India.

Ethical approval
Ethical Approval done by Ethical Committee of Nims University Rajasthan, Jaipur (India).

Conflict of interest
The authors confirm that they have no conflicts of interest and no funding to declare.

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