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Comprative study of transcranial direct current stimulation (tDCS) and conventional physiotherapy for motor recovery of upper extremity in ischemic stroke patients

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Abstract
Background: Stroke is the second leading cause of death and a substantial cause of disability worldwide... Restoration of upper extremity motor function are therefore highly relevant for people who are unable to do their ADL activities after stroke.
Objectives: To compare effect of tDCS along with physiotherapy on motor recovery of upper extremity in stroke patients.
Methods: The present study involved total of 80 ischemic stroke survivors which were randomly divided in two groups, each group consisting of 40 subjects. The subjects of group a received 12 sessions of anodal tDCS (2 mA) along with conventional physiotherapy. The subjects of group B received 12 sessions of sham tDCS along with conventional physiotherapy. The outcomes before and after 6 weeks of the therapy were measured by Jensen Taylor hand function test, NIHSS scale, modified ranking scale, Fugl-Meyer assessment-UE motor, and modified Barthel index.
Results: No statistically significant difference between the groups at baseline in the all variables JTHFT, FMA-UE and mBI. After the intervention, time taken to complete each task by the participants of the sham group (Group B) was higher as compared to the tDCS group (Group A) however significant differences were found in turning over the cards (p 0.001), feeding (p 0.001), stacking objects (p 0.031), and picking up large light objects (p 0.001).
Statistically significant difference in score between the two groups was also statistically different (p 0.050). After the interventional therapy, the mean FMA-UE score improved than that of the baseline values. The mean score of group A was found to be 38.91 with the standard deviation of 20.31, whereas group B had mean score of 33.42 with standard deviation of 19.88. the difference between theses scores of the two groups was not found to be statistically significant (p 0.393).
Conclusion: In this study we come to end that the use of tDCS along with physiotherapy may improve the upper limb motor functions. This technique has clinical potential for use in stroke recovery as it is easy to use, non-invasive, and safe. It also provides the importance in controlled clinical trials can be combined with other stroke recovery stimulation techniques. tDCS with physiotherapy was found more efficacious.

Keywords: stroke, tDCS, motor recovery, hand function

Introduction

Stroke is the second leading cause of death and a substantial cause of disability worldwide. As compared to the developed nations, stroke is more prevalent in developing countries, with ischemic stroke being the most common of all.

A stroke happens when a blood vessel in the brain bursts and bleeds or when the blood supply to the brain is cut off. Blood and oxygen cannot reach the brain's tissues because of the rupture or obstruction. Stroke is a primary cause of death in many developing and developed countries. Brain tissue and cells are damaged and start to die within minutes of being oxygen-deprived. The term "stroke" describes a group of illnesses brought on by the blockage or bleeding from blood arteries that supply the brain. Diabetes, atherosclerosis, high blood pressure, excessive homocysteine levels, and hereditary factors are all risk factors. Blood flow deficits, low ATP levels, low energy storage, ionic disturbance, and metabolic failure are most severe in the centre of the damaged brain region, and cell death advances within minutes. Cells in the ischemic penumbra, which surrounds the anoxic core, can be saved by quick therapy because it experiences less severe injuries (Lo E H *et al*., 2003).

Strokes often come in three different forms

- A blood clot is involved in a transient ischemic attack (TIA), which normally reverses on its own.
- An arterial obstruction brought on by a clot or plaque is what causes an ischemic stroke. The signs and problems of an ischemic stroke may persist permanently or linger longer than those of a TIA.
- A blood vessel that bursts or leaks into the brain is what causes a haemorrhagic stroke.

Damage to brain tissues results from reduced blood supply to the brain. The bodily functions regulated by the brain injury exhibit stroke symptoms. The better the prognosis for someone experiencing a stroke, the earlier they receive treatment. Because of this, being aware of the symptoms of a stroke will help you take prompt action. Some signs of a stroke include

- Paralysis
- Difficulty speaking or comprehending others slurred speech numbness or weakness in the arm, face, or leg, especially on one side of the body
- Lack of clarity, disorientation, or responsiveness
- Abrupt behavioural alterations, particularly increased agitation
- visual issues, such as double vision or difficulty seeing with one or both eyes that are blurry or blacked out

- Difficulty in walking, loss of coordination or both
- Dizziness
- Convulsions with a terrible, abrupt headache and no obvious reason
- Vomiting or Nausea

Seeking emergency medical assistance when the symptoms of a stroke is experienced because it is best to be extra careful while dealing with a stroke. Early intervention is essential to avoiding the following consequences:
- Long-term incapacity
- Brain injury
- Death

Stroke has a significant socioeconomic influence on society worldwide. In terms of media attention, patient and caregiver understanding, service advancements, and research, stroke is assuming an increasing influence. Over 9 million stroke survivors make up the 4.5 million stroke fatalities that occur annually in the world. If they live to be 85 years old, roughly one in four males and nearly one in five women that age can anticipate having a stroke. Stroke occurs from 2 to 25 times per thousand people nationwide. Over a five-year period, there is a 15-40% chance of recurrence. When compared to 1983, it is predicted that by 2023, there would be a 30 percent absolute increase in the number of people having their first stroke. The overall prevalence rate is about 5 per 1,000 people. Stroke is the leading cause of adult disability, with 65% of survivors functionally independent one year after a stroke (Wolfe C. D., 2000).
The use of tDCS has gained particular interest in stroke research as both short term and long- term effects of tDCS improve the functional outcomes. As tDCS improves interhemispheric inhibition by modifying the local cortical excitability, it has also shown to improve regional cerebral blood flow, which is beneficial by reducing the inflammation and protecting neurons in the ischemic regions. These effects of tDCS last throughout the stimulation period.
Ischemic stroke is the major type of stroke that is experienced by the people which is of above 80%.
It is treated through physical exercises and rehabilitation techniques but it takes more time for recovery. Since life after stroke happens only through the recovery from the disease.
Through Transcranial direct current simulation (tDCS) Ischemic stroke can be treated easily.
All participants performed Jensen - Taylor hand function test, movement function scale
(NIHSS), modified ranking scale, Fugl Meyer Assessment - UE motor (FMA –UE) and
Modified Barthel Index before and after 6 weeks of tDCS sessions.

Importance of proposed research
Proposed Research
The main importance of the proposed research is to provide the Ischemic stroke patients with low-cost treatment.
In stroke patients, upper extremity motor recovery is speeded up using the proposed research method.
The proposed research has the main motto to prove that the novel method of treatment is better than the conventional physiotherapy comparatively.
tDCS is the painless, non-invasive brain simulation treatment which uses the direct current for simulating the various parts of the brain.

Aim of the proposed study
The aim of the proposed research study is to provide low-cost treatment for the recovery of stroke patients by comparing the statistical analysis of tDCS treatment and conventional physiotherapy for the recovery of Ischemic stroke.

Objectives
The first objective of the research provides Transcranial Direct current simulation through painless anode treatment by passing the constant current between the two electrodes attached to the head.
The Second objective of the study is comparison of tDCS treatment with conventional physiotherapy for the treatment of Ischemic stroke using various test methods.
The third objective of the study is dividing of two group of patients with control for Anode tDCS with conventional physiotherapy is compared with Sham tDCS with conventional physiotherapy.
The fourth objective is performing Jebsen Taylor Hand Function Test, NIHSS, Modified Ranking Scale, Fugl Meyer assessment – UE Motor and Modified Barthel Index test.
The fifth objective is analysis of both the methods statistically using SPSS.

Hypothesis
The hypothesis of the proposed study is to evaluate the efficacy of anode transcranial direct current stimulation for post-stroke motor rehabilitation of the upper limb.

Research question
1. Does there any effect of tDCS on post stroke motor impairments of the upper limb?
2. Is anode tDCS efficacious than conventional physiotherapy on post stroke motor recovery of the upper limb?

Null hypothesis
1. Absence of effect of tDCS on post stroke impairments of the upper limb?
2. Lack of efficacious of anode tDCS than conventional physiotherapy on post stroke motor recovery of upper limb.

Methodology
Place of the study
The present study was undertaken at the Department of Physiotherapy and Rehabilitation, MSS Hospital, Delhi, India. The tDCS and physiotherapy on recruited stroke patients were performed at the Department of Physiotherapy.

Ethical Approval
The study was approved by the Institutional Ethics Committee for Human Research and written informed consent was obtained from every study participant before their recruitment.

Study design and population
The study design included the type of single blind, simple randomized control trial. The study population included 80 participants having stroke and they were categorized into two groups. It was done using the random selection method with the help of list of random numbers generated by the computer. Sample size was calculated on exploratory basis.

Study arms
The study participants were randomly assigned into two groups for the research study for the comparison of conventional physiotherapy and tDCS treatment.

Group A
The first group of 40 participants was allowed for Anode tDCS along with conventional physiotherapy. Anodal tDCS was administered to subjects in this arm six times per week for two weeks (12 sessions), with each session lasting 20 minutes. Within an hour of each anode tDCS session, conventional physiotherapy was started which lasted for 45 minutes.

Group B
The second group of 40 participants was allowed for Sham tDCS along with conventional physiotherapy. The subjects in this arm received sham transcranial direct current stimulation (tDCS), six times per week for two weeks (12 sessions), with each session lasting 20 minutes. Within an hour of each anode tDCS session, conventional physiotherapy was started and lasted for 45 minutes.

Follow-up
The study participants in the both the groups were followed up to 6 weeks.

Eligibility criteria
The study participants were selected based on the following eligibility criteria.

Inclusion criteria
1. Ischemic stroke as diagnosed by CT/MRI
2. Both gender; age ≥ 18 years and < 75 years
3. Conscious and understandable
4. Subjects were able to provide informed consent or assent with surrogate consent.

Exclusion criteria
1. Men and women ages < 18 years and > 75 years
2. Severe disability (NIHSS scale > 20)
3. Other major diseases with life expectancy ≤ 3 months.
4. Any uncontrolled health condition for which exercise was contraindicated.
5. Any neurologic or orthopaedic diseases that might interfere with the study.
6. Metallic implant within the brain or hearing aid
7. Epilepsy
8. Cardiac pace maker
9. Cognitive impairments
10. Pregnancy

Anode tDCS Procedure
The tDCS was applied with a battery-powered constant current electrical stimulator (at an intensity of 2 mA using a pair of surface salt solution impregnated 35 cm^2 sponge electrodes (5 × 7 cm), 6 times a week for 2 weeks, for 20 minutes per session and with electric current of 2mA. In anode tCDS, the anode electrode was mounted on the upper left side temporal gyrus, while the cathode was placed above contralateral upper region (cp5). Current was passed through the brain and other tissues of the head, from the anode to the cathode electrode. In sham tDCS, the anode was placed over the left superior temporal gyrus and the cathode was placed on contralateral supraorbital area, but there was no current used. All patients received the same procedure for tDCS.

Experimental procedure
All participants performed Jensen - Taylor hand function test, movement function scale (NIHSS), modified ranking scale, Fugl Meyer Assessment -UE motor (FMA –UE)
And Modified Barthel Index before and after 6 weeks after tDCS sessions.

Measures of outcomes
Jebsen Taylor hand function test
The Jebsen-Taylor Hand Function Test (JTHFT) uses simulated activities of daily living to provide a standard and objective assessment of fine and gross motor hand function (ADL). Writing, simulating page turns, lifting small objects, simulating feeding, stacking, and lifting large, lightweight, and heavy objects are the JTHFT's seven subsets. JTHFT is easily applicable in clinical settings since it may be administered quickly with supplies that are already in stock.

Using method
Each of the JTHFT's subsets is timed and can be compared to the established norms to assess hand function. The JTHFT consists of seven subtests that measure fine motor, non-weighted, and weighted hand function in activities of daily living, including
1. Printing a sentence with a reading level of third grade and 24 letters.
2. Flipping cards (Simulated page turning).
3. Gathering little, everyday objects and putting them in a container, such as pennies, paper clips, and bottle caps.
4. Piling up checkers (test of eye-hand co-ordination)
5. Represented feeding
6. Transporting heavy empty cans
7. Transporting heavy [0.45 kilogram] cans.

The subtests were graded by keeping track of how long it took to finish each test.

Time taken
The time taken for performing this test was about 15-45 minutes.

Scoring
Each subtest's total duration, which was rounded to the nearest second, determined the final score. Better performance was shown by shorter times.

Procedure
Each participant provided a brief medical history as well as some basic demographic data. The exam was conducted using the JTHFT's established protocols with the subjects seated in front of an adjustable Table. The exam consists of seven sequential subtests, including writing, turning over 3-by-5-inch cards (simulating page turning), picking up tiny objects from daily life, simulating feeding, stacking checkers, picking up empty large cans, and picking up weighted large cans. The subtests were administered with the non-dominant hand first and the dominant hand last. In order to ensure test familiarity, spoken standardised instructions were delivered before each subtest was followed by a set of questions. Each test's completion was timed with the use of a stopwatch. The measurement outcome comprised the time (in seconds) needed to finish each subtest; the most time allowed for a subtest was 120 seconds. The overall score was then calculated using the total duration for each of the seven subtests. Lower scores indicated higher hand function levels.

NIHSS

The NIHSS is a 15-item impairment scale designed to assess the level of recovery and neurologic outcome for stroke patients. The scale measures extraocular movements, visual fields, facial muscle function, limb strength, sensory function, coordination (ataxia), language (aphasia), speech (dysarthria), and hemi-inattention in addition to a person's state of awareness (neglect). NIHSS was developed to examine differences in interventions in clinical trials, but it is being used more frequently in patient care as an initial assessment tool and to decide how to handle post-acute care. The elements of the NIHSS are based on three previously used measures: the Toronto Stroke Scale, the Ox bury Initial Severity Scale, and the Cincinnati Stroke Scale (Brott *et al.*, 1989).

Modified ranking scale (mRS)

The modified Rankin Measure (mRS) is a regularly used scale for assessing how dependent or disabled people who have experienced a stroke or other neurological disability are in their everyday activities. For clinical trials involving stroke, it has emerged as the most often utilised clinical outcome metric.

The range lies between 0-6, with 0 representing perfect health with no symptoms and 6 representing death.

0 - No symptoms.

1. No obvious impairment. Despite minor symptoms, able to perform all daily tasks.
2. Minor impairment. The patient is able to manage one's affairs on one's own without help, yet unable to perform all prior activities.
3. Moderate disability. The patient is able to walk without assistance, but needs some assistance.
4. Disability level is moderately severe. The patient is unable to walk without assistance and unable to care for one's own physical requirements.
5. A severe disability. The patient is bedridden and incontinent, and requires ongoing nursing care.
6. Dead.

The patients were examined and mRS score was recorded as per their condition and response

Modified Barthel index (mBI)

The 10-item modified Barthel Index is designed to gauge a patient's level of independence from any assistance, no matter how small or unimportant. The most popular scale for evaluating performance in daily living tasks (ADL) is the Barthel Index (BI). The BI is a ten-item ordinal scale with a score range of 0 to 20 that addresses mobility and self-care dimensions. Entire ADL reliance is indicated by a score of 0, whereas total independence is indicated by a score of 20.

Ten ADL and mobility-related characteristics were rated, with a higher score indicating a greater capacity for independence after hospital discharge. Each item's value was assigned based on the amount of time and physical support needed to complete it. The Barthel Index gauges how much help a person needs with 10 ADLs related to mobility and self-care.

Results

The present study involved total of 80 ischemic stroke survivors which were randomly divided in two groups, each group consisting of 40 subjects. The subjects of group A received 12 sessions of anodal tDCS (2 mA) along with conventional physiotherapy. The subjects of group B received 12 sessions of sham tDCS along with conventional physiotherapy. The outcomes before and after 6 weeks of the therapy were measured by Jebsen Taylor hand function test, NIHSS scale, modified ranking scale, Fugl-Meyer assessment-UE motor, and modified Barthel index.

Demographic characteristics

Group A consisted of 24 males and 16 females whereas group B had 21 males and 19 females
(Figure7.1). The gender wise distribution in both study groups was not significantly different. Group A ranged from 45 to 60 years with a mean age of 52.60 ± 5.03 years where as group B ranged from 44 to 60 years with a mean age of 51.30 ± 5.24 years (Figure 7.2). No statistically significant difference was found in age distribution of two groups (p 0.172), as shown in Table 7.1.

Table 1: Demographic characteristics of stroke patients

Demographic data (sex)	Group A (n=40)	Group B (n=40)	p Value
Male (n)	24 (60%)	21(52.5%)	0.499
Female (n)	16 (40%)	19 (47.5%)	
Age (year) (mean ± SD)	52.60± 5.03	51.30 ± 5.24	0.172

Group A: tDCS + conventional physiotherapy, Group B: sham tDCS + conventional physiotherapy, n=number of subjects, p=level of significance; p≤0.05 was considered statistically significant, p calculated by Student t test

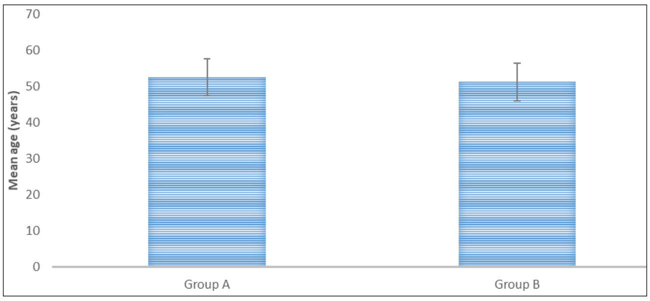

Fig 1: Distribution of males and females in study groups

Table 2: Duration and affected hand post stroke

	Group A (n=40)	Group B (n=40)	p Value
Post stroke duration	Mean ± SD	Mean ± SD	
Affected Hand	28.67 ± 9.42	30.51 ± 11.95	0.186
Dominant	34	35	
Non-dominant	6	5	0.745

Group A: tDCS + conventional physiotherapy, Group B: sham tDCS + conventional physiotherapy, n=number of subjects, p=level of significance; p<0.05 was considered statistically significant, p calculated by Student's t test

Group A subjects had mean duration of 28.67 months with standard deviation of 9.42 months, whereas subjects in group B had mean duration of 30.51 months with standard deviation of 11.95 months. The difference in the average duration post stroke in both the groups was not found to be significant. The majority of subjects in both the groups had their dominant hand affected in stroke, as shown in table.

Jebsen Taylor hand function test

All the subjects were analysed for UL function using JTHFT before and after the intervention. Table 4.3, and figure 4.3 show the performance of both the groups before the start of the therapy. The time taken in completion of all the seven parameters of JTHFT have been shown as mean ± standard deviation in the table along with the level of significance. The subjects of two groups did not show any significant time difference in any of the task performed before initiating the therapy.

Table 3: Outcomes of Jebsen Taylor Hand Function Test at baseline

Task	Time taken in completion in seconds (mean ± SD)		p Value
	Group -A(n=40)	Group-B (n=40)	
Writing	63.38 ± 18.42	64.09 ± 16.53	0.899
Turning over cards	28.50 ± 9.47	26.31 ± 12.86	0.543
Picking up small objects	30.86 ± 18.98	32.63 ± 15.21	0.747
Feeding	42.53 ± 13.54	41.91 ± 16.14	0.895
Stacking objects	56.06 ± 21.27	54.28 ± 22.94	0.801
Picking up large light objects	16.79 ± 5.21	18.67 ± 7.68	0.371
Picking up large heavy objects	18.53 ± 5.89	17.79 ± 4.50	0.658

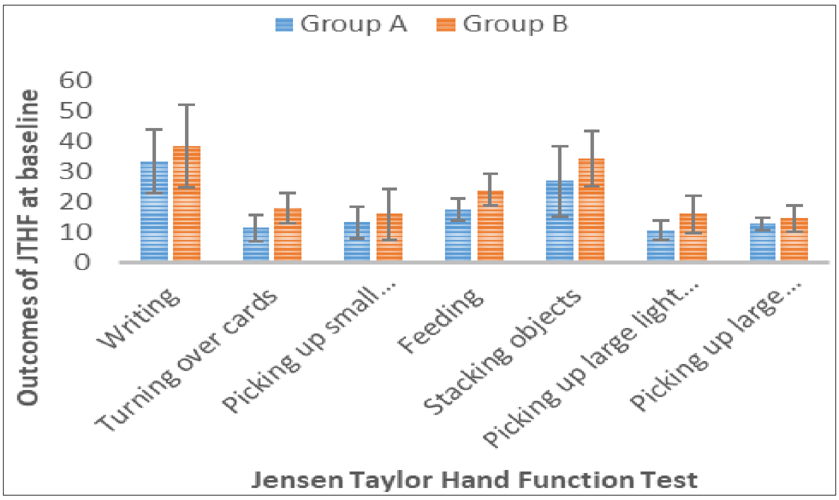

Fig 2

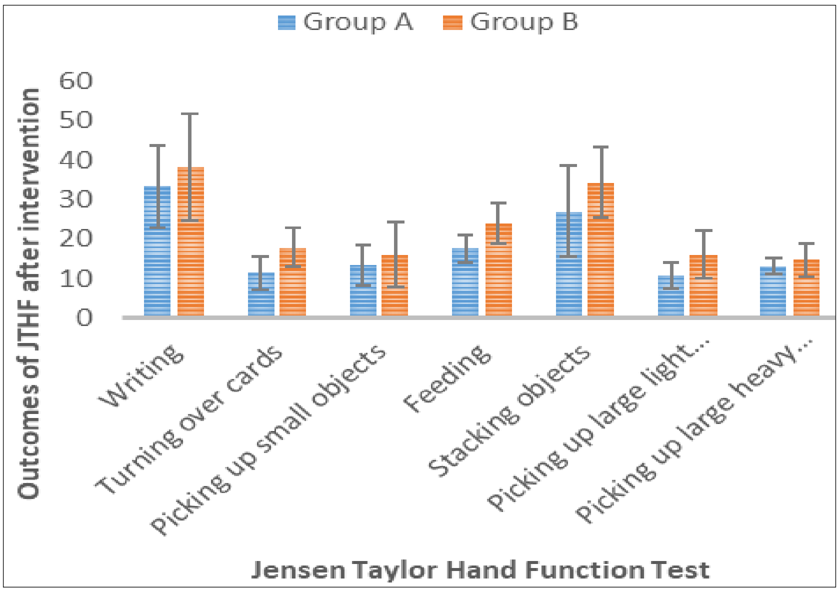

Fig 3

Table 4: Outcomes of Jebsen Taylor Hand Function Test after intervention

Task	Time taken in completion in seconds (mean ± SD)		p Value
	Group A(n=40)	Group B (n=40)	
Writing	33.28 ± 10.53	38.28 ± 13.61	0.202
Turning over cards	11.45 ± 4.21	17.84 ± 4.93	0.001
Picking up small objects	13.26 ± 5.08	15.99 ± 8.30	0.217
Feeding	17.53 ± 3.57	23.91 ± 5.22	0.001
Stacking objects	26.96 ± 11.52	34.28 ± 8.94	0.031
Picking up large light objects	10.69 ± 3.28	15.97 ± 6.03	0.001
Picking up large heavy objects	12.93 ± 2.02	14.71 ± 4.25	0.099

Group A: tDCS + conventional physiotherapy, Group B: sham tDCS + conventional physiotherapy, n=number of subjects, p=level of significance; $p<0.05$ was considered statistically significant, p calculated by paired t test

After the intervention, time taken to complete each task by the participants of the sham group (Group B) was higher as compared to the tDCS group (Group A) however significant differences were found in turning over the cards (p=0.001), feeding (p=0.001), stacking objects (p=0.031), and picking up large light objects (p=0.001), indicating the improvements in upper limb functioning through tDCS as depicted in table 7.4 and figure 7.4.
Above table, the average writing in Group A was 33.28±10.53 where as in Group B it was 38.28±13.61 and it was observed as statistically insignificant (p=0.202)

The National Institute of health-stroke Score
The NIHSS measures the stroke severity. The quantitative assessment by NIHSS at baseline and after 12 sessions of therapy for 2 weeks (after 6 weeks of intervention) has been depicted in table 4.5. the subjects of group A had median NIHSS score 10 with range of 5 to 19, and subjects of group B had median score of 11, range lying between 5 to 20.

Table 5: NIHSS score at baseline and intervention

	Group A (n=40)	Group B (n=40)	P value
NIHSS score	Median, range	Median, range	
Baseline	14 (9-19)	13 (8-18)	0.102
After 6 weeks	11 (5-17)	12 (7-17)	0.153

Group A: tDCS + conventional physiotherapy, Group B: sham tDCS + conventional physiotherapy, n=number of subjects, p=level of significance; p<0.05 was considered statistically significant, p calculated by ANOVA

After 6 weeks of intervention, the difference in median and range of two groups did not differ significantly (p=0.153). The median NIHSS score for group A was 11 with range of 5 to 17, whereas for group B, the median NIHSS score was 12 with range of 7 to 17, as presented in table 7.5. However significant difference in NIHSS score was found between pre and post intervention.

Modified ranking scale
At the baseline, the subjects of group A and B had an average of moderate disability where some assistance is needed to them to perform daily activities. Group A had a mean mRS score of 3.25 with standard deviation of 0.64. group B had a mean mRS score of 3.3 with standard deviation of 0.47. The difference in pre-interventional score was not found to be statistically significant (p 0.780), shown in table 7.6, and figure 7.5.

Table 6: Modified ranking scale before intervention

Variable	Group A(n=40)	Group B(n=40)	p Value
mRS (Baseline)	3.25 ± 0.64	3.3 ± 0.47	0.780

Group A: tDCS + conventional physiotherapy, Group B: sham tDCS + conventional physiotherapy, n=number of subjects, p=level of significance; p<0.05 was considered statistically significant, p calculated by Student’s t test

Table 7: Modified ranking scale after intervention

Variable	Group A (n=40)	Group B (n=40)	p Value
mRS (after 6 weeks)	2.60 ± 0.60	2.95 ± 0.51	0.050*

Group A: tDCS + conventional physiotherapy, Group B: sham tDCS + conventional physiotherapy, n=number of subjects, p=level of significance; p≤0.05 was considered statistically significant, p calculated by Student’s t test

After the intervention, the mRS score of both group A (tDCS) and group B (sham) reduced significantly, depicting the betterment of the subjects. The subjects of tDCS group had a mean mRS score of 2.60 with standard deviation of 0.60 whereas sham group subjects had mean mRS score of 2.95 with standard deviation of 0.51. the difference in score between the two groups was also statistically different (p 0.050) as shown in table 7.7, and figure 7.6

The modified Barthel index
The mBI of the study subjects at the baseline was found to be in the index of severe dependency (score 21 to 60). The subjects of tDCS group had mean mBI score of 38.43 with standard deviation of 17.81, whereas this score of sham group subjects was 39.75 ± 15.98. the difference between the groups was not significant (p=0.810), as presented in table 7.8 and figure 7.7.

Table 8: the modified Barthel Index before intervention

Variable	Group A(n=40)	Group B (n=40)	p Value
mBI(Baseline)	38.43 ± 17.81	39.75 ± 15.98	0.810

Group A: tDCS + conventional physiotherapy, Group B: sham tDCS + conventional physiotherapy, n=number of subjects, p=level of significance; p≤0.05 was considered statistically significant, p calculated by Student’s t test

Table 9: the modified Barthel Index after intervention

Variable	Group A (n=40)	Group B (n=40)	p Value
mBI (after 6 weeks)	55.49 ± 20.50	43.59 ± 24.60	0.105

Group A: tDCS + conventional physiotherapy, Group B: sham tDCS + conventional physiotherapy, n=number of subjects, p=level of significance; p<0.05 was considered statistically significant, p calculated by Student’s t test

After the intervention, the mBI score of both groups improved than that of baseline score, however it still lied under severe dependency index of the mBI. The difference was not statistically significant between the scores of group A and group B (p=0.105), as shown in table 7.9, and figure 7.8. The mean mBI score of group A was found to be 55.49 with the standard deviation of 20.50 and the same for group B was 43.59 with the standard deviation of 24.60.

Fugl-Meyer Assessment – UE Motor Test
The mean score of FMA-UE motor test of study subjects of group A was 27.89 with standard deviation of 18.53 out of 66. The group B had the mean score of 28.19 with standard deviation of 17.38. the difference between the score of two groups was not found to be significant (p=0.958), shown in table 7.10, and figure 7.9.

Table 10: Fugl Meyer Assessment Upper Extremity Motor test before intervention

Variable	Group A	Group B	p Value
FMA-UE (Baseline)	27.89 ± 18.53	28.19 ± 17.38	0.958

Group A: tDCS + conventional physiotherapy, Group B: sham tDCS + conventional physiotherapy, n=number of subjects, p=level of significance; p≤0.05 was considered statistically significant, p calculated by Student’s t test

After the interventional therapy, the mean FMA-UE score improved than that of the baseline values. The mean score of group A was found to be 38.91 with the standard deviation of 20.31, whereas group B had mean score of 33.42 with standard deviation of 19.88. the difference between theses scores of the two groups was not found to be statistically significant (p 0.393). The data has been resented in the table below (table 7.11, figure 7.10)

Table 11: Fugl Meyer Assessment Upper Extremity Motor test after intervention

Variable	Group A	Group B	p Value
FMA-UE (after 6 weeks)	38.91 ± 20.31	33.42 ± 19.88	0.393

Group A: tDCS + conventional physiotherapy, Group B: sham tDCS + conventional physiotherapy, n=number of subjects, p=level of significance; p≤0.05 was considered statistically significant, p calculated by Student's t test

Discussion

Stroke is the leading cause of disability in adults, and many affected people are left disabled and dependent on others for activities of daily living (Dobkin, 2005; Veerbeek *et al*., 2011) [6]. Strategies are needed to improve neuroplasticity and enhancing motor learning in such patients. One potential approach for the same is to use tDCS to enhance the effect of physical therapy (Fleming *et al*., 2017).

tDCS is a non-invasive brain stimulation technique that alter the cortical excitability and activity and it has been investigated as a treatment option for various neurological conditions (Pavlova *et al*., 2020). The effect of tDCS on stroke recovery, especially on motor function has been examined by many studies, and 10 to 30% improvement has been reported in forearm motor function in stroke patients. One possible way to enhance the effect of tDCS could be to intervene earlier after disease onset, as neuroplastic changes are more likely to occur in earlier phases of stroke recovery. However which phase to be considered for initiating this treatment is still uncertain (Tedesco Triccas *et al*., 2016).

Physical therapy can be regarded as a form of motor learning in which the modulated motor system is re-trained to optimise the functions of its remaining output. In this study, the effects of physical therapy along with and without (SHAM) anodal tDCS were examined for the rehabilitation of upper limb motor function in chronic stage (>6 months after stroke) of recovery post stroke. For rehabilitation after stroke, anodal tDCS of primary motor cortex on the lesioned side was employed. Anodal stimulation leads to increase in cortical excitability and activity. Direct current to the brain causes subthreshold polarity specific polarization of neuronal membrane, and after several minutes of stimulation, excitability changes last after the end of the session.

Experimentally, motor learning is commonly assessed as changes in motor preparation, speed and accuracy with the repetition of a movement. In this study the motor recovery after intervention was assessed by Jebsen Taylor Hand Function Test, Fugl Mayor Assessment -upper extremity, National Institute of Health Stroke Scale, Modified Ranking Scale, Modified Barthel Index.

The present study included 80 stroke subjects whose duration of stroke ranged from 19 to 41 months, their age ranged from 46 to 57 years as 95% of strokes occur in people aged 45 years or older. Older people have functional recovery at a lower capacity. It has been reported that there is 7% reduction in post-rehabilitation improvement in Barthel Index for every ten years after the age of 60. Age is one of the independent predictors for poor functional outcome after the stroke. Old age is usually linked with deterioration of elementary cognitive, sensory and sensorimotor functions which may further change the stereotypical structural and physiological response in the brain. These changes are also associated with falls especially in patients with neurological diseases.

Jebsen Taylor hand function test

The JTHFT, a performance based quantitative test, is based on the ability of patients to perform seven tests that are measured in time. Time taken in completion of tasks is used as a measure of dexterity and efficiency of movement (Davis Sears & Chung, 2010). Before the start of intervention, the time taken to complete the tasks of JTHFT performed by each subject of group A (tDCS + conventional physiotherapy) and group B (SHAMt DCS + conventional physiotherapy) was comparable, as no significant differences were found between the two groups in any of the task. But after the 12 sessions of the anode tDCS along with conventional physiotherapy, significant differences were observed in 4 tasks out of 7 tasks between the two groups. The subjects of group A took significantly lesser time in task completion (turning over the cards, feeding, stacking objects, and picking up large light objects) as compared to subjects of group B.

The writing activity was the most time consuming for all the patients. The speed of the writing may also be influenced by their educational level. The least time was taken for picking up large light objects suggesting the improvement in grasping ability. However, picking up the large heavy objects were significantly different between the two groups, which might suggest that the grip strength has not much improved after tDCS. The control of movements is the major factor involved in the accomplishment of tasks that require precise movements. Though not all the task had significant time difference between two groups, the time taken before the start of intervention was significantly lower after the interventional therapies.

The national institute of health- stroke scale

NIHSS is a widely used stroke scale with eleven levels for measuring the severity of motor disorders. In this study, the NIHSS score. The results were supported by many previous studies. Hosseinzadeh *et al* reported the significant improvement in NIHSS score in anodic tDCS group as compared to sham group (p<0.0001) even after 1 and 3 months of therapy (Hosseinzadeh *et al*., 2018). Similar findings were reported by Rossi *et al*, Lindenberg *et al*, and Yeung *et al*, where anodal tDCS showed convincing beneficial results in chronic stroke patients (Au-Yeung *et al*., 2014; Lindenberg *et al*., 2010; Rossi *et al*., 2013) [1]. These findings suggested that anodal tDCS application might lead to positive improvements in movement based on NIHSS score system.

Modified Rankin scale

The mRS is the most widely used primary outcome measure in stroke interventions. It is a good individual predictor for ischemic stroke patients following treatment as it evaluates the degree of independence and determines if the patient can perform self-care daily living activities. In this study, a statistically significant downward shift was seen in the distribution of mRS scores in tDCS group as compared to sham group. The differences in the score at baseline and after the intervention were also statistically significant. The findings were in agreement from previous literature in support of tDCS usage in stroke subjects which supported the evidence of improvement in daily living activities as per mRS in chronic stroke patient sifter DCS intervention (Elhabr *et al*., 2021; Sharma *et al*, 2020) [8].

Modified Barthel Index

The Barthel index is a commonly used outcome in post-stroke rehabilitation studies, as it adequately reflets the clinical practice. Though no significant differences were found in mBI score of tDCS and sham group post rehabilitation, but significant changes were observed when compared to their baseline score. This might be explained by the chronic duration of the stroke occurrence. There are studies that reported the significant difference in mBI between tDCS group and sham group post intervention ($p<0.01$). they showed the positive effects of tDCS application in acute and sub-acute stroke patients when assessed by mBI (Chow *et al*., 2022; Elsner *et al*., 2013; Joseph & Rhoda, 2013; Lee *et al*., 2014) [9, 3]. The significant difference was observed in overall scoring of the patients but it was limited to less improvement in one or another task. However, Fusco *et al* and Elsner *et al* reported no influence of tDCS on mBI score in chronic stroke patients (>12 months) (Elsner *et al*., 2014; Fusco, Iosa, *et al*., 2014). The improvement in the activities of daily living might be dependent on the duration of stroke event as it easier to recover in early phases of the insult.

Fugl-Meyer motor assessment- upper extremity

The upper extremity section of Fugl Meyer motor assessment is a reliable and valid test for assessing arm-hand function in stroke patient at the functional level. Though no significant difference was found between tDCS and sham group after the intervention, significant improvement was observed while comparing the FMA-UE scores at baseline. These findings were in support of many reported observations that tDCS was not superior to sham post-intervention (Bolognini *et al*., 2020; Edwards *et al*., 2019; Hesse *et al*., 2011; Triccas *et al*., 2015; Yao *et al*., 2020) [2, 7]. However, changes in mean scores from their baseline showed a positive effect of tDCS (Fusco, Assenza, *et al*., 2014; Pinto *et al*., 2021; Straudi *et al*., 2016).

Summary and conclusion

Stroke is the second leading cause of death and a substantial cause of disability worldwide. As compared to the developed nations, stroke is more prevalent in developing countries, with ischemic stroke being the most common of all.

The use of tDCS has gained particular interest in stroke research as both short term and long- term effects of tDCS improve the functional outcomes. As tDCS improves interhemispheric inhibition by modifying the local cortical excitability, it has also shown to improve regional cerebral blood flow, which is beneficial by reducing the inflammation and protecting neurons in the ischemic regions. These effects of tDCS last throughout the stimulation period.

Despite the fact that the sooner the rehabilitation is applied after the stroke, the better the functional outcomes, the available research is contradictory. Some researchers suggest tDCS as beneficial in stroke recovery whereas others find no significant effects. Thus, this study was aimed to measure the effects of tDCS along with physiotherapy and sham tDCS.

Transcranial Direct Current Stimulation (tDCS) employs direct electric currents to activate particular areas of the brain without being intrusive or painful. A continuous, low intensity electric current is supplied through two electrodes placed over the head to modulate brain activity by altering the neuronal membrane potentials based on the current polarity.

In this study we concluded that the use of tDCS along with conventional physiotherapy may improve the upper limb motor functions. This technique has clinical potential for use in stroke recovery as it is easy to use, non-invasive, and safe. It also provides the importance in controlled clinical trials by providing sham mode and can be combined with other stroke recovery stimulation techniques.

Significance of present work

Non-invasive, low cost tDCS found efficacious in improving upper extremity motor function.

Suggestions for further research

tDCS can be used for hemorrhagic stroke survivors for motor recovery of upper extremity with large sample size.

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