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Targetting Balance and Gait Rehabilitation with Multichannel Transcranial Direct Current Stimulation in a Sub-Acute Stroke Survivor-A Case Report

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Objective: Post stroke motor recovery is facilitated by the brain reorganization or the neuroplastic changes. The therapeutic approach mentioned in the current case is one of the approaches for enhancing motor recovery by stimulating the damaged neural networks directing the motor behaviour of a person. The aim of the present study was to establish the changes in the balance and gait pattern of an individual through multi target stimulation of areas of cerebral cortex by utilising multichannel trans cranial direct current stimulation (M-tDCS) in a sub-acute stroke survivor.

Design: A Case Report

Methods: The present patient was the participant of the trial (CTRI/2021/02/031044).The patient was intervened with M-tDCS (anodes over left primary motor cortex that is C3 point and left dorsolateral prefrontal cortex i.e., F3 point and cathodes over supraorbital areas, Intensity −1.2mA) for the duration of 20 minutes along with turbo med extern −an AFO to facilitate ankle dorsi flexion and conventional physiotherapy rehabilitation. The Fugl-Meyer assessment lower extremity (FMA-LE), Berg Balance Scale (BBS), Wisconsin Gait Scale (WGS) and the Stroke Specific Quality of Life (SSQOL) measures were used for outcome assessment. Baseline assessment was done on day 0 followed by assessment on 10 and 20 post intervention.

Results: Improvement was seen in all the tools i.e. (FMA -LE), BBS, SSQOL and WGS over the time period of 20 days.

Conclusions: M-tDCS resulted in improvement in gait parameters, balance and motor functions of lower extremity of the patient.

Key Words: Stroke, balance, Brain stimulation. Multichannel transcranial direct current stimulation

Introduction

Globally, one out of six people may experience stroke in their lifespan, about greater than 13.7 million suffer from stroke on a yearly basis, and 5.8 million people die in a year due to stroke [1]. Both high death rate and high morbidity of stroke make it as a universal burden. Stroke accounts for nearly 113 million disability-adjusted life years worldwide [2]. Thereby making it as the second major cause of mortality and the primary cause of disability around the world.

Damage of brain tissue at the lesion site along with surrounding areas leads to comprehensive dysfunction as the result of interruption of the structural and functional pathways in the brain. This leads to deregulation in excitability of motor cortex causing abnormal interhemispheric reactions [3].

The principal deficit attributable to stroke is motor impairment that is loss or limitation of muscle control function or limited mobility. Paresis is found in 80-90% of all patients after stroke. The other motor impairments affecting stroke survivors may manifest in the form of balance impairments and gait disturbances. Impaired balance is commonly seen after stroke. About 83% of people with stroke suffer from impairment in balance [4]. Sedentary lifestyle and increased disability

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would occur as a consequence of fear of falling, all of these factors negatively affect the quality of life of a stroke patient [5]. Apart from balance impairments, walking is also impaired in stroke survivors. About 80% of stroke survivors suffer from walking dysfunction [6] and 38% of stroke survivors are non ambulatory even 6 months after onset of stroke [7].

Despite of the existing rehabilitation strategies, majority of patients are left with significant physical, mental, and social impairments, which negatively affects the quality of life specifically in the aspects of mobility and activities of daily living [8]. Even 6 months after stroke, only 12% of the stroke survivors are able to attain complete motor recovery [9]. Partial functional recovery, dearth of effective neuro repair post stroke and limited functional independencepost stroke are the factors that leads to the search of novel alternative approaches that expand the scope for motor recovery post stroke [10].

A more targeted intervention approach that would target damaged neural circuits is required to ensure better functional recovery. Restoring the excitability in the ipsilesional hemisphere and /or rebalancing the abnormal interhemispheric reactions is thought to be one of the beneficial approaches for enhancing post stroke motor recovery [3]. Non-invasive brain stimulation (NIBS) is one of the techniques to alter and modify cortical excitability. NIBS has been used as alone or add-on rehabilitation tool for motor recovery in stroke survivors [11]. NIBS modifies neuronal synaptic plasticity in addition to accomplishment of motor skills post stimulation period. These modulatory effects enhance motor learning and also augment motor functions of paretic limb [12]. Stimulation of areas of cortex by utilisation of transcranial direct current stimulation is one of the advancements in management of stroke. Extensive literature is available on the utility of tDCS in motor recovery following stroke that had inferred promising outcomes [13,14,15]. According to the available research the use of tDCS has been helpful to restore the symmetry of two hemispheres and thereby modify the gait and balance of stroke population [16].

Areas of brain do not operate in isolation but are corelated. The effectiveness of stimulation might be constrained by restriction to stimulation of one or two cortical areas but not taking into consideration the complex networks engaged in corresponding functions [17]. This introduces the need for multi target stimulation areas of cerebral cortex by the use of multichannel transcranial direct current stimulation. Multichannel tDCS can be utilised to target appropriate cortical activations correlated to functional connectivity hubs to facilitate post stroke rehabilitation.

Ankle foot orthoses (AFO) are usually prescribed to control ankle motion in stroke survivors [18]. AFOs along with facilitating ankle control also provides mediolateral stability of ankle in stance phase. Besides facilitating gait in swing phase, AFOs aid in reducing energy expenditure during walking [19,20]. The conventional AFO being heavy in weight is not convenient to use for some patients and moreover is less cosmetically suitable. Turbomed Xtern is an AFO that fits outside the shoe, is easily transferable from one shoe to another. Thus Turbomed Xtern is an alternaive for people affected with foot drop and has several advantages over the conventional AFO [21].

Below is the case study of a subacute stroke survivor intervened with multichannel transcranial direct current stimulation (M-tDCS) together with Turbomed extern -an AFO and conventional physiotherapy program. Post treatment effects were notified.

METHODS

Patient information

A 27-year-old male (as a diagnosed case of sub-acute stroke) came to the neurorehabilitation unit with a history of hypertension and chief complaint of unable to walk independently and difficulty in executing activities of daily living. The patient had no previous history of cerebrovascular accident. The patient had no any relevant past medical history and not any alcohol, tobacco, or recreational drug use history. The patient experienced an episode of seizure along with urinary incontinence. The patient then lost his consciousness and was admitted in emergency with chief complaints of drowsiness, irritable condition with sudden loss of consciousness and seizure at home with history of urinary incontinence. CT scans of the patient depicted acute left basal ganglia haemorrhage with Intraventricular haemorrhage (IVH). Not any family history of preceding episodes of stroke is related with the participant. On examination GCS score was E4V3M5(12/15) along with right side hemiplegia.

Participant Selection Criteria

The present patient was the member of the trial (CTRI/2021/02/031044). A selection criterion was employed for the selection of participants. Inclusion criteria comprised participants of any gender with sub-acute stroke and with the age ranging between 20-75years, Spasticity grading on modified Ashworth scale score <2 for both upper or lower extremities, second stage of Brunnstrom stages of recovery, ambulatory individuals with MMSE score ≥23, and those desiring to take part in the study. The exclusion criteria comprised of individuals with cognitive deficit, with a history of neurological disorder except stroke, or any musculoskeletal injury/disease involving the LE, any recent surgery affecting lower limb movement, individuals with any metallic implant or history of systemic illness, individuals with history of any sensory deficit (Hyposensitivity or Hypersensitivity disorders, or unsupportive individuals [10].

Participant Consent and ethics

An information sheet was given to the patient to update him about aim, methods, interventions, any risks and/or expected benefits of the therapeutic approach followed. A written consent was taken preceding intervention. The patient was a part of the trial that has been registered with clinical trial registry of India (CTRI/2021/042/03104) and approved by Institutional ethics committee of Punjabi University (IRB No. 176/IEC-2020). The patient was guaranteed that his identity would be obscured.

Examination

A complete neurological assessment format was used for the initial screening of the participant. The screening included the complete history of the patient, assessment of higher mental functions, cranial nerve assessment, sensory assessment, reflex examination, motor examination and balance and gait evaluation with the aim to preclude any absolute contrain dications for any of the therapeutic interventions. The initial screening of the patient was conducted using the Mini Mental Status Examination (MMSE), Brunnstrom Stages (Lower Extremity), Edinberg Handedness Inventory and Modified Ashworth Scale (MAS) as screening tools.

Clinical Tools

Mini-mental status examination (MMSE) was employed for the cognitive screening of the patient that depicted the orientation of the patient to place, person and time. The MMSE score of the patient was 24. Right was dominant hand. The patient presented with +1 grade of spasticity for the right LE, measured on the Modified Ashworth scale. Reflex examination discovered exaggerated responses at knee and also presented with sensory deficits with reduced sensation of light touch and joint positionas measured by FMA-LE. Mild right facial droop along with difficulty in speech was observed.

Intervention

Objective Assessment

Pre intervention readings were noted by baseline assessment performed on day 0. The Fugl-Meyer assessment scale for the lower extremity FMA (LE) was used. The FMA is a performance-based impairment index that assess balance, joint functioning and sensation in the post stroke individuals. FMA has excellent construct validity along with intrarater and interrater reliability [22].

Berg Balance Scale (BBS), a 14-item scale intended to examine balance and risk of falls in adults has an excellent inter and intra rater along with test-retest reliability and it is a reliable outcome measure to evaluate balance and functional mobility in individuals with stroke [23].

The Wisconsin Gait Scale (WGS) is efficient tool utilised to make observational gait analysis more reliable. WGS has high test-retest reliability and also presents with high internal consistency. WGS has been found to have high interrater reliability [24].

Stroke Specific Quality of Life (SSQOL) constitutes the reliable tool that assesses health relatedquality of life particularly in post stroke individuals. SSQOL is a standardized, validated and reliable (reliability coefficient

0.92) scale that precisely evaluates the quality of life of post stroke individuals [25].

M-tDCS

The patient was treated using M-tDCS (anode over C3 and F3 and cathode over supraorbital areas, Intensity −1.2mA for a period of 20 minutes [26,27]. 10-20 electroencephalography international classification system was used to select points of stimulation [10]. The treatment was given for 5 sessions per week for 20 days. Conventional Physiotherapy treatment protocol for rehabilitation included balance rehabilitation, gait training, body weight supported treadmill training with turbomed extern, active and passive range of motion exercises. Along with application of M-tDCS, patient went for 10 minutes of body weight supported treadmill training besides wearing turbomed xtern. Following which patient underwent 10 minutes of balance training that included static balance training in both sitting and standing postures along with swiss ball training, trunk control exercises and stepping activities [28,29]. Beginning with static balance training with assistance, progression was made to unsupported sitting and standing and dynamic balance training.

Data analysis

To quantify the changes seen in the patient, Mid and post-intervention evaluation was done for all the outcome measures at day 10 and day 20 respectively. The BBS scores showed a significant clinical change with score of 07 at day 0 to 36 at day 20 (Figure 3) depicting improvement in the aspects of sitting to standing, unsupported sitting, standing, transfers and picking objects from floor. The changes in the readings of FMA-LE depicted improved motor functions. FMA-LE scores increased from 42 to 62 manifested as improved volitional movements at hip, knee and ankle in supine, sitting as well as standing position with reduced joint pain and improved sensation of position (Figure 4). Reduction in WGS scores measuring 35 at day 0 to 25 at day 20 (Figure 2) demonstrated the recovering gait parameters illustrating reduced use of hand held gait aid, improved stance time, weight shift, knee flexion and initial foot contact on the affected side Improvement was also observed in ovreral quality of life of the patient. Improvement in SSQOL scores from 76 to 125 within the span of 20 days manifested as improved energy, mobility, language, social domains in the patient (Figure 5). As stated by patient and family members they found better participation of the patient in social activities accompanied by reduced dependence for his tasks of daily living (Table 1).

Pre and Post test readings of Fugl Meyer Assessment Lower Extremity (FMA: LE), Berg balance Scale, Wisconsin Gait Scale, Stroke Specific Quality of life scale are described in Table 1.

Changes observed with the help of outcome measure, results were obtained on Day 0 and Day 10 and 20.

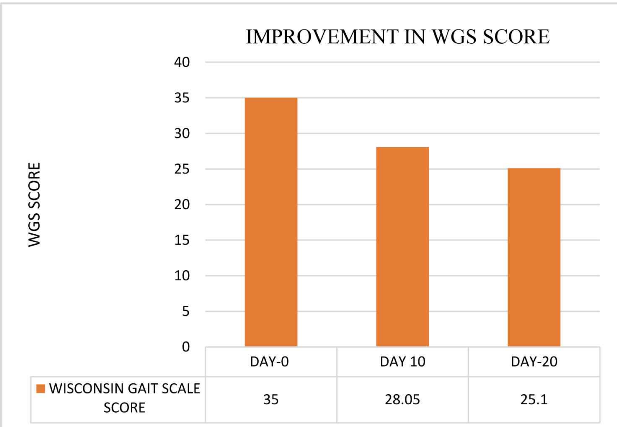

Figure 1. Improvement seen in WGS score

Table 1. Pre and Post Test scores for the outcome measures

S No.	Assessment Tool	Total Score	Pre-Test (Day-0)	Post-Test 1 (Day-10)	Post-Test 2 (Day-20)
1.	FMA: LE	86	42	43	62
2.	BERG BALANCE SCALE	56	07	23	36
3.	WISCONSIN GAIT SCALE	42	35	28.05	25.10
4.	STROKE SPECIFIC QUALITY OF LIFE SCALE	245	76	103	125

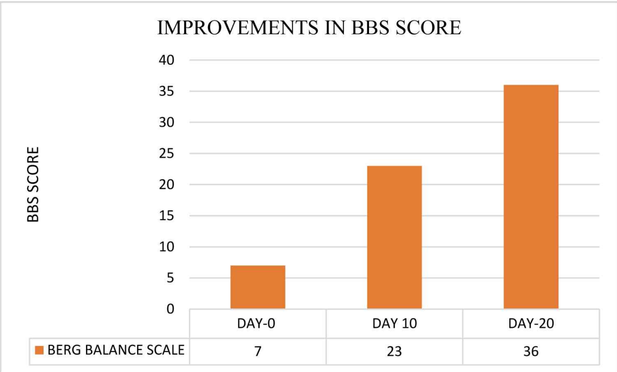

Figure 2. Improvement observed in BBS score

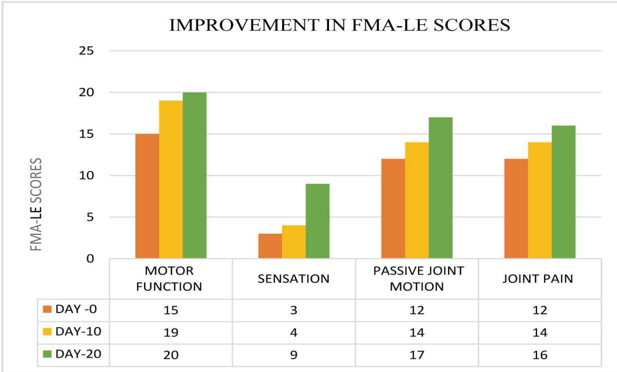

Figure 3. Improvement in FMA-LE score

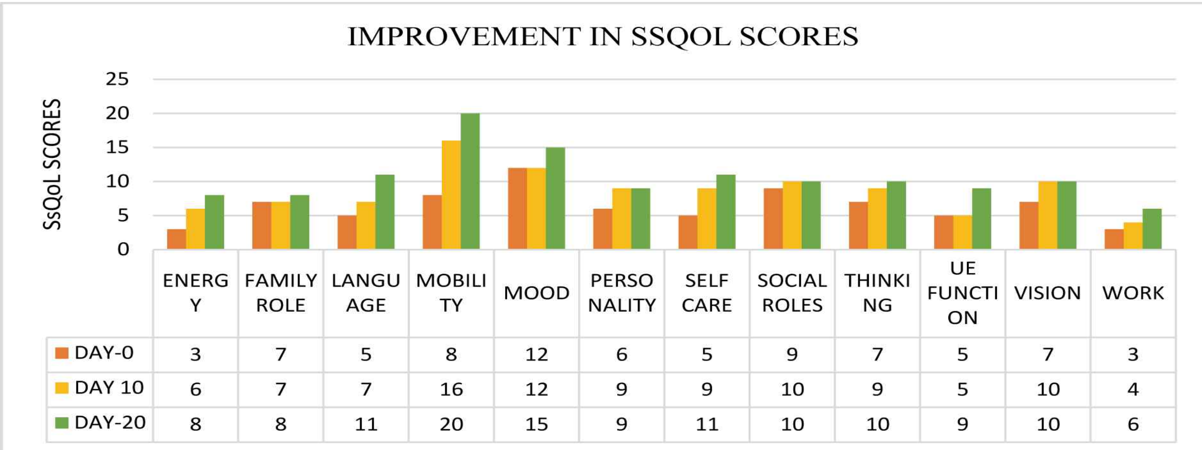

Figure 4. Improvement in SSQOL score

Improvement was seen in the score of all outcome measure which is explained in Table 1.

Discussion

Transcranial direct current stimulation (tDCS) is one of the methods of NIBS that consists of application of constant weak electric currents on patients scalp with the aim of stimulating specific brain areas. Numerous clinical experiments evaluating the utility of tDCS in motor recovery in stroke survivors have depicted with promising results. Studies have been conducted to evaluate the role of tDCS on balance and gait in stroke survivors [30,31]. But the current work is distinct in its application of the M-tDCS accompanied by Turbomed extern and conventional physiotherapeutic treatment for the time span of 20 days determining their effect on balance and gait in a subacute stroke survivor.

Targeting an isolated cortical region may not yield longer lasting improvements as stroke represents a heterogenous disease with respect to extent and site of lesion and cerebral cortex is a hub of neural connections. Not taking into consideration, that various functional networks in brain are involved in respective functions rather than a single isolated area is one of the main factors that limits the effectiveness of current stimulation protocols. So, there is a need to target several functionally correlated cortical hubs involved [17]. This introduces the need for multi target stimulation of areas of cerebral cortex by utilising multichannel transcranial direct current stimulation.

tDCS acts as neuromodulatory intervention involving the application of direct current that alters cortical excitability and activity. The physiological changes induced by tDCS leads to the plastic changes in brain [32]. Altered cortical excitability as a result of polarisation of neuronal membranes is the primary effect of tDCS.

Synaptic plasticity involves Long Term Potentiation (LTP) and Long Term Depression (LDP). Stimulation for adequate period of time is the prerequisite to modify the cortical function beyond the stimulation period. This results in lasting or after effects of tDCS that are characterized by strengthening of synaptic connections (LTP like effects) and weakening of synaptic connections (LDP like effects). Thus stimulation by tDCS results in LTP and LTD like after effects that persist beyond stimulation period and alters cortical excitability [33]. Thus, M-tDCS has an immediate as well as long term effects.

The principal that there exists a powerful interconnection amongst motor learning and cognitive functions involving planning, attention, working memory and executive control has been employed in the present study for stimulating the multiple cortical areas thereby influencing the related neural circuits. Primary motor cortex (M1) is one of the primary brain areas required in motor function along with planing and execution of movements. Thus M1 serves as a common target for facilitating post stroke motor function. The DLPFC is another area that plays significant role in working memory and may serve as a crucial element of the motor learning network [3]. Thus, the present study involved the application of M-tDCS over the left Primary Motor Cortex (PMC) and L-Dorso Lateral Pre-Frontal Cortex (L-DLPFC) (C3 and F3 position as per International 10/20 EEG classification).

The results of the present case study have been found corresponding to a clinical experiment conducted on individuals suffering from Parkinson Disease. This experiment involved the patients diagnosed with Parkinson were treated using multichannel transcranial direct current stimulation over the areas primary motor cortex and left dorsolateral prefrontal cortex. The study revealed improved gait and mobility of patients with decrease of freezing episodes of gait with improved gait speed [27].

A thorough search of relevant literature revealed that there is lack of literature depicting clinical efficacy of multichannel tDCS in stroke survivors. So, this case study can serve as significant support as it would pave the way for discovering further evidences emphasising the utility of multichannel tDCS in post stroke rehabilitation. This case study postulated as the evidence for clinical utility M-tDCS in post stroke individuals but a trial with higher no. of participants shall be needed to strengthen this study and improve the quality of evidence. Therefore, a randomized controlled trial with a greater number of participants can augment in firmly establishing the results.

Limitations

As present functional recovery results were obtained from a single patient so generalisation of the findings of this study is not possible. Moreover, a comparison lacks to determine the effectiveness of M-tDCS. However, the combined approach of M-tDCS has offered the additional benefit with reference to the improvement in lower limb motor functions along with balance and gait parameters of the sub-acute stroke survivor. But there is a need of trials with huge sample size to determine the efficacy of M-tDCS in post stroke individuals.

To come to the conclusion, M-tDCS led to improvements in balance, gait parameters and motor functions of the lower limb of patient.

CONCLUSION

In the present case study score of FMA, Berg balance Scale, Wisconsin Gait Scale, Stroke Specific Quality of life scale improved. This case study of a single participant gave us the evidence that multichannel tDCS can be used concomitantly with the conventional treatment protocol but there is strong need of larger trial to establish the quality evidence.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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