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Case Report

Physiotherapy Section

# Effect of Functional Electrical Stimulation combined with Treadmill Training and Challenging Tasks in a Patient with Stroke: A Case Report

DEEPANSHI SRIVASTAVA[1], AVI CHOUDHARY[2], JAISHREE[3], HIMANI KAUSHIK[4], ARUSHI VERMA[5]



## ABSTRACT

Stroke is one of the leading causes of death globally. Advancements in medical science and technology have contributed to a reduction in the mortality rate among individuals who have experienced a stroke. The present study presents findings from a single case report employing a single-subject research design. To achieve optimal rehabilitation outcomes, Functional Electrical Stimulation (FES) was incorporated with Treadmill Training (TT), accompanied by challenging tasks during physiotherapy. Hereby, the authors present a case report of a 66-year-old male post-stroke patient with left-sided weakness, impaired grip strength, and mobility issues following a right Middle Cerebral Artery (MCA) ischaemic stroke. His medical history includes type 2 diabetes mellitus and systemic hypertension, with no significant family medical history reported. The patient presented with notable motor deficits and functional limitations resulting from the right MCA ischaemic stroke. Interventions targeting spasticity reduction, muscle strengthening, endurance, and gait retraining were essential to improve the patient's functional mobility and overall quality of life. The findings revealed significant improvement in various outcome measures, including the Modified Ashworth Scale (MAS), Voluntary Motor Control (VMC), Dynamic Gait Index (DGI), Berg Balance Scale (BBS), and Functional Independence Measure (FIM), indicating positive changes and enhanced quality of life in stroke survivors. The cumulative effect of FES and TT with challenging tasks can significantly improve gait, muscle strength, and balance in patients recovering from stroke.

**Keywords:** Dynamic gait index, Extension synergy, Timed-up go test

## CASE REPORT

A 66-year-old male presented to the Physiotherapy Department with complaints of left-sided weakness affecting both the upper and lower extremities, difficulty in walking, impaired grip strength, and challenges in performing Activities of Daily Living (ADLs). The patient experienced an ischaemic stroke while using the restroom at home.

Patients medical history included type 2 diabetes mellitus and systemic hypertension, with no significant family medical history reported. During hospitalisation, the patient was administered subcutaneous anticoagulants, oral antiplatelet agents, statins, antihypertensives, and other neuro-supportive medications. After discharge, the patient was prescribed Tablet Tazloc 20 mg to be taken regularly.

Observation revealed flexion synergy in the upper extremity and extension synergy in the lower extremity. Gait analysis demonstrated a circumduction gait pattern. Magnetic Resonance Imaging (MRI) findings showed an acute infarct in the right posterior corona radiata, the posterior limb of the right internal capsule, and the posterior aspect of the right lentiform nucleus. Additionally, discrete Fluid Attenuated Inversion Recovery (FLAIR)/T2 hyperintensities without diffusion restriction were noted in the bilateral fronto-periventricular and deep white matter, indicating small ischaemic changes consistent with Fazekas Grade 1.

- Vital signs on examination were:
- Blood pressure: 124/79 mmHg
- Pulse rate: 80 bpm
- Respiratory rate: 15 breaths per minute
- Temperature: 37.3°C

Neuromuscular assessment: The patient's cognitive functions were normal; he was alert, oriented, attentive, and able to recall information. Calculation abilities and language function were also normal. Extension synergy was observed in the lower limb, with notable hyperextension of the knee joint, as per the observational examination method. The patient was unable to maintain knee flexion, exhibited weakness in the external rotators, and tightness in the plantar flexors. He was unable to evert or dorsiflex the foot.

Assessment of muscle tone using the Modified Ashworth Scale (MAS) [1] indicated mild spasticity on the left side, graded as 2. Positive Babinski sign [2] and exaggerated deep tendon reflexes (biceps, knee, and ankle jerks) were observed, along with associated reactions [3]. Muscle strength, measured using Voluntary Motor Control (VMC) [4], was graded as 4.

Functional assessment [4] scores were as follows:

- Berg Balance Scale (BBS): 45/56
- Dynamic Gait Index (DGI): 15/24
- Timed-up and Go Test (TUG): 23 seconds
- Functional Independence Measure (FIM): 77/126

The patient presented with a notable motor deficit and functional limitations following a right MCA ischaemic stroke. Interventions targeting spasticity reduction, strength improvement, endurance enhancement, and gait retraining were essential to improve the patient's functional mobility and quality of life.

The treatment protocol aimed to reduce spasticity, increase muscle strength, enhance functional independence, and improve gait performance.

The treatment protocol consisted of four weeks of therapy, conducted three days per week, for a total of 12 sessions. Each session lasted 30 minutes. The electrodes were placed on the tibialis anterior and gluteus medius muscles during task-oriented Treadmill Training (TT), as shown in [Table/Fig-1]. The parameters of Functional Electrical

Stimulation (FES) were progressively adjusted according to the patient's response—pulse frequency increased from 35 to 40 Hz, pulse duration from 300 to 450 microseconds, and intensity was set according to the patient's tolerance and the desired muscle response [5,6]. Side-walking, cones, and bars were incorporated to make the program more challenging for the patient.

**[Table/Fig-1]:** FES+TT combined with challenging tasks.

Other physiotherapy interventions included Proprioceptive Neuromuscular Facilitation (PNF) exercises, stretching, and task-based upper limb training. These were administered for four weeks, three days per week, comprising 12 sessions. Each session lasted 30 to 40 minutes and was conducted on alternate days to the FES+TT sessions, following a challenging task protocol as shown in [Table/Fig-2] [5-7]. Post-rehabilitation outcome measures were assessed as shown in [Table/Fig-3].

| FES+TT training (For 4-weeks) [5,6] | Physiotherapy exercises (For 4-weeks) [7] |
|---|---|
| The treatment protocol consists of four weeks for 3 days/week, consisting of 12 sessions, and each session consists of 30 minutes.<br>The placement of electrodes was on the tibialis anterior and gluteus medius with challenging TT.<br>The parameters FES progressed as per the patient's response to the treatment from lower to higher pulse frequency (35-40 Hz), duration of the wave from smaller to higher (300-450 microseconds), and intensity was set as per the patient's tolerance and desirable response. | The PNF exercises (For four weeks, three days a week, and consisted of 12 sessions; 30-40 minutes on alternate days of FES+TT).<br>Diagonal patterns (D1 and D2) with dumbbells as per the patients tolerance in flexion and extension directions.<br>1 pattern performed for 10 repetitions with 3 sets. |
| Side-walking, cones and bars were used to make the program challenging for the patient. | Stretching (mild stretching of Upper Limb (UL) muscle groups with 30 seconds hold 3 repetitions and 2 sets) |
| | Task-based training (Patient is asked to practise different tasks with breaks like object transfers, writing, buttoning and unbuttoning, combing, locking and unlocking, door opening and closing, etc.,) for 15-20 minutes in a day during the therapy in front of the mirror. |

**[Table/Fig-2]:** Treatment protocol [5-7].

| Outcome measures | Pre-intervention | Post-intervention (After 4-weeks) |
|---|---|---|
| MAS | 2 | 1 |
| VMC | 3 | 6 |
| Berg Balance Score (BBS) | 45/56 | 51/56 |
| Dynamic Gait Index (DGI) | 15/24 | 21/24 |
| Timed-up Go Test (TUG) | 23 seconds | 14 seconds |
| Functional Independence Measure (FIM) | 77/126 | 111/126 |

**[Table/Fig-3]:** Pre and post-intervention of the 4-weeks of FES+TT with challenging tasks.

After four weeks of intervention, spasticity in the affected muscle groups significantly decreased from grade two at baseline to grade one at the end of the 12th session. Muscle strength improved from grade three at baseline to grade six at the end of the program. The patient's balance also improved, as indicated by an increase in the Berg Balance Scale (BBS) score from 45 at baseline to 56 after the 12th session. Mobility, assessed using the Dynamic Gait Index (DGI) and Timed-up and Go (TUG) test, also showed marked improvement. The DGI score increased from 15 to 21, while the TUG time decreased from 23 seconds to 14 seconds after 12 sessions. Functional activities assessed using the Functional Independence Measure (FIM) significantly improved from a baseline score of 77 to 111 at the end of the program. The active range of motion in both the upper and lower limbs also showed notable improvement.

The patient's gait pattern was recorded and analysed pre- and post-intervention using Kinovea software. The findings demonstrated significant changes in gait characteristics after 12 sessions, showing improved ground clearance of the affected lower limb and increased knee flexion range of motion, as detailed in the supplementary files.

## DISCUSSION

The present case report investigates the effectiveness of combining Functional Electrical Stimulation (FES) with TT involving challenging tasks to achieve optimal rehabilitation outcomes in post-stroke patients. The findings revealed significant improvements across various outcome measures, indicating positive functional changes and an overall enhancement in the quality of life of the stroke survivor. These results are consistent with previous studies that have highlighted the benefits of FES combined with TT in neurological rehabilitation.

A distinctive feature of present case report is the inclusion of challenging tasks during the training, which contributed to greater improvements in gait performance compared to previous studies. The combination of FES and TT with challenging tasks proved to be an effective approach for improving gait in stroke patients. Dantas MTAP et al., reported that FES+TT significantly enhances sensorimotor function, balance, endurance, and coordination among stroke patients [8]. Similarly, Lee Y and Kim K (2022) demonstrated significant improvements in motor function, balance, and gait ability following FES+TT intervention, though without the integration of challenging tasks [Table/Fig-4] [8,9].

| Study | Intervention | Findings | Key differentiators |
|---|---|---|---|
| Present case report | FES+TT involving challenging tasks | Spasticity reduced, muscle strength improved, balance improved, DGI score increased, TUG improved, FIM score improved and significant gait improvements observed post-intervention. | Focused on challenging tasks during TT, leading to enhanced gait performance and overall functional outcomes. |
| Dantas MTAP et al., (2023) [8] | FES+TT | Improved sensorimotor functions, balance, endurance, and co-ordination among stroke patients. | Did not specify the inclusion of challenging tasks during TT, which may have limited further gait enhancement. |
| Lee Y and Kim K (2022) [9] | FES+TT | Substantial improvements in motor functions, balance, and gait ability. | Focused on FES+TT but without integrating challenging tasks, limiting exploration of their potential added benefits. |

**[Table/Fig-4]:** Comparison of the interventions and findings [8,9].

The incorporation of challenging tasks not only engages patients during the training intervention period but also fosters sustained attention, which is associated with favourable rehabilitation

outcomes. However, to the best of present knowledge, no study has specifically analysed the effectiveness of FES combined with TT incorporating challenging tasks in post-stroke patients. Therefore, present study was conducted and recommends that future research include larger sample sizes and controlled studies with longer follow-up periods to better understand the effectiveness of FES+TT with challenging tasks in post-stroke rehabilitation.

Stroke, as defined by the World Health Organisation (WHO), is characterised by the sudden onset of clinical signs indicating either focal or global disturbances in cerebral function lasting more than 24 hours or resulting in death due to vascular causes. Common pathological mechanisms include thrombosis, embolism, vessel rupture, and hypoxia [10]. Despite advancements in medical science reducing stroke-related mortality, survivors often experience significant motor, cognitive, and socioeconomic challenges [11]. Rehabilitation therefore plays a pivotal role in improving post-stroke outcomes, with organisations such as the World Stroke Organisation advocating for evidence-based interventions [12].

Physical therapy interventions, including FES-triggered gait training, have been shown to be effective in promoting recovery by improving gait speed, stride length, and balance [13,14]. The combination of FES and TT represents a promising innovation in this field, as supported by meta-analyses demonstrating improvements in walking speed, endurance, and energy efficiency [15]. The present case report highlights the innovative incorporation of challenging tasks into FES+TT protocols, demonstrating significant potential for enhancing motor recovery, balance, and quality of life in post-stroke rehabilitation.

Despite its encouraging results, present study is limited by its single-subject design and lack of long-term follow-up. Larger randomised controlled trials are necessary to validate these findings, assess cognitive engagement and adherence, and confirm long-term efficacy. FES+TT with challenging tasks thus represents a valuable advancement in rehabilitation protocols.

## CONCLUSION(S)

The combined effect of FES and TT with challenging tasks has the potential to significantly improve gait, muscle strength, and balance in patients recovering from stroke. Moreover, the inclusion of additional physiotherapeutic interventions further enhances overall functionality and quality of life in stroke patients. Further investigations are warranted to strengthen these findings and guide evidence-based clinical practice.

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**PARTICULARS OF CONTRIBUTORS:**

1. Student, Department of Physiotherapy, Banarsidas Chandiwala Institute of Physiotherapy, New Delhi, India.
2. Senior Assistant Professor, Department of Physiotherapy, Banarsidas Chandiwala Institute of Physiotherapy, New Delhi, India.
3. Head, Department of UPSMF, Indian Head Injury Foundation, Noida, Uttar Pradesh, India.
4. Assistant Professor, Department of Physiotherapy, Banarsidas Chandiwala Institute of Physiotherapy, New Delhi, India.
5. Occupational Therapist, Department of UPSMF, Indian Head Injury Foundation, Noida, Uttar Pradesh, India.

**NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:**
Avi Choudhary,
Senior Assistant Professor, Department of Physiotherapy, Banarsidas Chandiwala Institute of Physiotherapy, Kalkaji-110019, New Delhi, India.
E-mail: chaudharyavi31@gmail.com



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