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CASE REPORT

Effect of an integrated exercise programme and use of electromyography to track chronic functional recovery

Asma Parveen[1] | Prathap Suganthirababu[1] | Lavanya Prathap[2] | Debadutta Patra[3]

[1]Department of Physiotherapy, Saveetha College of Physiotherapy, Saveetha Institute of Medical and Technical Science, Chennai, India
[2]Department of Anatomy, Saveetha College of Physiotherapy, Saveetha Institute of Medical and Technical Science, Chennai, India
[3]Department of Physiotherapy, Alva's College of Physiotherapy and Research Centre, Moodubidri, India

Abstract

Background: Hemorrhagic stroke often results in persistent motor impairments and functional dependence, particularly in chronic stages where recovery is usually considered limited. Emerging evidence suggests that intensive, task-oriented rehabilitation combined with objective neuromuscular monitoring may enhance long-term functional outcomes by promoting neuroplastic adaptations.

Case description and management: A 56-year-old women with left-sided hemiplegia following a hemorrhagic stroke in 2015 presented with significant motor deficits and reduced functional independence despite prior conventional rehabilitation. Ten years post-stroke (March 2025), she continued to experience spasticity, impaired mobility, and difficulty performing activities of daily living. Baseline assessment revealed low Functional Independence Measure (FIM) scores, increased muscle tone on the Modified Ashworth Scale (MAS), and reduced neuromuscular activation on electromyograph. The patient underwent a structured 15-week integrated physiotherapy programme, consisting of high-intensity sessions conducted six days per week. The intervention included task-specific functional training, strengthening, balance and gait training, spasticity management techniques, and oromotor and facial muscle stimulation. Electromyography was used to objectively monitor changes in muscle activation and motor unit recruitment throughout the rehabilitation period. Following the intervention, the patient demonstrated meaningful improvements in functional independence, reduced spasticity, and enhanced neuromuscular activation, as reflected by improved FIM, MAS, and electromyographic outcomes.

Conclusion: This case highlights that significant functional recovery and neuromuscular adaptation remain achievable even in the chronic phase of hemorrhagic stroke through an intensive, integrated rehabilitation approach supported by objective assessment tools.

Correspondence
Asma Parveen
asmap9575@gmail.com

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0000-0002-1736-1342

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A: Mohammad Tariqul Islam
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Key messages

Persistent motor deficits in chronic hemorrhagic stroke can be significantly improved through a high-intensity, 15-week integrated exercise programme. The use of electromyography provides essential objective evidence of neuromuscular adaptation, proving that neuroplasticity remains achievable long after the acute phase. Electromyography-tracked motor unit action potential changes serve as a critical biomarker for motor unit recruitment, validating the efficacy of intensive exercise in promoting long-term functional recovery.

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Introduction

Stroke is a leading cause of disability and mortality globally, traditionally defined as a neurological deficit resulting from an acute focal injury of the central nervous system (CNS) due to a vascular cause, such as cerebral infarction, intracerebral hemorrhage (ICH), or subarachnoid hemorrhage (SAH). ICH accounts for 10–15% of strokes, with persistently high morbidity and mortality rates. Recovery is challenging due to extensive neural damage and complex motor deficits, requiring comprehensive rehabilitation strategies [1]. An integrated stroke rehabilitation programme combines muscle stimulation, balance training, strengthening, task-specific activities, and mobility drills to improve muscle activation, reduce spasticity, and enhance functional independence [2]. Electromyography (EMG) assesses muscle activation and neuromuscular function, offering objective insights to optimise rehabilitation strategies [3]. The Functional Independence Measure (FIM) evaluates a patient's ability to perform daily activities independently, tracking recovery progress [4]. The Modified Ashworth Scale (MAS) assesses muscle spasticity by measuring resistance to passive movement, aiding in neurological recovery assessment [5].

This case study was carried out in the rehabilitation department to examine the effectiveness of an integrated physiotherapy programme in enhancing functional recovery in a patient with chronic hemorrhagic stroke.

Case description and management

A 56-year-old unmarried women suffered a hemorrhagic stroke following a right-sided Basal Ganglia hemorrhage involving Internal Capsule as reveled by the magnetic resonance imaging 9 on December 2015, while getting ready for work. She suddenly experienced a severe headache and lost the ability to move her left arm and leg. She was immediately taken to the hospital, where she underwent a craniotomy and duraplasty. As a result of the stroke, she developed left-sided hemiplegia. At the baseline assessment, the patient had an mini-mental state examination score of 27/30. Sensation was intact, though proprioception in the left lower limb was diminished. The MAS score was 3 in the upper limb and 2 in the lower limb. Functional status examination required significant assistance for activities of daily living (Baseline FIM; 32). There were substantial residual left-sided facial palsy (House-Brackmann Grade III), characterized by noticeable but not disfiguring asymmetry at rest and secondary weakness in lip closure. The patient also reported mild oropharyngeal dysphagia, specifically difficulty with bolus formation and occasional coughing when consuming thin liquids. These deficits necessitated the inclusion of muscle stimulation and the Motor Relearning Programme (MRP) for oromotor control to improve both aesthetic symmetry and functional swallowing safety. There was no prior medical history of hypertension, diabetes, or substance use. Family and socio-economic history was irrelevant.

After receiving standard physiotherapy treatment during the acute phase, she continued to face functional limitations even after ten years. In March 2025, she began regular physiotherapy sessions at a rehabilitation center, Bhubaneswar, Odisha, India. Before initiating the intervention, informed consent was obtained, and pre-treatment assessments were conducted to evaluate her neuromuscular function and overall physical condition.

This patient with left sided hemiplegia following a stroke and continued to experience mobility challenges despite undergoing prior rehabilitation. A detailed medical examination was conducted, including sociodemographic data, clinical history, neurological assessments, and electromyographic analysis to assess neuromuscular activation. Neuromuscular activation was assessed using a Clarity Octopus surface EMG system. Bipolar electrodes were placed on the biceps brachii and rectus femoris following Surface Electromyography for the Non-Invasive Assessment of Muscles guidelines. Data were sampled at 1000 Hz, and the Root Mean Square (RMS) amplitude was calculated during Maximal Voluntary Isometric Contractions to quantify motor unit recruitment. Functional impairments were evaluated using range of motion assessments, muscle tone grading, and functional independence scoring. A 15-week rehabilitation programme was implemented, consisting of six sessions per week, each lasting an hour and 15 mins [2, 6, 7]. For details please see **Table 1**.

Post-treatment evaluations revealed significant improvements in functional mobility, neuromuscular activation, and muscle tone. Outcome measures confirmed the physiotherapy regimen's effectiveness. The FIM score rose from 32 to 55, reflecting greater autonomy in self-care, mobility, and daily tasks. The MAS showed reduced muscle stiffness, with upper limb scores decreasing from 3 to 2, enhancing movement control. Lower limb scores declined from 2 to 1, indicating less spasticity and better voluntary movement. EMG assessments demonstrated improved neuromuscular activation, increased motor unit recruitment, and enhanced muscle coordination, underscoring neuromuscular adaptation and recovery.

Discussion

This case report suggests that a 15-week integrated physiotherapy protocol may contribute to functional recovery in a patient with chronic hemorrhagic stroke. While recovery often slows in the chronic phase, the improvements observed in this instance point toward the potential utility of task-specific training. By focusing on functional mobility and Activities of Daily Living (ADLs), the protocol aimed to facilitate motor relearning, a process which—in this specific case—aligned with the improvements in coordination noted by Richardson *et al.* [8]

Table 1 Fifteen weeks integrated exercise protocol[a]

Exercise	Purpose	Repetitions	Progression
Muscle stimulation (facial)	To prevent muscle atrophy and re-educate denervated facial muscles via low-frequency current.	Motor threshold (visible contraction without pain).	Week1-5: Passive stimulation. Weeks 6-15: Combined with active-assisted facial expressions.
Oromotor training	To enhance bolus control, reduce aspiration risk, and improve lip seal through the motor relearning programme.	Sub-maximal effort; focused on precision.	Weeks 1-5: Sensory stimulation. Weeks 6-15: Resistance exercises (e.g., tongue depressor push-backs).
Upper limb strengthening	To facilitate neuroplasticity and motor unit recruitment through bilateral symmetric movement.	Borg scale: 12–14 (somewhat hard).	Weeks 1-5: Gravity-eliminated range of motion. Weeks 6-15: Resisted training with 0.5 kg–2 kg dumbbells/ therabands.
Lower limb strengthening	To improve stance stability and force production during the swing phase of gait.	60–70% of estimated 1-Rep Max.	Weeks 1-5: Isometric & supine active range of motion. Weeks 6-15: Standing weight-shifts and resisted knee extensions.
Gait and balance training	To improve postural control and reduce fall risk by challenging the vestibular/ proprioceptive systems.	Moderate (Target heart rate: 50-60% of Max).	Weeks 1-5: Parallel bar support. Weeks 6-15: Standing with one limb support
Functional task training	To promote "Task-specific plasticity" by practicing activities of daily living.	High repetition; goal-oriented.	Weeks 1-5: Simple bed mobility. Weeks 6-15: Supported "Sit-to-Stand" and complex multi-step tasks (e.g., reaching while sitting).
Spasticity management	To inhibit alpha-motor neuron excitability and provide mechanical elongation of shortened tissues.	Mild discomfort during stretches.	Weeks 1-5: Prolonged icing and therapist-led stretching. Weeks 6-15: stretching techniques and weight-bearing inhibition.

[a] Contents of the table are based on references 2, 6, 7.

The inclusion of EMG served as a supplemental tool for monitoring neuromuscular activity. As noted by Monte-Silva *et al.*, EMG-triggered feedback can be a helpful adjunct in stroke rehabilitation. In this case, the use of EMG provided a preliminary framework for adjusting exercise intensity; however, it is important to note that surface EMG readings are a proxy for muscle activation and do not provide direct evidence of cortical neuroplasticity. Rather, the data appears to reflect an improvement in voluntary muscle control and recruitment patterns during the study period [9].

The transition from gravity-eliminated movements to resisted training (60–70% of 1-Rep Max) was associated with increased stance stability in the patient. Consistent with the framework described by Li X *et al.*, combining resistance training with moderate-intensity gait tasks may have addressed some of the muscular atrophy common in chronic stroke. Furthermore, the use of spasticity management (icing and stretching) seemed to provide a temporary window of reduced excitability, potentially allowing for higher-quality repetitions during functional training [10].

As a case report, these findings are limited by the lack of a control group and cannot be generalized to the broader stroke population. The improvements noted in the FIM and EMG signals should be interpreted with caution, as they represent the response of a single individual. While the results are encouraging, they merely highlight the possibility that structured, late-stage intervention can be beneficial. Further large-scale, randomized controlled trials are necessary to determine if these outcomes are reproducible and to establish standardized protocols for the chronic stroke population.

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Author contributions

Manuscript drafting and revising it critically: AP. *Approval of the final version of the manuscript:* AP, PS, LP, DP. *Guarantor accuracy and integrity of the work:* DP.

Conflict of interest

We do not have any conflict of interest.

Data availability statement

We confirm that the data supporting the findings of the study will be shared upon reasonable request.

Supplementary file

None

AI disclosure

During the preparation of this manuscript, the author(s) used AI Tools in order to refine academic language.

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