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Effectiveness of Electrical Stimulation and Passive Exercise in Incomplete Paraplegia: A Case Report

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Abstract

Introduction: Paraplegia is paralysis of both lower extremities caused by spinal cord disorders, including compression by spinal meningioma, which disrupts motor, sensory, and functional abilities.
Objective: This case report aimed to evaluate the effectiveness of combined electrical stimulation and passive exercise in improving sensory function and reducing spasticity in a patient with incomplete paraplegia following thoracic meningioma surgery.
Methods: A 41-year-old female with incomplete paraplegia Frankel B due to thoracic (T10–T11) meningioma underwent four physiotherapy sessions over four weeks, each lasting approximately 30 minutes. Assessments included sensory function (key point dermatome), spasticity (Modified Ashworth Scale), muscle strength (Manual Muscle Testing), range of motion (goniometry), and functional independence (Spinal Cord Independence Measure III).
Results: Post-intervention evaluation showed improved sensory function and reduced spasticity, indicating a positive response to the combined intervention.
Conclusion: Electrical stimulation combined with passive exercise was effective in improving sensory function and reducing spasticity in incomplete paraplegia following thoracic meningioma surgery.

Keywords
Paraplegia; Spinal Cord Neoplasms; Electric Stimulation Therapy; Exercise Therapy; Muscle Spasticity

Introduction

Paraplegia is a condition characterized by paralysis of both lower extremities due to spinal cord injury or dysfunction.[1] One of the non-traumatic causes of paraplegia is meningioma, a benign tumor originating from arachnoid cells or fibroblasts of the dura mater surrounding the spinal cord.[2] The exact etiology of primary spinal cord tumors remains unclear, but possible contributing factors include viral infections, genetic abnormalities, and exposure to carcinogenic agents.

Spinal cord injury at the thoracic level may result in incomplete paraplegia, affecting the trunk and lower extremities or the lower extremities alone.[3] In the Frankel B classification, patients retain sensory function below the lesion but experience complete motor loss, which significantly impacts independence and necessitates a structured rehabilitation program.[4]

According to the World Health Organization, more than one billion people, or approximately 15% of the global population, live with disabilities, with a higher prevalence reported in developing countries. In Indonesia, national survey data revealed an annual injury prevalence of 9.2%, higher in men (11%) than in women (7.4%), and most frequent in the 15–24-year age group.[5] The high incidence of disability and spinal cord injury underscores the urgent need for effective rehabilitative interventions to minimize functional limitations.

Physiotherapy plays a crucial role in the management of paraplegia, not only to maintain and improve muscle function but also to prevent complications such as joint stiffness, contractures, and circulatory disorders.[3] Electrical stimulation (ES) has been shown to enhance muscle contraction and improve neurological function in paralyzed patients.[6] Meanwhile, passive exercise helps maintain joint range of motion and prevent complications such as contractures and spasms.[7] The combination of these two interventions may provide more optimal outcomes compared to their use in isolation. However, scientific evidence exploring their combined effectiveness in patients with paraplegia following thoracic meningioma surgery remains limited.

This case report is significant as it comprehensively examines the effects of combining electrical stimulation and passive exercise in a patient with incomplete paraplegia Frankel B after thoracic meningioma surgery, a condition rarely reported in the literature. The patient was a 41-year-old woman who presented with weakness and complete motor loss in both lower extremities, accompanied by sensory disturbances. Prior to beginning physiotherapy, she underwent surgical removal of the meningioma but had not yet received structured physiotherapy interventions. Based on this background, the present case report aims to evaluate the impact of combining electrical stimulation and passive exercise on sensory function, spasticity, muscle strength, joint range of motion, and functional ability in a patient with incomplete paraplegia Frankel B caused by a thoracic meningioma at vertebrae X–XI, treated at Muhammadiyah Hospital Lamongan.

Methods

This study is a prospective case report involving a single patient who received physiotherapy intervention without a control group. The subject was selected purposively based on diagnostic criteria and willingness to complete the entire intervention protocol. The patient was a 41-year-old woman diagnosed with incomplete paraplegia Frankel B due to a meningioma at the thoracic vertebrae

X–XI, for which she had undergone surgical tumor excision. The study was conducted at Muhammadiyah Hospital Lamongan, East Java, in May 2025 over a four-week period (four therapy sessions, one session per week).

During the initial anamnesis and physical examination, the patient presented with lower extremity weakness, sensory loss below the lesion level, and inability to perform functional activities independently. Mild spasticity was also detected on muscle tone assessment. Physiotherapy assessments included: sensory evaluation at key point dermatomes, the Modified Ashworth Scale (0–4) to assess muscle tone, Manual Muscle Testing (MMT, 0–5 scale) for muscle strength, active range of motion (ROM) in degrees using goniometry, and the Spinal Cord Independence Measure III (SCIM III), a validated and reliable tool for evaluating independence in individuals with spinal cord injury.

The therapeutic management in this case was structured through a series of planned interventions designed to address the patient's specific impairments and functional limitations. Table 1 summarizes the intervention procedures applied during the treatment sessions, including the therapeutic techniques and modalities administered. To provide a clearer overview of the sequence and progression of therapy, Table 2 presents the intervention timeline, outlining the activities conducted in each session and the corresponding clinical observations.

Table 1. Intervention procedures

Intervention	Description
Electrical Stimulation (ES)	Target muscles: gluteus maximus, quadriceps femoris, hamstrings, gastrocnemius. Parameters: frequency 35 Hz, pulse duration 300 μs, continuous mode, intensity adjusted to patient tolerance. Duration: approximately 10 minutes per muscle, bilaterally. Purpose: to stimulate muscle contraction, enhance neuromuscular connectivity, and support sensorimotor activation.
Passive Exercise	Movements: hip flexion–extension, abduction–adduction, internal–external rotation; knee flexion–extension; ankle plantarflexion–dorsiflexion. Patient position: supine. Repetitions: 20 per joint, 3 sets, with 1-minute rest between sets. Purpose: to maintain or improve ROM, reduce spasticity, prevent contractures, and support functional capacity.

Table 2. Intervention timeline

Week	Activity
1	Baseline assessment + ES + passive exercise + evaluation
2	ES + passive exercise + evaluation
3	ES + passive exercise + evaluation
4	ES + passive exercise + final evaluation

Ethical approval for this study was obtained from the Ethics Committee of Muhammadiyah Hospital Lamongan. Written informed consent was obtained from the patient prior to participation in the intervention.

Results

The patient was a 41-year-old woman diagnosed with incomplete paraplegia Frankel B caused by a thoracic meningioma at vertebrae X–XI, who had undergone tumor excision surgery. Physiotherapy intervention was delivered across four sessions over four weeks, with each session lasting approximately 30 minutes. The intervention consisted of electrical stimulation applied to passively stimulate lower limb muscles and passive exercises aimed at improving range of motion (ROM), reducing spasticity, and supporting functional activity. To provide a visual representation of the therapeutic approach, the figures illustrate the main techniques applied during the intervention. Figure 1 demonstrates the electrode placement for electrical stimulation targeting the gluteus, hamstrings, quadriceps, and gastrocnemius muscles, which aimed to facilitate muscle activation and improve neuromuscular control. In addition, Figure 2 presents the sequence of passive exercises, including hip flexion–extension, abduction–adduction, and internal–external rotation, as well as knee flexion–extension and ankle plantarflexion–dorsiflexion, performed to maintain joint mobility and prevent stiffness.

Figure 1. Electrode placement for electrical stimulation on the gluteus, hamstrings, quadriceps, and gastrocnemius.

Figure 2. Passive exercise consisting of hip flexion–extension, abduction–adduction, and internal–external rotation; knee flexion–extension; and ankle plantarflexion–dorsiflexion.

Evaluation was performed after each session using the following parameters: sensory function (key point dermatome), spasticity (Modified Ashworth Scale), muscle strength (Manual Muscle Testing, MMT), active ROM, and functional activity (Spinal Cord Independence Measure, SCIM III). Assessments were limited to the intervention period, with no long-term follow-up. The patient completed all sessions without significant complaints, and no adverse events or complications were observed.

The outcomes of the intervention were evaluated through a series of standardized clinical assessments. Table 3 presents the changes in sensory function at key point dermatomes, reflecting improvements in sensory responsiveness. Table 4 summarizes the changes in spasticity scores measured by the Modified Ashworth Scale, indicating the degree of muscle tone reduction. Furthermore, Table 5 provides the results of active range of motion (ROM) assessment of the lower extremities, while Table 6 highlights the muscle strength evaluation based on Manual Muscle Testing (MMT). Finally, Table 7 reports the Spinal Cord Independence Measure (SCIM III) scores, which comprehensively demonstrate the patient's functional independence following the intervention.

Table 3. Changes in sensory function at key point dermatomes

Site of examination	T1	T2	T3	T4
LTR right	51	52	53	54
LTR left	41	43	45	47
PPR right	47	48	49	51
PPR left	36	40	43	46

Note: Progressive improvement in sensory function was observed, with the greatest increase at the left PPR.

Table 4. Changes in spasticity score (Modified Ashworth Scale)

Movement	T1	T2	T3	T4
Knee flexion R	1	1	1	0

Note: Spasticity decreased from score 1 to 0, indicating muscle tone relaxation after intervention.

Table 5. Active range of motion (ROM) of the lower extremities

Region	Right T1	Right T4	Left T1	Left T4
Hip	0°	0°	0°	0°
Knee	0°	0°	0°	0°
Ankle	0°	0°	0°	0°

Note: No active movement was observed in any lower limb joints before or after therapy.

Table 6. Muscle strength assessment (MMT)

Muscle	T1	T2	T3	T4	Change
Gluteus maximus	0	0	0	0	No change
Quadriceps femoris	0	0	0	0	No change
Hamstrings	0	0	0	0	No change
Gastrocnemius	0	0	0	0	No change

Note: No improvement in muscle strength was observed. All major lower limb muscles remained at MMT grade 0.

Table 7. SCIM III scores

Assessment domain	T1	T2	T3	T4	Change
Self-care	18	18	18	18	No change
Sphincter control	36	36	36	36	No change
Mobility	18	18	18	18	No change
Total score	72	72	72	72	No change

Note: No changes in functional activity were recorded after the intervention.

Summary of intervention outcomes: Sensory function increased by an average of 5.75 points, spasticity decreased from 1 to 0, whereas muscle strength, active ROM, and functional activity showed no change.

Discussion

The findings of this study demonstrate that electrical stimulation (ES) combined with passive exercise over four sessions produced a positive response in the form of improved sensory function and reduced spasticity. Sensory enhancement is presumed to occur through activation of afferent neural pathways, lowering of mechanoreceptor thresholds, and increased sensory integration within the central nervous system via Hebbian plasticity mechanisms.[8] The reduction in spasticity may be explained by neural modulation effects through reflex and descending pathway activation, as well as proprioceptive receptor stimulation, which reduces stretch reflex excitability and maintains muscle length to prevent contractures and spasms.[9] These results are consistent with previous studies reporting that passive exercise and ES are effective in improving joint range of motion, decreasing muscle tone, and strengthening neuromuscular responsiveness.[7,8]

Despite improvements in sensory and muscle tone parameters, no significant gains were observed in muscle strength, active range of motion (ROM), or overall functional capacity. The patient's Manual Muscle Testing (MMT) values remained at grade 0 across all major lower limb muscles, and SCIM III scores showed no change. This may be attributed to the relatively short therapy duration, limited frequency of sessions (once per week), and the absence of independent active exercises outside physiotherapy sessions.[10] Motor function recovery in patients with spinal cord injury generally requires intensive, consistent, and long-term interventions to induce meaningful neuromuscular adaptations.

Several factors may have limited therapeutic outcomes, including the patient's full dependence on physiotherapists without independent home exercises, lack of intervention variety specifically targeting muscle strengthening, and potentially suboptimal environmental and family support.[11] Successful neurological rehabilitation depends not only on clinic-based therapy but also on family involvement and patient engagement in long-term exercise programs.[12]

These findings suggest that ES combined with passive exercise may serve as an initial rehabilitation protocol for patients with incomplete paraplegia following surgery, particularly to enhance sensory function and reduce spasticity. However, achieving long-term goals such as increased muscle strength, active ROM, and functional independence requires extended therapy programs with higher intensity and frequency, long-term supervision, and active family involvement in supporting home-based training. Future studies should adopt experimental designs with control groups, larger sample sizes, and longer intervention durations to confirm the effectiveness of this combined approach.

Future studies should adopt more robust research designs, such as randomized controlled trials with larger sample sizes and longer intervention durations, to confirm the effectiveness of this combined approach. Additional investigations should also evaluate the minimum effective therapy duration required to achieve motor recovery, and examine the influence of psychosocial and motivational factors on rehabilitation outcomes.

Conclusion

In this case report, physiotherapy interventions consisting of electrical stimulation and passive exercise in a 41-year-old female patient with incomplete paraplegia Frankel B following thoracic meningioma resection demonstrated positive outcomes in terms of improved sensory function and reduced spasticity. However, no significant changes were observed in muscle strength, active range of motion (ROM), or functional activity.

Motor function recovery in such conditions requires a longer, more intensive, and continuous rehabilitation program. It is recommended that physiotherapists develop long-term treatment plans with appropriate intensity and provide family education to support independent home-based exercises. Further research with larger sample sizes and longer intervention durations is warranted to strengthen these findings.

Author Contribution

Adiba Hanim Fairuzza contributed to patient assessment, intervention implementation, data collection, and manuscript drafting.
Diah Rosyida Maulidina contributed to data analysis, interpretation of clinical findings, and manuscript revision.
Yeni Tri Nur Hayati contributed to study supervision, conceptual guidance, methodological review, and critical revision of the manuscript.
All authors read and approved the final manuscript.

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Conflict of Interest Statement

The authors declare no conflict of interest related to this study.

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Ethics Statement

Ethical approval was obtained from the Ethics Committee of Muhammadiyah Hospital Lamongan. Written informed consent was obtained from the patient prior to participation in this study. Written informed consent for publication of clinical data and images was obtained from the patient.

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