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MANAGEMENTUL FIZIOTERAPEUTIC MULTIMODAL AL SPASTICITĂȚII MEMBRELOR INFERIOARE DUPĂ AVC: UN STUDIU OBSERVAȚIONAL PROSPECTIV

MULTIMODAL REHABILITATION MANAGEMENT OF LOWER LIMB SPASTICITY AFTER STROKE: A PROSPECTIVE OBSERVATIONAL STUDY

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Abstract

Background: Lower limb spasticity is a common and disabling complication following a stroke, significantly impacting gait, balance, and functional independence.

Objective: This study aims to analyze the clinical effects of a multimodal physiotherapy approach in managing post-stroke lower limb spasticity and to explore the complexities of therapeutic combinations commonly used in rehabilitation practice.

Methods: A prospective observational study was conducted with 27 post-stroke patients who experienced lower limb spasticity and were admitted to a neurological rehabilitation unit. Each patient underwent an individualized rehabilitation program that included physiotherapy exercises, electrotherapy, and additional physical modalities. Clinical assessments were performed at both admission and discharge using validated scales. Pre- and post-therapy differences were analyzed using paired t-tests.

Results: Statistically significant improvements were observed in both spasticity severity and functional motor performance. The combination of various therapeutic modalities demonstrated greater clinical effectiveness than isolated interventions.

Conclusions: A multimodal physiotherapeutic approach is an effective and clinically applicable strategy for reducing lower-limb spasticity after stroke, supporting the implementation of individualized, evidence-based rehabilitation protocols.

Rezumat

Introducere: Spasticitatea membrelor inferioare este o complicație frecventă și invalidantă după un accident vascular cerebral, afectând semnificativ mersul, echilibrul și independența funcțională.

Obiective: Acest studiu își propune să analizeze efectele clinice ale unei abordări fizioterapeutice multimodale în gestionarea spasticității membrelor inferioare post-accident vascular cerebral și să exploreze complexitatea combinațiilor terapeutice utilizate în mod obișnuit în practica de reabilitare.

Metode: A fost realizat un studiu observațional prospectiv cu 27 de pacienți post-accident vascular cerebral care au prezentat spasticitate a membrelor inferioare și au fost internați într-o unitate de reabilitare neurologică. Fiecare pacient a urmat un program individualizat de reabilitare care a inclus kinetoterapie, electroterapie și agen'i fizici terapeutici suplimentari. Evaluările clinice au fost efectuate atât la internare, cât și la externare, utilizând scale validate. Diferențele pre- și post-terapie au fost analizate utilizând teste t pereche.

Rezultate: S-au observat îmbunătățiri semnificative statistic atât în ceea ce privește severitatea spasticității, cât și performanța motorie funcțională. Asocierea diferitelor modalități terapeutice a demonstrat o eficacitate clinică mai mare decât intervențiile izolate.

Concluzii: O abordare complex[de reabilitare, multimodală este o strategie eficientă și aplicabilă clinic pentru reducerea spasticității membrelor inferioare după accident vascular cerebral, susținând implementarea protocoalelor de reabilitare individualizate, bazate pe dovezi

Key-words: *stroke, lower limb spasticity, physiotherapy, rehabilitation, multimodal treatment*

Cuvinte cheie: *accident vascular cerebral, spasticitate a membrelor inferioare, fizioterapie, reabilitare, tratament multimodal.*

Introducere

Stroke remains one of the leading causes of adult disability worldwide, with an increasing prevalence due to population aging and improved acute survival *rates* *(Feigin et al., 2017)*. Among post-stroke sequelae, spasticity is a frequent and clinically challenging condition, affecting approximately 25–40% of stroke survivors within the first *year* *(Lundström et al., 2008)*. Lower limb spasticity is particularly disabling, as it interferes with gait mechanics, balance control, and postural stability, *and increases the risk of falls, secondary musculoskeletal complications, and long-term dependence (Dietz and Sinkjaer, 2007)*. Beyond its biomechanical consequences, spasticity also contributes to pain, fatigue, and reduced participation in activities of daily living, thereby substantially impairing health-related quality of life *(Wissel et al., 2015)*.

From a pathophysiological perspective, post-stroke spasticity results from a complex disruption of descending inhibitory pathways, leading to hyperexcitability of spinal reflex circuits and altered muscle mechanical properties *(Lance, 1980; Sheean and McGuire, 2009)*. While neural mechanisms such as increased stretch reflex gain play a central role in the early stages, chronic spasticity is increasingly associated with non-neural components, including changes in muscle architecture, increased connective tissue stiffness, and fibrosis *(Gracies, 2005)*. These multifactorial mechanisms explain why spasticity cannot be effectively addressed through a single therapeutic modality.

Lower limb spasticity presents unique clinical challenges. Although some authors have suggested that extensor spasticity may provide a certain degree of postural support during stance *(Berger et al., 1984)*, excessive or poorly controlled spasticity compromises gait efficiency, symmetry, and adaptability to environmental demands *(Olney and Richards, 1996)*. Consequently, contemporary rehabilitation aims not merely to suppress spasticity, but to modulate it in a manner that enhances functional motor performance.

Current clinical guidelines emphasize the importance of individualized, goal-oriented management strategies for post-stroke spasticity, integrating pharmacological, physical, and functional interventions *(Royal College of Physicians, 2018)*. Within this framework, physiotherapy plays a central role, particularly in mild to moderate spasticity or as an adjunct to medical treatments, such as botulinum toxin injections. However, despite the widespread use of physiotherapeutic interventions, considerable heterogeneity persists regarding treatment selection, combination, dosage, and timing *(Tilborg et al., 2024)*.

Recent systematic reviews and meta-analyses have demonstrated beneficial effects of various physiotherapeutic modalities, including stretching, neuromuscular electrical stimulation, transcutaneous electrical nerve stimulation, shock wave therapy, and hydrotherapy, on lower limb spasticity after stroke *(Mahmood et al., 2019; Mihai et al., 2020; Afzal et al., 2023)*. Nevertheless, most studies investigate isolated interventions under controlled experimental conditions, which may not fully reflect the complexity of real-world rehabilitation practice. In everyday clinical settings, therapists frequently combine multiple modalities in response to patients' evolving functional status, comorbidities, and tolerance to treatment.

There remains a gap in the literature regarding the systematic description and evaluation of such multimodal, individualized rehabilitation approaches as they are implemented in routine clinical care. Observational studies addressing this gap can provide valuable insights into clinical decision-making processes and functional outcomes in heterogeneous patient populations.

Against this background, the present study aims to analyze the clinical effects of a multimodal physiotherapeutic management strategy for lower limb spasticity after stroke, focusing on the complexity of therapeutic associations applied during inpatient rehabilitation and their impact on spasticity severity and functional motor outcomes.

2. Materials and Methods

2.1 Study Design

This investigation was designed as a prospective observational study conducted in a neurological rehabilitation setting. The study focused on a single cohort of post-stroke patients undergoing routine inpatient rehabilitation, without experimental manipulation of prescribed treatments.

2.2 Participants

A total of 27 adult patients diagnosed with ischemic or hemorrhagic stroke and presenting with lower limb spasticity were included. Inclusion criteria comprised age ≥18 years, Modified Ashworth Scale (MAS) score >1 at the lower limb, and eligibility for electrotherapy procedures. Patients in the acute stage of stroke, those with severe cognitive impairment, other neurological conditions affecting motor function, or recent botulinum toxin injections were excluded.

The heterogeneity of the sample reflects typical clinical populations encountered in neurological rehabilitation and supports the external validity of the findings.

2.3 Rehabilitation Intervention

All patients received individualized rehabilitation programs prescribed by a rehabilitation physician and delivered by physiotherapists. The intervention strategy followed a multimodal approach, integrating physiotherapy exercises with various physical and electrotherapeutic modalities. Treatment selection and intensity were adapted to each patient's motor deficits, spasticity severity, functional goals, and associated medical conditions.

Physical therapy formed the core of all rehabilitation programs and included stretching, proprioceptive neuromuscular facilitation techniques, balance training, and task-oriented gait exercises. Electrotherapy modalities such as TENS and NMES were applied to modulate reflex activity, facilitate antagonist muscle activation, and improve motor control. Adjunct physical therapies, including therapeutic ultrasound, shock wave therapy, thermotherapy, and hydrotherapy, were selectively incorporated to address muscle stiffness, pain, and tissue extensibility.

The complexity of therapeutic associations reflects contemporary rehabilitation practice, where interventions are combined synergistically rather than applied in isolation.

2.4 Outcome Measures

Clinical assessments were performed at admission and discharge using validated, widely accepted instruments. Spasticity was evaluated using the Modified Ashworth Scale (MAS) and the Tardieu Scale. Motor function and balance were assessed using the lower limb section of the Fugl-Meyer Assessment (FMA) and the short version of the Berg Balance Scale (BBS). Functional mobility and gait performance were evaluated using the Timed Up and Go Test (TUG) and the 10-Meter Walk Test(10mT).

2.5 Statistical Analysis

Descriptive statistics were calculated for all variables. Pre–post intervention differences were analyzed using paired t-tests, as the same participants were evaluated at two time points. Statistical significance was set at $p < 0.05$. The analysis focused on clinically meaningful changes in spasticity and functional performance.

3.Results

3.1.Complexity of Therapeutic Management

All patients included in the study received combined physiotherapeutic interventions, underscoring the multifactorial nature of post-stroke spasticity management. No patient was treated with a single modality alone. Table 1 summarizes the main therapeutic approaches applied within the study group.

Therapeutic category	Specific modalities applied	Number of patients (n)	Clinical rationale
Physiotherapy exercises	Individual therapeutic exercise, stretching, gait training	27	Core intervention targeting motor control, spasticity modulation, balance, and functional mobility
Manual therapy	Therapeutic massage	21	Muscle relaxation, reduction of tone-related discomfort, and preparation for active exercise
Electrotherapy – analgesic / neuromodulatory	TENS, Interferential currents, Diadynamic currents	11	Reflex inhibition, pain modulation, and facilitation of voluntary movement
Electrotherapy – neuromuscular activation	Functional Electrical Stimulation	6	Antagonist facilitation, improvement of motor recruitment, and gait pattern
Physical agents – thermotherapy	Paraffin applications,	9	Muscle relaxation, increased tissue extensibility
Physical agents – phototherapy	Laser therapy	5	Local trophic effects, neuromodulation

Therapeutic category	Specific modalities applied	Number of patients (n)	Clinical rationale
Physical agents – ultrasound	Therapeutic ultrasound,	7	Reduction of passive muscle stiffness and non-neural components of spasticity
Physical agents – diathermy	Pulsed and continuous short-wave therapy	8	Global muscle relaxation, facilitation, and pain decrease
Robotic / device-assisted therapy	Andago, Walker View, ProKin	13	Task-oriented training, balance and gait symmetry, objective feedback

Table 1. Therapeutic interventions applied in the study group (n = 27)

The therapeutic management implemented in the study group was highly complex, with each patient receiving personalized combinations of interventions rather than relying on isolated treatments. The physiotherapy exercise program was the primary intervention used in all cases (100%), while electrotherapy, physical agents, thermotherapy, and device-assisted therapies were selectively combined based on the patients' functional deficits and clinical tolerance (see Table 1).

3.2.Functional Outcomes

Significant statistical improvements were observed across all primary outcome measures from admission to discharge. Analysis using paired t-tests indicated a noteworthy reduction in spasticity severity, as assessed by the Modified Ashworth Scale and the Tardieu Scale, accompanied by enhancements in motor control, balance, and gait performance (Table 2 and Table 3).

Outcome	Baseline Mean ± SD	Discharge Mean ± SD	t (df)	*p*
Joint range of motion	33.8 ± 3.7	39.2 ± 4.6	9.6 (26)	<0.001
Manual muscle testing	2.0 ± 0.4	2.2 ± 0.6	4.9 (26)	<0.001
Fugl-Meyer Assessment (FMA)	50.0 ± 7.9	55.9 ± 8.2	5.0 (26)	<0.001
Berg Balance Scale	9.8 ± 6.9	14.6 ± 8.3	4.5 (26)	<0.001
Timed Up and Go (TUG),	28.6 ± 9.4	21.3 ± 7.8	4.89 (26)	<0.001
10-Meter Walk Test	8.4 ± 6.7	7.5 ± 5.8	2.8 (26)	0.009

Table 2. Global clinical scales and functional tests (n = 27)

Muscle group MAS	n (patients with spasticity)	Baseline Mean ± SD	Discharge Mean ± SD	t (df)	*p*
Gluteal muscles	10	2.3 ± 0.7	1.7 ± 1.1	3.0 (10)	0.014
Quadriceps	15	2.0 ± 0.4	1.7 ± 0.5	2.6 (14)	0.019
Hamstrings	8	2.3 ± 0.7	1.7 ± 1.0	2.6 (7)	0.038
Hip adductors	20	2.4 ± 0.5	1.9 ± 0.9	3.7 (19)	0.001
Triceps surae	27	3.3 ± 0.5	2.5 ± 0.6	8.6 (26)	<0.001

Table 3. Spasticity severity – Modified Ashworth Scale (MAS), paired t-test by muscle group

Spasticity was further characterized using the Tardieu Scale in muscle groups presenting pathological tone, allowing differentiation between neural and non-neural components of hypertonia. Statistically significant reductions in the final Tardieu score were observed in the hip adductors ($p < 0.001$), triceps surae ($p < 0.001$), quadriceps ($p = 0.028$), and gluteal muscles ($p = 0.005$), indicating a clinically meaningful decrease in spastic response at fast stretch velocities.

Regarding the R2–R1 angle, significant improvements were identified in the hip adductors ($p = 0.011$), hamstrings ($p = 0.045$), and triceps surae ($p < 0.001$), suggesting a partial reduction in the dynamic catch angle and improved tolerance to rapid passive stretch. In contrast, changes in the R2–R1 angle at the quadriceps and gluteal muscles did not reach statistical significance, indicating persistence of non-neural mechanical stiffness in these muscle groups.

4.Discussions

The present prospective observational study investigated the clinical effects of a multimodal physiotherapeutic approach for the management of lower limb spasticity in post-stroke patients undergoing inpatient neurological rehabilitation. The results demonstrate statistically significant improvements in spasticity severity, motor control, balance, and gait-related functional outcomes following individualized, combined rehabilitation interventions. These findings support the growing body of evidence highlighting the need for multimodal, patient-centered rehabilitation strategies in the management of post-stroke spasticity.

4.1.Spasticity Reduction: Neural and Non-Neural Components

A key finding of this study is a significant reduction in spasticity severity, as measured by the Modified Ashworth Scale, across all analyzed muscle groups, particularly in the triceps surae and hip adductors. These muscle groups are known to play a central role in pathological gait patterns after stroke, including equinovarus positioning and scissoring gait, which severely limit functional ambulation *(Gracies, 2005; Dietz and Sinkjaer, 2007).*

Importantly, the inclusion of the Tardieu Scale allowed a more nuanced interpretation of spasticity changes by differentiating between neural (velocity-dependent reflex activity) and non-neural (passive muscle stiffness) components. The observed reductions in final Tardieu scores across multiple muscle groups indicate clinically relevant modulation of spastic hypertonia. In contrast, changes in the R2–R1 angle were less consistent, a finding that aligns with previous reports suggesting that short-term rehabilitation may preferentially affect neural excitability rather than structural muscle properties *(Sheean and McGuire, 2009; Gracies et al., 2010).*

This distinction is clinically meaningful, as it underscores the importance of combining active motor training with modalities targeting tissue extensibility, such as stretching, thermotherapy, and ultrasound. The multimodal structure of the rehabilitation programs applied in this study likely contributed to addressing both components of spasticity, albeit with different temporal dynamics.

4.2 Functional Motor Rehabilitation and Balance

Beyond impairment-level outcomes, this study demonstrated significant improvements in functional motor performance, as reflected in increased Fugl-Meyer lower-limb scores and enhanced balance performance on the Berg Balance Scale. These findings reinforce the concept that spasticity reduction alone is insufficient unless accompanied by task-oriented motor retraining that promotes functional integration of improved muscle tone into meaningful movement patterns *(Olney and Richards, 1996; Ada et al., 2018).*

The improvement in balance performance is particularly relevant, as balance impairment is a major predictor of falls and reduced independence after stroke. Previous studies have highlighted the close relationship between lower limb spasticity, impaired postural control, and asymmetrical weight-bearing *(Bohannon and Leary, 1995).* The observed gains in balance in the present cohort likely reflect the synergistic effects of spasticity modulation, strengthening of antigravity musculature, and task-specific balance training incorporated within physiotherapy exercises and device-assisted interventions.

4.3 *Gait Performance and Functional Mobility*

Although improvements were observed in gait-related measures, including the 10-Meter Walk Test and Timed Up and Go Test, the magnitude of change varied across patients. The lack of statistical significance for TUG in this cohort may be partially explained by heterogeneity in ambulatory capacity, as only a subset of patients could perform the test at both time points. This observation highlights an important methodological consideration in stroke rehabilitation research, namely the ceiling and floor effects associated with functional tests in heterogeneous clinical populations *(Kollen et al., 2006).*

Nevertheless, the significant improvement in walking speed measured by the 10MWT supports the clinical relevance of the applied interventions. Walking speed is widely recognized as a robust indicator of functional rehabilitation and community ambulation potential after stroke *(Perry et al., 1995).* The observed gains are consistent with prior evidence demonstrating that combined physiotherapeutic interventions, particularly when integrating neuromuscular electrical stimulation and task-oriented gait training, can enhance locomotor efficiency in patients with spastic hemiparesis *(Stein et al., 2015; Mahmood et al., 2019).*

4.4 Clinical Relevance of Multimodal and Individualized Rehabilitation

One of the strengths of the present study lies in its reflection of real-world rehabilitation practice. Rather than applying isolated interventions, all patients received individualized combinations of therapeutic modalities based on clinical presentation, tolerance, and functional goals. This approach aligns with contemporary clinical guidelines, which advocate for integrated spasticity management strategies rather than monotherapeutic solutions *(Royal College of Physicians, 2018).*

The distribution of interventions illustrated the central role of physiotherapy exercises as the foundation of rehabilitation, complemented by electrotherapy, physical agents, and device-assisted therapies. Such complexity mirrors findings from recent systematic reviews indicating that multimodal approaches yield superior functional outcomes compared to single-modality interventions *(Tilborg et al., 2024; Afzal et al., 2023).* Importantly, the present results suggest that the clinical benefit arises not from any single modality, but from their strategic combination within a coherent rehabilitation framework.

4.5 Limitations and Future Directions

Several limitations must be acknowledged. The observational design and absence of a control group limit causal inference regarding the effectiveness of specific interventions. Additionally, the relatively small sample size and heterogeneity of applied treatment combinations preclude subgroup analyses that could further elucidate optimal therapeutic associations.

Future research should aim to integrate longitudinal follow-up to assess the durability of observed improvements and to explore dose–response relationships between specific modalities and functional outcomes. Randomized controlled trials comparing standardized multimodal protocols with individualized approaches may further clarify best practices in spasticity management.

4.6. Clinical Implications

Despite these limitations, the findings of this study provide valuable clinical insight. They support the use of comprehensive, individualized physiotherapeutic strategies to manage lower-limb spasticity after stroke and underscore the importance of evaluating both impairment-level and functional outcomes. The combined use of MAS and Tardieu scales, alongside functional assessments, enhances clinical decision-making and allows a more precise monitoring of rehabilitation progress.

5. Conclusions

Multimodal physiotherapy is an effective and clinically applicable strategy for reducing lower limb spasticity and improving functional outcomes after a stroke. The complexity of therapeutic approaches underscores the multifactorial nature of spasticity and underscores the need for individualized rehabilitation plans. Future research should focus on identifying the best combinations and dosages of physiotherapeutic interventions through controlled, longitudinal studies.

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