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Effects of Combined Transcutaneous Electrical Nerve Stimulation and Cryotherapy on Upper Limb Spasticity in Adults with Chronic Stroke

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ABSTRACT

Background: Upper limb spasticity is one of the most common motor impairments following stroke and significantly compromises functional independence, movement quality, and quality of life. Conventional physiotherapy often incorporates adjunctive modalities to reduce muscle hypertonia; however, evidence regarding the combined therapeutic effects of Transcutaneous Electrical Nerve Stimulation (TENS) and cryotherapy remains limited, particularly in individuals with chronic stroke.

Objective: This study aimed to evaluate the effects of combined Transcutaneous Electrical Nerve Stimulation (TENS) and cryotherapy on upper limb spasticity in adults with chronic stroke.

Methods: A single-group pre–post experimental study was conducted among fifteen adults with chronic stroke (13 males and 2 females) aged 51–69 years presenting with upper limb spasticity. Participants met predefined inclusion criteria, including Modified Ashworth Scale (MAS) grades 1–3 and the ability to ambulate with or without assistance. The intervention consisted of high-frequency TENS (100 Hz; pulse width 200 µs) administered to the affected upper limb, followed by 20 minutes of cryotherapy using crushed ice packs applied over the spastic musculature. Treatment sessions were conducted six days per week for four weeks. Spasticity was assessed before and after the intervention using the Modified Ashworth Scale (MAS). Pre- and post-intervention scores were compared using a paired-samples t-test, with statistical significance established at $p < 0.05$.

Results: Following the four-week intervention, participants demonstrated a significant reduction in upper limb spasticity compared with baseline measurements. Improvements were reflected by lower Modified Ashworth Scale scores after treatment, indicating decreased muscle hypertonia and enhanced voluntary motor control of the wrist and hand. Statistical analysis confirmed that the combined intervention produced a significant therapeutic effect ($p < 0.05$).

Conclusion: The findings suggest that combined TENS and cryotherapy may serve as an effective adjunctive rehabilitation strategy for reducing upper limb spasticity in adults with chronic stroke. The intervention appears to facilitate improved neuromuscular regulation and voluntary motor performance. Although the present findings are encouraging, larger randomized controlled trials with extended follow-up periods and functional outcome measures are recommended to confirm long-term clinical effectiveness.

Keywords: Stroke, Chronic Stroke, Upper Limb Spasticity, Transcutaneous Electrical Nerve Stimulation, TENS, Cryotherapy, Neurorehabilitation, Modified Ashworth Scale, Physical Therapy, Experimental Study.

INTRODUCTION

Stroke remains one of the leading causes of long-term disability and mortality worldwide, imposing a substantial clinical, social, and economic burden on healthcare systems and affected families. Despite remarkable advances in acute stroke management, including thrombolytic therapy, endovascular thrombectomy, and specialized stroke care units, a considerable proportion of survivors continue to experience persistent neurological impairments that adversely affect their independence and quality of life. Improvements in emergency care have increased survival rates over the past two decades; however, the growing population of stroke survivors has consequently increased the prevalence of chronic neurological complications requiring prolonged rehabilitation. Among these complications, upper limb motor dysfunction and spasticity are particularly debilitating because they directly interfere with voluntary movement, dexterity, self-care activities, occupational participation, and social reintegration. Consequently, optimizing rehabilitation strategies that effectively reduce spasticity while promoting functional recovery has become a major priority in contemporary neurorehabilitation research (Powers et al., 2019).

Stroke is characterized by the sudden interruption of cerebral blood flow resulting from either vascular occlusion (ischemic stroke) or intracerebral hemorrhage (hemorrhagic stroke), leading to neuronal injury, disruption of neural networks, and subsequent neurological deficits. The extent and pattern of impairment depend on multiple factors, including lesion location, lesion volume, vascular territory involved, age, premorbid functional status, and the timing of therapeutic intervention. Although spontaneous neuroplasticity contributes to partial recovery during the early post-stroke period, many survivors experience persistent impairments in motor control that remain evident months or even years after the initial cerebrovascular event. Epidemiological studies indicate that upper limb dysfunction persists in a substantial proportion of chronic stroke survivors, with only a minority regaining normal hand function despite comprehensive rehabilitation. The limited recovery of upper extremity function highlights the complexity of corticospinal damage and underscores the need for evidence-based interventions capable of enhancing motor relearning while simultaneously reducing secondary complications such as muscle overactivity and contracture (Langhorne et al., 2011; Winstein et al., 2016; Pollock et al., 2014).

Among the various neurological sequelae following stroke, spasticity represents one of the most challenging impairments encountered during rehabilitation. Traditionally defined as a velocity-dependent increase in tonic stretch reflexes resulting from hyperexcitability of the stretch reflex, spasticity constitutes only one component of the broader upper motor neuron syndrome. Contemporary neuroscience recognizes that post-stroke spasticity develops through a complex interaction of central and peripheral mechanisms rather than through reflex hyperexcitability alone. Damage to descending corticoreticular and corticospinal pathways disrupts inhibitory supraspinal control over spinal interneurons, producing exaggerated alpha-motor neuron excitability, altered reciprocal inhibition, abnormal sensorimotor integration, and increased excitability of spinal reflex circuits. Over time, these neural alterations are accompanied by secondary biomechanical changes including muscle shortening, collagen deposition, connective tissue remodeling, altered viscoelastic properties, and contracture formation, all of which contribute to increased resistance during passive movement and further compromise voluntary motor performance. These multifactorial mechanisms explain why effective management of post-stroke spasticity often requires multimodal therapeutic approaches targeting both neural and non-neural contributors to muscle hypertonia (Pandyan et al., 2005).

Upper limb spasticity frequently affects the shoulder adductors, elbow flexors, forearm pronators, wrist flexors, and finger flexors, resulting in the characteristic flexor synergy pattern observed in many individuals with chronic stroke. The excessive muscle tone associated with this abnormal posture restricts active joint movement, reduces manual dexterity, impairs grasp-and-release functions, and significantly limits performance during activities of daily living such as dressing, feeding, writing, personal hygiene, and object manipulation. Beyond its mechanical consequences, spasticity is commonly associated with pain, fatigue, joint stiffness, soft tissue shortening, skin complications, sleep disturbance, caregiver burden, and psychological distress. These consequences collectively reduce quality of life while increasing healthcare utilization and rehabilitation costs. Furthermore, persistent spasticity interferes with task-specific motor practice, thereby limiting opportunities for cortical reorganization and functional recovery. Consequently, early identification and effective management of upper limb spasticity are considered essential components of comprehensive stroke rehabilitation aimed at maximizing long-term functional independence. (Francisco et al., 2021).

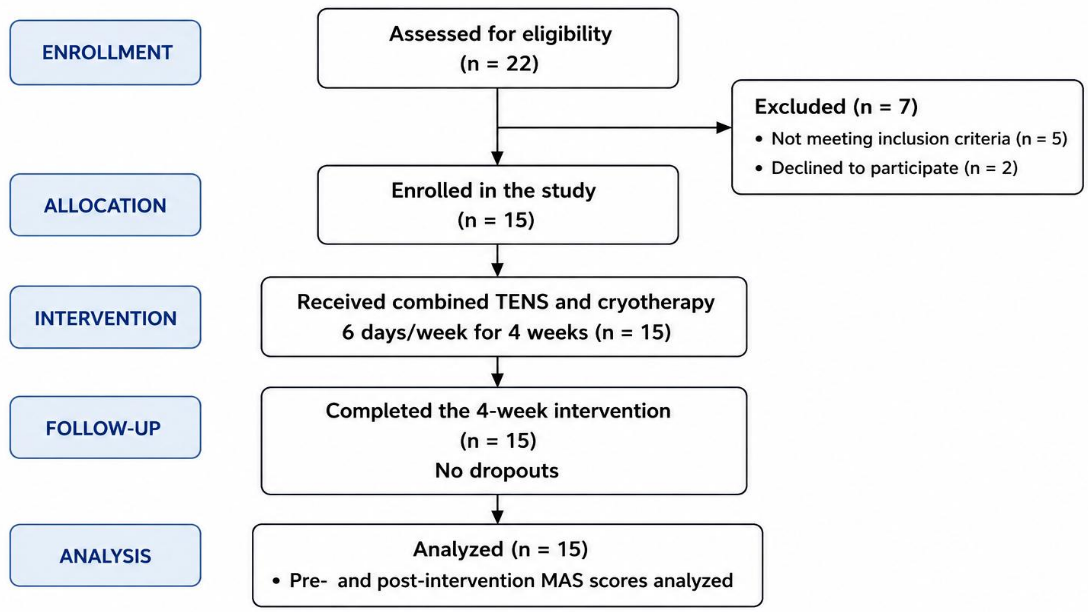
Current clinical management of post-stroke spasticity involves a multidisciplinary approach integrating pharmacological, physical, and surgical interventions. Pharmacological management commonly includes oral antispastic agents such as baclofen, tizanidine, diazepam, and dantrolene; however, systemic adverse effects including sedation, muscle weakness, dizziness, and reduced functional participation often limit long-term adherence. Botulinum toxin type A has become the preferred focal treatment for localized upper limb spasticity because of its ability to temporarily inhibit acetylcholine release at the neuromuscular junction. Nevertheless, repeated injections are costly, require specialized expertise, and do not consistently translate into meaningful improvements in functional activity unless combined with intensive rehabilitation. Surgical procedures such as selective neurotomy, intrathecal baclofen therapy, or orthopedic interventions are generally reserved for severe or refractory cases because of their invasiveness and associated risks. Consequently, increasing attention has shifted toward safe, non-invasive rehabilitation modalities capable of modulating neural excitability while facilitating active motor training and functional recovery.

Within contemporary neurorehabilitation, physical therapy remains the cornerstone of spasticity management. Conventional rehabilitation typically combines stretching, range-of-motion exercises, strengthening, task-oriented training, constraint-induced movement therapy, mirror therapy, proprioceptive neuromuscular facilitation, robotic-assisted therapy, functional electrical stimulation, and sensory stimulation techniques. However, the effectiveness of individual interventions varies considerably because post-stroke spasticity arises from heterogeneous neurophysiological mechanisms that differ across patients and stages of recovery. Increasing evidence therefore supports individualized multimodal rehabilitation programs that combine complementary therapeutic modalities capable of simultaneously addressing neural excitability, muscle stiffness, sensory dysfunction, and motor relearning. In this context, transcutaneous electrical nerve stimulation (TENS) and cryotherapy have emerged as promising adjunctive interventions because both are inexpensive, widely available, non-invasive, and relatively easy to integrate into routine physiotherapy practice (Mahmood et al., 2019).

MATERIALS & METHODS

Study Design: This study employed a single-group pre–post experimental design to investigate the effects of combined Transcutaneous Electrical Nerve Stimulation (TENS) and cryotherapy on upper limb spasticity in adults with chronic stroke. Participants were assessed before the commencement of the intervention (pre-test) and immediately after completion of the four-week intervention protocol (post-test). The study was conducted following the ethical principles outlined in the Declaration of Helsinki (2013) for research involving human participants.

Figure 1. CONSORT-style Flow Diagram



TENS: Transcutaneous Electrical Nerve Stimulation; MAS: Modified Ashworth Scale

Study Setting: The study was conducted at the Department of Physiotherapy, College of Applied Education and Health Sciences (CAEHS), Meerut, Uttar Pradesh, India, where all participant recruitment, intervention sessions, and outcome assessments were performed under the supervision of qualified physiotherapists.

Participants: A total of 15 individuals diagnosed with chronic stroke participated in the study. Participants were recruited using a convenience sampling technique from patients attending the outpatient neurorehabilitation services of the institution. Prior to enrolment, all participants underwent a comprehensive clinical examination to determine eligibility according to the predefined inclusion and exclusion criteria.

Among the enrolled participants, 13 were males and 2 were females, with an age range of 51–69 years. Nine participants had ischemic stroke, whereas six had hemorrhagic stroke. Eight participants presented with left-sided hemiplegia and seven with right-sided hemiplegia.

Inclusion Criteria
Participants were included if they fulfilled all of the following criteria:

- Diagnosed with chronic stroke (≥4 months post-stroke)
- Age between 50 and 70 years
- Both male and female participants
- Presence of upper limb spasticity graded 1–3 on the Modified Ashworth Scale (MAS)
- Medically stable and able to participate in physiotherapy sessions
- Willingness to participate and provide written informed consent

Exclusion Criteria
Participants were excluded if they had:

- Acute stroke (<4 months)
- Severe cognitive impairment or inability to follow verbal instructions
- Other neurological disorders affecting motor function
- Orthopedic conditions limiting upper limb movement
- Cardiac pacemaker or implanted electrical devices contraindicating TENS
- Uncontrolled hypertension or unstable cardiovascular disease

Ethical Considerations:
Prior to data collection, the study protocol was approved by the Institutional Research Committee of the College of Applied Education and Health Sciences, Meerut. Each participant received detailed verbal and written information regarding the objectives, procedures, potential benefits, and possible risks of the study. Written informed consent was obtained from every participant before enrolment. Confidentiality of participant information was maintained throughout the study, and participants were informed of their right to withdraw from the study at any stage without affecting their routine medical care.

Outcome Measure:
Upper limb spasticity was evaluated using the Modified Ashworth Scale (MAS), one of the most widely accepted clinical tools for measuring resistance to passive muscle stretch in neurological rehabilitation. The MAS grades muscle tone on a six-point ordinal scale ranging from 0 (no increase in muscle tone) to 4 (affected part rigid in flexion or extension). The assessment was performed by the same experienced physiotherapist before and after completion of the intervention to minimize inter-rater variability.

Intervention Protocol:
Transcutaneous Electrical Nerve Stimulation (TENS)
A commercially available HMS Transcutaneous Electrical Nerve Stimulation unit was used throughout the study.
The stimulation parameters were standardized for all participants:

- Frequency: **100 Hz**
- Pulse Width: **200 µs**
- Intensity: Adjusted to produce a strong but comfortable sensory stimulation without visible muscle contraction
- Treatment Duration: **30 minutes**
- Electrode Placement: Bipolar adhesive electrodes positioned over the motor points and muscle belly of the spastic wrist and finger flexor muscles.

Participants remained comfortably seated with the affected upper limb adequately supported throughout the stimulation period.

Cryotherapy:
Immediately following TENS application, cryotherapy was administered using approximately 500 g of crushed ice enclosed within a plastic bag and wrapped in a moist towel to prevent direct skin contact.
The cryotherapy pack was applied over the spastic flexor muscles of the affected forearm for 20 minutes while participants remained in a relaxed seated position. Skin integrity and participant comfort were

continuously monitored during treatment to prevent cold-induced tissue injury.

Treatment Schedule:
Each participant received:

- One treatment session per day
- Six sessions per week
- Total intervention duration: **4 weeks**
- Total number of treatment sessions: **24 sessions**

All intervention sessions were administered by the same physiotherapist to ensure treatment consistency.

Data Collection Procedure
Baseline demographic and clinical characteristics, including age, sex, stroke type, side of hemiplegia, and baseline Modified Ashworth Scale scores, were recorded prior to intervention. Following completion of the four-week treatment protocol, post-intervention MAS scores were obtained using identical assessment procedures. All outcome measurements were recorded under standardized environmental conditions to minimize measurement bias.

Statistical Analysis

Descriptive statistics were calculated for demographic and clinical variables and presented as mean ± standard deviation (SD) for continuous variables and frequencies with percentages for categorical variables.
The normality of data distribution was assessed using the Shapiro–Wilk test. Differences between pre- and post-intervention Modified Ashworth Scale scores were analyzed using a paired-samples t-test. Statistical significance was established at $p < 0.05$.
To quantify the magnitude of treatment effectiveness, Cohen's d effect size and 95% confidence intervals (95% CI) were also calculated.

RESULT

Participant Characteristics
A total of **15 participants** with chronic stroke completed the study, and no participant withdrew during the intervention period. The study population consisted of **13 males (86.7%)** and **2 females (13.3%)**, with a mean age of **59.0 ± 6.2 years** (range: 51–69 years). Among the participants, **nine (60.0%)** had ischemic stroke, whereas **six (40.0%)** had hemorrhagic stroke. Eight participants (53.3%) presented with left-sided hemiplegia, while seven (46.7%) exhibited right-sided hemiplegia.

Table 1: Characteristics of the Study Participants

Variable	Value
Sample size	15
Age (years)	59.0 ± 6.2
Male, n (%)	13 (86.7)
Female, n (%)	2 (13.3)
Ischemic stroke, n (%)	9 (60.0)
Hemorrhagic stroke, n (%)	6 (40.0)
Right hemiplegia, n (%)	7 (46.7)
Left hemiplegia, n (%)	8 (53.3)

Values are presented as mean ± standard deviation or frequency (%).

Effect of Combined TENS and Cryotherapy on Upper Limb Spasticity
Upper limb spasticity was evaluated before and after the four-week intervention using the Modified Ashworth Scale (MAS). The mean MAS score decreased from **2.07 ± 0.70** at baseline to **1.33 ± 0.72** following the intervention, representing an average reduction of **0.73 MAS units**.
Because the Modified Ashworth Scale is an ordinal clinical measure, both a paired-samples *t*-test and a non-parametric Wilcoxon signed-rank test were performed. The paired *t*-test demonstrated a statistically

significant reduction in spasticity (t = 3.56, p = 0.003). Consistent with this finding, the Wilcoxon signed-rank test also indicated a significant improvement following treatment (W = 0.00, p = 0.009). The calculated effect size (Cohen's dz = 0.92) indicated a **large treatment effect**, suggesting that the intervention produced clinically meaningful improvements in muscle tone.

Table 2: Comparison of Pre- and Post-intervention Modified Ashworth Scale Scores

Outcome Measure	Pre-intervention (Mean ± SD)	Post-intervention (Mean ± SD)	Mean Difference	Test Statistic	p value	Effect Size
Modified Ashworth Scale	2.07 ± 0.70	1.33 ± 0.72	0.73	t = 3.56	0.003**	Cohen's dz = 0.92

**p < 0.01

Table 3: Wilcoxon Signed-Rank Test for Modified Ashworth Scale Scores

Outcome	Test	Test Statistic	p value
Modified Ashworth Scale	Wilcoxon Signed-Rank Test	W = 0.00	0.009**

**p < 0.01

Clinical Interpretation

Following four weeks of combined Transcutaneous Electrical Nerve Stimulation and cryotherapy, participants demonstrated a statistically significant reduction in upper limb spasticity. The observed decrease in Modified Ashworth Scale scores indicates improved regulation of muscle tone and suggests enhanced voluntary motor control of the affected upper extremity. The large effect size further supports the clinical relevance of the intervention, indicating that the improvements were not only statistically significant but also potentially meaningful in routine neurorehabilitation practice.

DISCUSSION

The present study investigated the effectiveness of combined Transcutaneous Electrical Nerve Stimulation (TENS) and cryotherapy in reducing upper limb spasticity among adults with chronic stroke. Following four weeks of intervention, a statistically significant reduction in Modified Ashworth Scale (MAS) scores was observed, indicating that the combined therapeutic approach effectively decreased muscle hypertonia in the affected upper extremity. The magnitude of improvement, demonstrated by both the paired-samples t-test and Wilcoxon signed-rank test, suggests that the intervention produced not only statistical significance but also clinically meaningful improvements in neuromuscular function. These findings support the growing body of evidence that multimodal physiotherapeutic interventions can effectively modulate post-stroke spasticity while enhancing motor performance and functional recovery (Mahmood et al., 2019). The reduction in spasticity observed in the present investigation is likely attributable to the complementary neurophysiological mechanisms of TENS and cryotherapy. High-frequency TENS primarily activates large-diameter afferent sensory fibers, which enhance presynaptic inhibition of Ia afferent pathways, facilitate reciprocal inhibition, and suppress hyperexcitability of spinal motor neurons. These mechanisms reduce abnormal stretch reflex activity and decrease involuntary muscle contraction characteristic of upper motor neuron lesions. Additionally, repeated sensory stimulation may promote cortical reorganization and improve sensorimotor integration through activity-dependent neuroplasticity, thereby facilitating voluntary motor control (Levin et al., 1992; Mahmood et al., 2019; Carson & Buick, 2021). Consequently, participants in the present study demonstrated improved regulation of muscle tone following repeated TENS sessions. Cryotherapy likely augmented these effects through different but complementary physiological pathways. Local cooling decreases motor and sensory nerve conduction velocity, reduces muscle spindle sensitivity, suppresses gamma motor neuron activity, and temporarily lowers stretch reflex excitability. Furthermore, cryotherapy decreases local metabolic demand and inflammatory activity while reducing pain and muscle stiffness, thereby allowing greater ease of passive movement and facilitating subsequent therapeutic exercise. The transient reduction in hypertonia created by cooling may provide an optimal therapeutic window during which voluntary movement training becomes more effective (Garcia et al., 2019; Alcantara et al., 2019). The sequential application of TENS followed by cryotherapy employed in the present study may therefore have produced additive or synergistic neuromuscular effects, explaining the substantial reduction in MAS scores observed after four weeks of treatment.

The findings of the present study are consistent with those reported by Mahmood et al. (2019) in their systematic review and meta-analysis, which concluded that TENS significantly reduces post-stroke spasticity and improves motor function when incorporated into comprehensive rehabilitation programs. Similarly, Darshan Laddha et al. (2016) demonstrated that both 30-minute and 60-minute applications of high-frequency TENS significantly reduced plantar flexor spasticity while improving walking speed in individuals with chronic stroke. Cho et al. (2013) also reported immediate reductions in gastrocnemius spasticity together with improvements in balance following a single session of TENS, emphasizing the ability of electrical stimulation to rapidly modulate spinal reflex excitability. Collectively, these investigations support the present findings by demonstrating that appropriately dosed TENS can effectively reduce spasticity across different muscle groups affected by stroke. Comparable benefits have also been reported for cryotherapy as an adjunctive intervention in neurorehabilitation. Garcia et al. (2019) observed significant reductions in lower limb spasticity after 20 minutes of localized cryotherapy without adversely affecting joint position sense, suggesting that cooling effectively suppresses hypertonia while preserving proprioceptive function. Alcantara et al. (2019) similarly demonstrated that cryotherapy significantly reduced calf muscle hypertonia in chronic stroke survivors, although improvements in gait parameters were not immediately evident. Combining these interventions may therefore produce greater therapeutic benefits than either modality alone. This concept aligns with current rehabilitation paradigms advocating multimodal treatment strategies capable of simultaneously addressing neural, muscular, and functional impairments rather than relying on a single intervention. Although the present study did not include separate TENS-only or cryotherapy-only comparison groups, the observed improvements suggest that integrating complementary modalities into routine rehabilitation may enhance treatment efficiency in chronic stroke management.

The clinical implications of these findings are particularly relevant for rehabilitation settings with limited access to advanced technologies. Both TENS and cryotherapy are inexpensive, non-invasive, readily available, and easily administered by trained physiotherapists. Unlike pharmacological management, these interventions are associated with minimal systemic adverse effects and can be safely incorporated into daily rehabilitation programs. Furthermore, reducing upper limb spasticity may improve patient participation in task-oriented training, facilitate active range-of-motion exercises, enhance hand function, and ultimately increase independence during activities of daily living. Consequently, the combined intervention investigated in the present study may represent a practical and cost-effective strategy for optimizing long-term neurorehabilitation outcomes in individuals with chronic stroke. Despite these encouraging findings, several limitations should be acknowledged. First, the relatively small sample size limits statistical power and restricts the generalizability of the findings to the broader stroke population. Second, the absence of a randomized control group precludes definitive attribution of the observed improvements solely to the intervention and does not eliminate the possibility of spontaneous recovery or other confounding influences. Third, spasticity was evaluated using the Modified Ashworth Scale, which, although widely accepted in clinical practice, remains an ordinal measure with recognized limitations regarding sensitivity and inter-rater reliability. Finally, the study evaluated only immediate post-intervention outcomes and therefore cannot determine the long-term sustainability of treatment effects. Future investigations should employ randomized controlled trial designs with larger sample sizes, longer follow-up periods, objective neurophysiological assessments (e.g., H-reflex, electromyography), and functional outcome measures such as the Fugl–Meyer Assessment, Action Research Arm Test, and Stroke Impact Scale to establish the long-term effectiveness of combined TENS and cryotherapy. Overall, the findings of the present study indicate that the combination of Transcutaneous Electrical Nerve Stimulation and cryotherapy provides a clinically effective, safe, and economical intervention for reducing upper limb spasticity in adults with chronic stroke. The observed improvements are biologically plausible, supported by existing neurophysiological evidence, and consistent with contemporary rehabilitation literature. These findings further strengthen the rationale for incorporating multimodal non-pharmacological interventions into comprehensive stroke rehabilitation programs aimed at maximizing functional recovery and improving quality of life.

CONCLUSION

The present study demonstrated that the combined application of Transcutaneous Electrical Nerve Stimulation (TENS) and cryotherapy produced a significant reduction in upper limb spasticity among adults with chronic stroke following a four-week intervention program. The observed improvement in Modified Ashworth Scale scores indicates that the integration of these two non-invasive therapeutic modalities effectively decreased muscle hypertonia and enhanced neuromuscular regulation. The statistically significant findings, together with the large treatment effect, suggest that the combined intervention has meaningful clinical value in the management of post-stroke spasticity. The therapeutic benefits observed in this study are supported by the complementary physiological mechanisms of TENS and cryotherapy. While TENS facilitates presynaptic inhibition, modulates spinal reflex excitability, and enhances sensorimotor integration, cryotherapy temporarily reduces nerve conduction velocity, muscle spindle sensitivity, and reflex-mediated muscle activity. The integration of these mechanisms appears to provide a favorable environment for reducing spasticity and promoting voluntary motor control of the affected upper limb. Consequently, this combined approach may improve patient participation in rehabilitation exercises and contribute to better functional recovery during chronic stroke rehabilitation. From a clinical perspective, both TENS and cryotherapy are inexpensive, non-invasive, widely accessible, and easily incorporated into routine physiotherapy practice. Their favorable safety profile and minimal adverse effects make them practical adjuncts to conventional rehabilitation, particularly in resource-limited healthcare settings where access to advanced rehabilitation technologies may be restricted. The findings of the present study therefore support the inclusion of combined TENS and cryotherapy as part of comprehensive multidisciplinary rehabilitation programs for individuals with chronic stroke presenting with upper limb spasticity. Despite these encouraging findings, certain limitations should be acknowledged. The relatively small sample size, absence of a randomized control group, reliance on a single clinical outcome measure, and lack of long-term follow-up limit the generalizability of the results. Future research should focus on well-designed multicenter randomized controlled trials with larger sample sizes, extended follow-up periods, and the inclusion of objective neurophysiological, biomechanical, and functional outcome measures to further establish the long-term efficacy of this combined intervention. Comparative studies evaluating combined TENS and cryotherapy against individual treatment modalities would also help determine their relative therapeutic contributions. In conclusion, the present study provides evidence that combined Transcutaneous Electrical Nerve Stimulation and cryotherapy constitute an effective, safe, and clinically feasible intervention for reducing upper limb spasticity in adults with chronic stroke. The findings contribute to the growing evidence supporting multimodal, non-pharmacological rehabilitation strategies and may assist clinicians in developing more effective, evidence-based rehabilitation protocols aimed at improving functional outcomes and quality of life in stroke survivors.

Declaration by Authors

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