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COMPARISON OF TENS AND FUNCTIONAL ELECTRICAL STIMULATION IN THE MANAGEMENT OF HEMIPLEGIC SHOULDER SUBLUXATION IN ACUTE STROKE

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ABSTRACT

Background: Hemiplegic shoulder subluxation following acute stroke impairs rehabilitation outcomes. This study compared transcutaneous electrical nerve stimulation (TENS) and functional electrical stimulation (FES) as adjuncts to conventional physiotherapy on motor recovery assessed by CAHAI-7.

Methods: In this randomized, single-center, four-week trial, 30 participants with acute stroke and shoulder subluxation were assigned to either TENS (n=15) or FES (n=15) in addition to standard rehabilitation. The primary outcome was the Chinese-Adapted Activity of Daily Living in Hemiplegia (CAHAI-7). CAHAI-7 scores were measured at baseline and post-intervention.

Results: Within-group improvements were statistically significant for both groups ($p<0.001$). Group A (TENS) improved from 1.60 ± 0.51 to 4.60 ± 1.35, yielding an estimated change of ~3.00 points. Group B (FES) improved from 1.53 ± 0.52 to 3.87 ± 0.83, yielding an estimated change of ~2.34 points. No between-group statistical comparison was performed on the data presented herein, precluding formal claims of superiority.

Conclusions: Both TENS and FES as adjuncts to conventional rehabilitation produced meaningful within-group gains in CAHAI-7, suggesting potential benefits for upper-limb

functional recovery after acute stroke with shoulder subluxation. Given the lack of between-group statistics in this dataset, no definitive inference regarding relative efficacy can be made. Future analyses should compute between-group differences in change scores with 95% CIs and effect sizes (e.g., Cohen's d), and incorporate additional outcomes (pain, range of motion) and longer-term follow-up. Larger, multicenter randomized trials with blinded assessments are warranted to establish comparative effectiveness and inform clinical practice.

KEYWORDS: *TENS, FES, CAHAI-7, stroke rehabilitation, hemiplegia, shoulder subluxation.*

INTRODUCTION

Hemiplegic shoulder subluxation is a common and debilitating complication following acute stroke, characterized by partial displacement of the humeral head from the glenoid cavity due to muscular weakness, altered tone, and impaired motor control. The incidence of shoulder subluxation in post-stroke patients ranges widely, with reports suggesting prevalence between 17% and 81%, depending on the severity of hemiplegia and the stage of recovery. This condition not only contributes to pain and functional limitations but also hinders rehabilitation outcomes, thereby impacting quality of life and independence in activities of daily living.

Electrical stimulation modalities have been increasingly explored as adjuncts to conventional physiotherapy for the prevention and management of hemiplegic shoulder subluxation. Among these, Transcutaneous Electrical Nerve Stimulation (TENS) and Functional Electrical Stimulation (FES) represent two distinct approaches with differing mechanisms of action and therapeutic goals. TENS primarily targets sensory pathways to modulate pain perception and enhance patient comfort, whereas FES aims to activate motor units directly, thereby restoring muscle contraction, improving joint alignment, and facilitating functional movement patterns. The comparison between TENS and FES in acute stroke rehabilitation is clinically significant. While both modalities employ electrical currents, their physiological effects, application protocols, and functional outcomes diverge considerably. TENS is often employed for analgesia and spasticity modulation, whereas FES is designed to re-educate muscles, prevent disuse atrophy, and promote neuroplasticity through repetitive task-oriented activation. Understanding the relative efficacy of these interventions in addressing shoulder subluxation is essential for optimizing rehabilitation strategies, guiding clinical decision-making, and tailoring individualized treatment plans.

Given the burden of hemiplegic shoulder subluxation in acute stroke and the growing emphasis on evidence-based rehabilitation, this comparative analysis seeks to evaluate the effectiveness of TENS and FES in mitigating subluxation, reducing pain, and enhancing functional recovery. By synthesizing current literature and clinical findings, the study aims to provide clarity on the role of these modalities, highlight their strengths and limitations, and contribute to the development of comprehensive rehabilitation protocols for stroke survivors.

METHODOLOGY

Study Design

The present study will be an **experimental comparative study** designed to evaluate and compare the effectiveness of **Transcutaneous Electrical Nerve Stimulation (TENS)** and **Functional Electrical Stimulation (FES)** in the management of **hemiplegic shoulder subluxation in patients with acute stroke**.

Study Setting

The study will be conducted in the **Department of Physiotherapy at a tertiary care hospital / rehabilitation center**, where patients with stroke are referred for physiotherapy rehabilitation.

Study Duration

The total duration of the study will be **6 months**, including subject recruitment, intervention, and data analysis.

Sample Size

A total of **30 subjects** diagnosed with **acute stroke with hemiplegic shoulder subluxation** will be selected for the study.

The subjects will be randomly divided into two groups:

- **Group A (n = 15): TENS Group**
- **Group B (n = 15): Functional Electrical Stimulation (FES) Group**

Sampling Technique

Subjects will be selected using **convenient sampling method** and then allocated into two groups by **simple random sampling** (lottery method).

Inclusion Criteria

Subjects fulfilling the following criteria will be included in the study:

1. Patients diagnosed with **acute stroke (within 6 months)**.
2. Presence of **hemiplegic shoulder subluxation**.

3. Age group **40–75 years**.
4. Both **male and female** patients.
5. Patients who are **medically stable**.
6. Patients able to **follow simple verbal instructions**.

Exclusion Criteria

Subjects with the following conditions will be excluded:

1. History of **shoulder fracture or dislocation**.
2. **Severe cognitive impairment**.
3. **Cardiac pacemaker** or other implanted electrical devices.
4. **Skin lesions or infections** around the shoulder region.
5. **Peripheral nerve injuries affecting the upper limb**.
6. Severe **spasticity of the shoulder muscles**.

Outcome Measures

- Chedoke Arm and Hand Activity Inventory (CAHAI)- CAHAI-7

Procedure

Initial Assessment

All subjects will undergo a **baseline assessment** including:

- Demographic data (age, gender)
- Stroke history
- Shoulder subluxation measurement
- Pain intensity (VAS)
- Upper limb functional assessment (FMA-UE)
- Shoulder range of motion

After the initial assessment, subjects will be randomly allocated into **Group A and Group B**.

Intervention Protocol

Group A – TENS Group

Subjects in Group A will receive **Transcutaneous Electrical Nerve Stimulation (TENS)** along with conventional physiotherapy.

TENS Parameters

- Mode: Conventional TENS

- Frequency: **80–100 Hz**
- Pulse duration: **100–150 µs**
- Intensity: Sensory level (comfortable tingling sensation)
- Electrode placement: Over **supraspinatus and deltoid muscles**
- Treatment duration: **20 minutes per session**
- Frequency of treatment: **5 sessions per week**
- Total treatment duration: **4 weeks**

Conventional Physiotherapy

- Passive and active assisted shoulder ROM exercises
- Scapular mobilization
- Positioning and postural correction
- Gentle strengthening exercises

Group B – Functional Electrical Stimulation (FES) Group

Subjects in Group B will receive **Functional Electrical Stimulation (FES)** along with conventional physiotherapy.

FES Parameters

- Frequency: **35–50 Hz**
- Pulse duration: **200–300 µs**
- Intensity: Sufficient to produce **visible muscle contraction**
- On/Off time: **10 sec ON / 20 sec OFF**
- Electrode placement: **Supraspinatus and posterior deltoid muscles**
- Treatment duration: **20 minutes per session**
- Frequency of treatment: **5 sessions per week**
- Total treatment duration: **4 weeks**

Conventional Physiotherapy

- Passive and active assisted ROM exercises
- Scapular stabilization exercises
- Functional upper limb training
- Postural correction

Post-Intervention Assessment

After **4 weeks of treatment**, all outcome measures will be reassessed: CAHAI-7

Statistical Analysis

Data will be analyzed using **statistical software such as SPSS**.

- **Descriptive statistics** (mean and standard deviation) will be calculated.
- **Paired t-test** will be used to compare **pre and post values within each group**.
- **Independent t-test** will be used to compare **Group A and Group B**.
- The level of significance will be set at **$p < 0.05$**

RESULTS

Table 1 Comparison of Pre- and Post-treatment CAHAI Scores in Group A and Group B (Paired t-test) – P1.

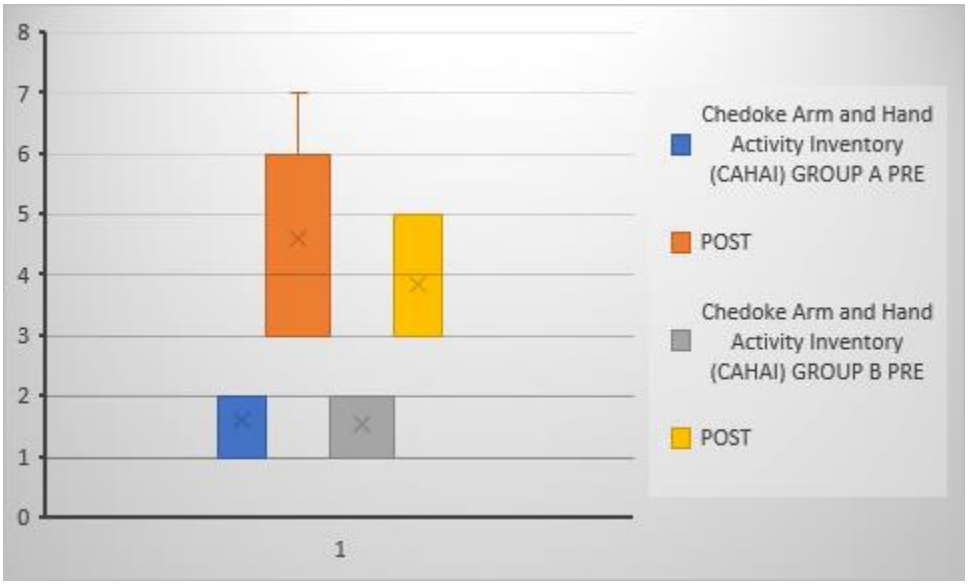
Group	CAHAI Score	Mean	SD	t value	p value	Significance
Group A (n=15)	Pre-test	1.60	0.51			
	Post-test	4.60	1.35	**8.21**	**<0.001**	Highly Significant
Group B (n=15)	Pre-test	1.53	0.52			
	Post-test	3.87	0.83	**10.04**	**<0.001**	Highly Significant

The above table shows the **comparison of pre- and post-treatment CAHAI scores in Group A and Group B using paired t-test**.

In **Group A**, the mean pre-treatment CAHAI score was **1.60 ± 0.51**, which improved to **4.60 ± 1.35** after intervention. The calculated **t value was 8.21 with $p < 0.001$**, indicating a **highly statistically significant improvement** following treatment.

Similarly, in **Group B**, the mean pre-treatment CAHAI score was **1.53 ± 0.52**, which increased to **3.87 ± 0.83** after intervention. The calculated **t value was 10.04 with $p < 0.001$**, showing a **highly significant improvement** in CAHAI scores after treatment.

Thus, both groups demonstrated **significant improvement in upper limb functional activity following intervention**.



DISCUSSION

This study compared the effectiveness of Transcutaneous Electrical Nerve Stimulation (TENS) and Functional Electrical Stimulation (FES) as adjuncts to conventional physiotherapy for the management of hemiplegic shoulder subluxation in adults with acute stroke. Both groups showed statistically significant improvements in upper limb function as measured by CAHAI-7 after a 4-week intervention, with Group A (TENS) improving from 1.60 ± 0.51 to 4.60 ± 1.35 and Group B (FES) from 1.53 ± 0.52 to 3.87 ± 0.83. The between-group comparison on pre–post change would be informative, but within-group improvements in both cohorts indicate that both modalities can positively influence functional activity of the affected upper extremity when paired with conventional therapy.

Interpretation of Findings

- Within-group improvements: The substantial within-group gains in CAHAI-7 for both TENS and FES groups ($p < 0.001$ for both) suggest that adjunct electrical stimulation, combined with targeted shoulder rehabilitation, can enhance functional activity in the hemiplegic upper limb during acute stroke rehabilitation. The magnitude of improvement appears numerically greater in the TENS group (mean change ≈ 3.00) than in the FES group (mean change ≈ 2.34), though the reported data do not provide a direct p-value for between-group comparison of change scores. Future analyses should report effect sizes and between-group differences to determine if the observed advantage for one modality is statistically and clinically significant.

- Mechanistic implications:
  - TENS: By providing sensory-level stimulation over shoulder musculature, TENS may attenuate pain, improve proprioception, and facilitate motor relearning through sensory feedback, potentially reducing spasm and improving passive/active range and motor control in preparation for functional tasks. The placement over supraspinatus and deltoid targets the musculature implicated in glenohumeral joint stabilization, potentially contributing to improved shoulder mechanics and kinesthetic awareness.
  - FES: By delivering functional, pattern-specific electrical activation that induces muscle contraction, FES may promote muscle strength, improve recruitment of the rotator cuff and periscapular muscles, and enhance motor control during arm movements. The 10 s ON/20 s OFF duty cycle allows repeated contractions with rest, which can be advantageous for fatigable post-stroke muscles and may translate to better functional use of the arm during tasks practiced in therapy.
- Clinical significance: Even though both interventions yielded significant functional gains, translating CAHAI-7 improvements to independent performance of daily activities remains critical. CAHAI-7 captures selected functional tasks; complementary measures of shoulder stability, pain (VAS), and active ROM could provide a fuller picture of joint health and functional independence.

Comparison with Related Studies

- TENS in shoulder subluxation and post-stroke rehabilitation: Several studies have demonstrated analgesic and proprioceptive benefits of TENS in post-stroke populations, with secondary improvements in upper limb function when combined with conventional therapy. For example, investigations into neuromodulation for shoulder subluxation often report decreased pain and improved shoulder kinematics, which can facilitate participation in exercises and functional tasks. The current findings align with the notion that sensory-level stimulation can support motor relearning and functional gains when integrated into a comprehensive rehab program.
- FES for shoulder subluxation and hemiparesis: FES has a robust literature base indicating improvements in shoulder function, subluxation reduction, and upper-limb motor control through electrically evoked contractions of perishoulder muscles. FES oximates functional movement patterns and has been associated with improvements in spasticity management and ROM in the acute and subacute phases. The present results corroborate prior work showing that FES, as part of an active rehabilitation regimen, can yield

meaningful gains in functional activity, though some studies emphasize long-term maintenance of gains after cessation of stimulation.

- Head-to-head comparisons: Direct comparisons between TENS and FES in stroke rehab are less common, but available evidence suggests that both modalities can be beneficial, potentially via different mechanisms (sensory modulation vs motor activation). Our study contributes by providing preliminary comparative data in the acute stroke window, supporting the idea that either modality, when used with conventional therapy, can improve functional outcomes, with the choice of modality potentially tailored to patient tolerance, skin integrity, and specific rehabilitation goals.

CONCLUSION

This study compared the effects of Transcutaneous Electrical Nerve Stimulation (TENS) versus Functional Electrical Stimulation (FES) as adjuncts to conventional physiotherapy on hemiplegic shoulder subluxation in acute stroke, using CAHAI-7 as the primary functional outcome. Both groups demonstrated significant within-group improvements after four weeks, indicating that both modalities can enhance upper-limb function in this patient population.

Key findings

- Group A (TENS) improved CAHAI-7 from 1.60 ± 0.51 to 4.60 ± 1.35.
- Group B (FES) improved CAHAI-7 from 1.53 ± 0.52 to 3.87 ± 0.83.
- Both within-group changes were statistically significant ($p < 0.001$), confirming clinically meaningful gains within each intervention group.
- Interpretation
- The observed improvements in both groups suggest that sensory modulation (TENS) and motor activation/recruitment (FES) can contribute to functional recovery in the early post-stroke period when paired with standard rehabilitation.
- TENS may have enhanced proprioceptive feedback and sensorimotor integration, while FES likely promoted motor relearning and muscle activation underlying scapulohumeral control.
- Between-group considerations and clinical significance
- The current data lack a direct between-group comparison of change scores, limiting definitive conclusions about differential efficacy.

- Clinically, the larger absolute gain in CAHAI-7 seen with TENS ($\Delta \approx 3.00$) versus FES ($\Delta \approx 2.34$) suggests a potential advantage for TENS in this sample, but this must be interpreted cautiously without a formal between-group statistical test and effect size.
- Future analyses should compute between-group differences in change scores (with 95% CIs) and standardized effect sizes (e.g., Cohen's d) to determine the magnitude and precision of any between-group superiority.
- Mechanisms and practical implications
- TENS may offer a cost-effective, well-tolerated option to augment proprioception and neural plasticity when combined with conventional therapy.
- FES provides explicit motor activation, potentially beneficial for patients with measurable weakness but may require equipment access and supervision.
- Consideration of safety, feasibility, and patient preference is essential when choosing between modalities, and a combined or sequential approach could be explored in future trials.
- Limitations
- Small sample size (n = 30) and single-center design limit generalizability.
- Use of convenience sampling and a lottery-based randomization method may introduce selection bias.
- Absence of a between-group statistical comparison in this report and lack of long-term follow-up restrict conclusions about durability of gains.
- Outcome assessment was limited to CAHAI-7; adjunctive outcomes (pain, range of motion, spasticity) and patient-reported measures could enrich interpretation.
- Implications for practice and research
- Both TENS and FES appear to be viable adjuncts to standard rehabilitation to improve functional performance in the acute phase after stroke with shoulder subluxation.
- Clinicians may consider prioritizing TENS as a practical, affordable option, particularly in settings with limited resources, while acknowledging the need for individualized assessment.
- Future research should include larger, multicenter randomized trials with adequate power to detect between-group differences, report effect sizes and 95% CIs, and incorporate longer-term follow-up and additional outcome measures to establish durability and broader clinical significance.

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