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Effects of Functional Electrical Stimulation on Pain and Shoulder Subluxation in Hemiplegic Patients: A Randomised Clinical Trial

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KEYWORDS

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DECLARATIONS

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ABSTRACT

Background: Shoulder pain is common in hemiplegic stroke patients, frequently reported across studies. It is a disabling symptom requiring continuous management alongside stroke rehabilitation. If untreated, it may lead to prolonged capsular stretch, irreversible damage, and shoulder subluxation, significantly affecting recovery and functional independence in the long term. **Objective:** To determine the effects of functional electrical stimulation on pain intensity, shoulder subluxation, and upper extremity motor function in hemiplegic patients. **Methodology:** A clinical trial was conducted at Nishtar Hospital, Multan, over nine months, with 60 patients selected via purposive sampling. Participants were divided into an experimental group receiving functional electrical stimulation and a control group with conventional therapy. Participants admitted no later than four months post-stroke with hemorrhagic or thromboembolic cerebrovascular disease, presenting with Brunnstrom stages 1 to 4, and the ability to comprehend study procedures, both genders were included. Exclusion criteria were unconscious patients, those with recurrent stroke, bilateral hemiplegia, neurological deficits, or epilepsy. Assessments at baseline, 3rd, and 6th weeks used t-test, repeated measures ANOVA, and Mann-Whitney U tests to evaluate functional independence, pain, motor function, ability, and subluxation outcomes. **Results:** The functional electrical stimulation group showed a significant difference at the 3rd and 6th week assessment with p-values of 0.012 and 0.041, respectively, for the functional independence measure. Pain score was also improved significantly at the 3rd and 6th week with p-values of 0.000 and 0.021, respectively. Motor function was equally improved up to the 3rd week with a p-value of 0.713 and significantly improved at final measurement with a p-value of 0.000. The Mann-Whitney U Test for functional ability scale showed significant improvement at both post-operative levels (p=0.000). At the same time, subluxation outcomes were equal at final measurement, which was important at the 3rd week. (p=0.367 and 0.001). **Conclusion:** There were significant effects of functional electrical stimulation in reducing pain, increasing function, and short-term management of shoulder subluxation. In the long term, conventional therapy showed marked but equal improvement.

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INTRODUCTION

Hemiplegia is a significant global health issue that presents with both serious and debilitating consequences.[1] In developed nations, it ranks as the third leading cause of mortality and stands among the top 25 causes of acquired disability in adults. While a large number of individuals survive the initial hemiplegic episode, the lasting impact is often marked by prolonged disability, affecting not only patients but also their families. Research indicates that approximately 40% of survivors retain marked dysfunction in the affected upper limb after three months; another 40% exhibit mild to moderate impairment, and only 20% regain full functionality.[2] Persistent motor deficits in the arm frequently result in dependence on caregivers for daily living tasks. Moreover, this ongoing dysfunction can result in secondary complications such as shoulder subluxation and pain.[1-5]

Shoulder subluxation represents a major barrier in post-stroke rehabilitation. It interferes with upper limb recovery and often leads to additional problems like pain, which can further hinder functional improvement. Reports suggest that the incidence of shoulder subluxation in stroke survivors ranges from 17 to 81%, making it a prevalent motor dysfunction consequence. It is commonly identified as inferior subluxation, in which the gravitational pull on the arm causes the humeral head to shift downward due to the weakened or paralysed supraspinatus and posterior deltoid muscles, both of which are essential in counteracting this force.[6-8]

Secondary complications following a stroke can severely impede rehabilitation efforts. One notable issue is pain in the hemiplegic shoulder, which can delay functional recovery and extend hospital stays. Hemiplegic shoulder pain (HSP) occurs in up to 84% of stroke survivors and is linked to reduced rehabilitation outcomes.[9-11] The frequency of shoulder pain varies between 9% and 40%, depending on the population studied and research methodology. While early onset (within two weeks) is possible, the condition typically emerges two to three months post-stroke. HSP is known to obstruct rehabilitation, prolong hospitalisation, and contribute to psychological issues like depression and diminished quality of life. Contributing factors include paralysis, limited shoulder movement, muscle spasticity, lesions in the right cerebral hemisphere, left-sided hemiplegia, sensory deficits, diabetes, low Barthel Index scores, and improper patient handling. Fortunately, around 80% of patients eventually recover from shoulder pain.[12-14]

Hemiplegia, often accompanied by motor paralysis and cognitive impairments, remains a leading source of long-term disability in survivors. Upper limb dysfunction significantly hampers the rehabilitation process in stroke patients, limiting progress and functional independence. Shoulder problems are the most important component of upper extremity complications in patients with stroke. Disturbed shoulder biomechanics lead to subluxation and shoulder pain. Post-hemiplegic shoulder pain often occurs with subluxation, but the correlation between these factors is controversial. The causes of hemiplegic shoulder pain are complex, and shoulder subluxation is one of the major causes.[9] Shoulder subluxation, defined as increased translation of the humeral head relative to the glenoid fossa, can interfere with rehabilitation
[15, 16]

Spastic paralysis commonly emerges as a notable symptom in stroke patients approximately three months after stroke onset. During this phase, the upper limb often adopts a disrupted capsular posture marked by scapular retraction, depression of the acromioclavicular joint, internal rotation, and adduction of the shoulder. These postural abnormalities frequently lead to persistent shoulder pain, causing patients to disengage from all stages of rehabilitation. Shoulder pain following a stroke is among the most prevalent complications in hemiplegic individuals, significantly hindering both motor recovery and psychological well-being.

Multiple underlying causes contribute to the development of shoulder pain in hemiplegia. Some are joint-related, such as inferior-anterior humeral head subluxation, rotator cuff injuries, and reflex sympathetic dystrophy. Others stem from neurological factors, including sensory loss, spatial neglect, and spasticity. Various therapeutic approaches have been explored and implemented to alleviate shoulder pain post-stroke. These include passive and active range of motion exercises, strength-building protocols, and in some cases, surgical interventions. Functional Electrical Stimulation (FES) has demonstrated positive outcomes when introduced in the early stages following a stroke. It has been shown to reduce pain, correct subluxation, and enhance shoulder mobility.[5] Between 55% and 75% of stroke survivors experience prolonged difficulty with everyday tasks such as grasping, holding, and manipulating items, even three to six months post-stroke. Complete functional recovery of the upper limb six months after a middle cerebral artery ischemic stroke is observed in only 11.6% of cases, despite engagement in regular rehabilitation. These rehabilitation strategies often involve extended exercise duration and intensity, task-oriented training, and supplementary techniques such as surface neuromuscular electrical stimulation.[2]

To improve arm motor function in hemiplegic patients, a variety of therapeutic methods have been utilised. Among these, FES stands out by using carefully controlled electrical impulses to activate nerves linked to the paralysed muscles. This stimulation replicates natural voluntary movements, aiming to reinstate lost functional abilities. FES seeks to create motion patterns that resemble typical voluntary actions, thus restoring related motor functions.[17-19] In the context of shoulder rehabilitation, FES targets muscles responsible for stabilising the humeral head within the glenoid cavity. Stimulating these muscles helps prevent or correct subluxation, relieves shoulder discomfort, and supports functional recovery. FES differs from other electrical stimulation techniques due to its specific technical attributes. It operates within a frequency range of 10 to 50 Hz and targets motor nerves or their specific motor points instead of directly stimulating muscle fibres. Additionally, FES allows for the application of electrical impulses in a controlled sequence and intensity, enabling the execution of purposeful muscle actions required for functional tasks.[20-23]

Existing literature highlights a gap in research regarding the use of Functional Electrical Stimulation in treating shoulder subluxation and pain in hemiplegic individuals within the first four months of stroke onset. Applying this modality during the early recovery period could lead to greater improvements in functional outcomes and contribute to a better overall quality of life for patients.

METHODOLOGY

A randomised clinical trial was conducted over nine months at the Department of Physical Therapy, Nishtar Hospital, Multan, Pakistan. The study included 66 patients diagnosed with hemiplegic shoulder, who were randomly assigned into two equal groups of 33 each. The sample size was calculated using the WHO sample size determination formula with a study power of 99% and a 5% level of significance, assuming a 44.12% difference in pain relief proportions between the FES and control groups. A purposive sampling technique was employed to recruit patients meeting the inclusion criteria: individuals with either right- or left-sided acute or chronic stroke, admitted no later than four months post-stroke with hemorrhagic or thromboembolic cerebrovascular disease, presenting with Brunnstrom stages 1 to 4, and the ability to comprehend study procedures. Both male and female patients were included.

Exclusion criteria were unconscious patients, those with recurrent stroke or bilateral hemiplegia, patients without shoulder subluxation or pain, individuals with ongoing neurological deficits from prior strokes, and those who were non-operative or epileptic. All participants received an introductory session explaining the background and potential benefits of FES. Initial assessments were performed by a trained physical therapist who was blinded to the allocation process and was not involved in the treatment. Randomisation was conducted using computer-generated numbers (1–66) and assigned via sealed envelopes to ensure confidentiality. Blinding was maintained for both participants and the assessor.

Participants in the experimental group underwent FES along with routine physiotherapy. FES was applied using a biphasic current at a frequency of 36 Hz, with stimulation lasting 10–30 seconds, rise and fall times of 1 second, rest intervals ranging from 2–12 seconds, impulse duration of 250 ms, and a total session length of 60 minutes. Electrodes were positioned on the hemiplegic side over the supraspinatus and posterior deltoid muscles, three times a week over six weeks (totalling 18 sessions). Proper alignment during treatment was maintained using a shoulder sling and armchair support. Meanwhile, the control group received only conventional therapy, involving strengthening and functional training for the affected shoulder for one hour daily over the same six-week period, with shoulder sling support. Assessments for both groups were performed at baseline, at the 3rd and 6th week. Statistical analysis was carried out using SPSS version 20. Mean and standard deviation were used to describe quantitative variables such as age, while qualitative variables were shown as percentages and illustrated using bar or pie charts. For normally distributed continuous variables, independent t-tests were conducted to compare the groups, and Pearson's Chi-square test was used to compare categorical data. A p-value<0.05 was considered statistically significant.

Ethical clearance was granted by the Institutional Review Board of the University of Lahore. All participants gave written informed consent. The study ensured participants' confidentiality and anonymity, and they were informed of their right to withdraw from the study at any point without facing any consequences.

RESULTS

A total of 60 hemiplegic patients were included in the study, with 30 participants in the FES group and 30 in the control group. The mean age in the FES group was 49.97±3.58 years, and in the control group, it was 52.47±5.3 years. A statistically significant difference was observed in age between the groups (p=0.037). At baseline, there was no significant difference in Functional Independence Measure (FIM) scores between the FES and control groups (p=0.198). However, after 3 weeks of intervention, the FES group showed significantly higher FIM scores compared to the control group (mean difference=3.70, p=0.012). This significant difference was maintained at 6 weeks (mean difference=3.77, p=0.041). Repeated measures ANOVA showed statistically significant within-group improvement over time in both groups (p<0.001). Baseline Numeric Pain Rating Scale (NPRS) scores were comparable between groups (p = 0.632). At the end of the 3rd week, the FES group had a significantly greater reduction in pain compared to the control group (mean difference=-1.20, p<0.001). By the 6th week, both groups had improved, but the FES group maintained a statistically significant difference (mean difference=0.33, p=0.021).

Before treatment, the Wolf Motor Function Test (WMFT) scores were significantly lower in the group receiving FES, indicating reduced motor function (p<0.001). At the end of the third week, no significant variation was found between the groups (p=0.713); however, by the sixth week, the FES group exhibited significantly greater improvement compared to the control group (mean difference=1.53, p<0.001). Analysis using the Mann–Whitney U test revealed no significant initial difference in the Functional Ability Scale between the groups (p=0.595). Nonetheless, marked improvements were recorded in the FES group at both the 3rd and 6th week (p<0.001) relative to the control group.

Assessments of shoulder subluxation revealed no notable difference at baseline (p=0.545). However, by the third week, the FES group showed a significant reduction in subluxation (p=0.001), though this improvement did not remain statistically significant by the sixth week (p=0.367). In terms of gender distribution, 33.3% of participants in the FES group were male and 66.7% were female, whereas in the control group, males accounted for 56.7% and females 43.3%. Stroke onset distribution was also similar, with 50% of the FES group and 63.3% of the control group experiencing stroke onset within one month.

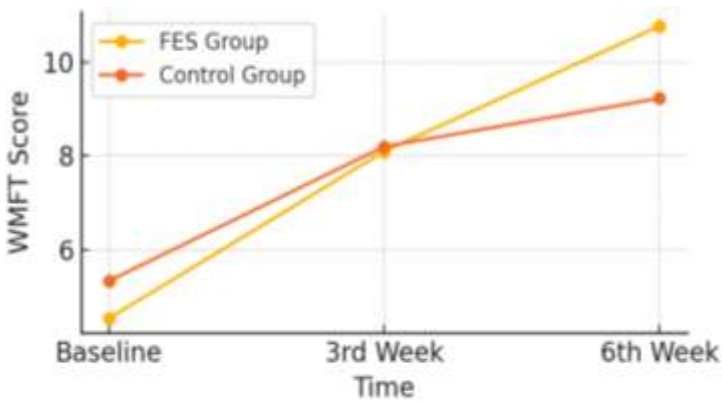
DISCUSSION

The findings of this study suggest that adding FES to standard physiotherapy significantly improves shoulder-related outcomes in stroke survivors with hemiplegia. Patients in the FES group showed greater reductions in shoulder pain and subluxation, along with improved motor performance and overall functional independence, compared to those who received conventional therapy alone. These results support earlier research indicating that FES can play a meaningful role in stroke rehabilitation, especially in managing shoulder complications like subluxation and pain.[3]

One of the main benefits of FES is its ability to stimulate key shoulder-stabilising muscles, specifically the supraspinatus and posterior deltoid, during the early, flaccid phase of recovery. This muscle activation helps prevent downward displacement of the humeral head, which commonly occurs due to gravity and weak muscle support in the hemiplegic shoulder.[24] Pain reduction was also a significant outcome in this study. The use of FES was associated with a more pronounced decrease in shoulder pain by the third week, and this benefit was sustained through the sixth week. A possible explanation

Figure 1: FIM scores over time

Figure 2: WMFT scores over time



lies in how FES stimulates sensory pathways and mechanoreceptors, which may interfere with pain signals, consistent with the gate control theory of mechanoreceptors, which may interfere with pain signals, consistent with the gate control theory of pain modulation.[25] These effects have also been observed in other studies and highlight the dual role of FES, not only in improving motor control but also in easing discomfort.[6] Motor function, as measured by the Wolf Motor Function Test (WMFT), also improved considerably in the FES group.

Interestingly, although the control group began with slightly better motor scores, the FES group caught up and eventually surpassed them by the end of six weeks. This turnaround indicates that FES may accelerate motor relearning by helping the brain form new movement patterns, a process supported by research on neuroplasticity and task-specific stimulation.[20] The improvement in FIM further strengthens the case for FES as a valuable tool in early rehabilitation. Patients who received FES showed faster and more consistent improvements in their ability to perform daily tasks compared to those in the control group. These findings align with systematic reviews that describe how FES can enhance real-world functional outcomes when used alongside conventional therapy.[26]

It's also worth noting that FES had the strongest impact during the earlier stages of intervention, particularly by the third week. By week six, although the FES group still had an edge, some of the control group's improvements began to catch up. This may suggest that while conventional therapy is beneficial over time, FES provides a crucial boost in the early phase of rehabilitation when muscle activation, alignment, and movement patterns are being re-established.[27] These studies also have some limitations. The sample size was relatively small, and the intervention period was limited to six weeks. Moreover, patients in the FES group may have been influenced by the novelty of using a device, leading to increased motivation or placebo-driven gains. Nevertheless, the consistent trends observed across multiple outcome measures make a strong case for integrating FES into early post-stroke care.

The FES appears to be an effective adjunct to traditional therapy, particularly in the short-term recovery phase. It helps reduce pain, correct subluxation, and boost motor function, ultimately enhancing patients' independence and quality of life. The findings of this study suggest that adding FES to standard physiotherapy significantly improves shoulder-related outcomes in stroke survivors with hemiplegia. Patients in the FES group showed greater reductions in shoulder pain and subluxation, along with improved motor performance and overall functional independence, compared to those who received conventional therapy alone.

These results support earlier research indicating that FES can play a meaningful role in stroke rehabilitation, especially in managing shoulder complications like subluxation and pain.[16] One of the main benefits of FES is its ability to stimulate key shoulder-stabilising muscles, specifically the supraspinatus and posterior deltoid, during the early, flaccid phase of recovery. This muscle activation helps prevent downward displacement of the humeral head, which commonly occurs due to gravity and weak muscle support in the hemiplegic shoulder.[17] Pain reduction was also a significant outcome in this study. The use of FES was associated with a more pronounced decrease in shoulder pain by the third week, and this benefit was sustained through the sixth week. A possible explanation lies in how FES stimulates sensory pathways and mechanoreceptors, which may interfere with pain signals, consistent with the gate control theory of pain modulation.

These effects have also been observed in other studies and highlight the dual role of FES, not only in improving motor control but also in easing discomfort.[19] The improvement in FIM further strengthens it as a valuable tool in early rehabilitation. Patients who received FES showed faster and more consistent improvements in their ability to perform daily tasks compared to those in the control group. These findings align with systematic reviews that describe how FES can enhance real-world functional outcomes when used alongside conventional therapy. It's also worth noting that FES had the strongest impact during the earlier stages of intervention, particularly by the third week. By week six, although the FES group still had an edge, some of the control group's improvements began to catch up. This may suggest that while conventional therapy is beneficial over time, FES provides a crucial boost in the early phase of rehabilitation when muscle activation, alignment, and movement patterns are being re-established.

Advanced equipment is needed needing of today's rehabilitation. To get a fast recovery, better technology, such as functional electrical stimulation, is required. It can save patients from complications and prolonged disability.

CONCLUSION

The findings concluded that there was a significant effect of functional electrical stimulation in reducing pain, increasing function, and short-term management of shoulder subluxation. In the long term, conventional therapy showed marked but equal improvement.

DECLARATIONS

Consent to participate: Written consent had been obtained from patients. All methods were performed following the relevant guidelines and regulations.

Availability of Data and Materials: Data will be made available upon request. The corresponding author will submit all dataset files.

Competing interests: None

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CONSORT Guidelines: All methods were performed following the relevant guidelines.

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