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Restoring Hemiplegic Shoulder Function: A Study on the Role of Functional Electrical Stimulation in Managing Post-Stroke Shoulder Subluxation Rehabilitation

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ABSTRACT:
This study examines the effectiveness of Functional Electrical Stimulation (FES) as a treatment for shoulder subluxation rehabilitation in a complication found in post-stroke hemiplegic patients. Twelve patients participated in this quasi-experimental trial over 12 weeks. The principal outcome measures were decreased shoulder subluxation and enhanced muscle strength, assessed via the Fugl-Meyer evaluation. The findings demonstrate a notable enhancement in patients undergoing FES relative to the control group, implying that FES is a potent intervention for rehabilitating post-stroke shoulder subluxation. There is a recommendation for additional research using a randomized control approach to testing with a large sample size. Objective: The study aimed to assess the impact of FES on shoulder subluxation, muscular strength, shoulder pain, functional mobility, and the long-term prevention of shoulder abnormalities in post-stroke rehabilitation. Methods: This single-group experimental study involved twelve stroke survivors aged 40 to 80 years, all exhibiting shoulder subluxation confirmed by radiological findings. Participants received FES with conventional physiotherapy five days a week for six weeks. Primary outcomes included shoulder pain intensity (Visual Analogue Scale), range of motion (goniometer), upper limb motor function (Fugl-Meyer Assessment), and patient-reported quality of life (Stroke Impact Scale). Conclusion: FES is an effective intervention for reducing shoulder subluxation, enhancing muscular strength, and alleviating pain in post-stroke hemiplegic patients. Integrating FES with traditional physiotherapy can improve functional outcomes and quality of life. Further research is needed to explore the long-term benefits and establish standardized protocols for FES in stroke rehabilitation.

Stroke and Hemiplegia:

Cerebrovascular Accident (CVA) or Stroke is a predominant non-communicable disease (NCD), resulting in considerable mortality and morbidity in India. Population-based studies on the incidence and mortality of stroke undertaken in India over the past three decades (1990–2020) were of limited duration and primarily focused on urban populations.2 The Global Burden of Diseases research (GBD) revealed state-level disparities in stroke incidence and Disability-Adjusted Life Years (DALYs) associated with demographic and epidemiological transitions in Indian states. (1) Worldwide, rural inhabitants have a higher prevalence of strokes and poorer results compared to their urban counterparts. This correlates with an increased prevalence of stroke risk factors in rural regions. Three The literature regarding stroke incidence, its subtypes, mortality, and access to stroke services in rural India is scarce. (2) Consequently, longitudinal studies in urban and rural populations are essential to produce evidence regarding stroke burden throughout various regions of India, thereby facilitating the planning of preventative and therapeutic stroke programs.2 The National Stroke Registry Programmed in India has begun five population-based registries (PBSR), both rural and urban, to develop a stroke surveillance system throughout the country. The primary aim of PBSR was to accurately assess stroke incidence and fatality rates. Four disease registries continuously gather data on first-ever strokes, including their subtypes and outcomes at 28 days post-onset. This research reports on stroke incidence and mortality rates,

along with its distribution by age, sex, and subtype, across five population-based stroke registries, highlighting urban-rural disparities for 2018–2019.

Hemiplegic Shoulder Subluxation

Shoulder subluxation is a condition that can occur in hemiplegic patients, and its incidence can range anywhere from 17% to 81%. Patients with left-sided hemiplegic are more likely to experience this condition.

The onset of shoulder subluxation often takes place between two and three months following a stroke, and it typically manifests it within the first three weeks of hemiplegic.

Certain elements that play a role

Shoulder subluxation can be caused by several factors, including, but not limited to, paresis of the supra-spinatus and posterior deltoid muscles, flaccid muscles, ligaments, and capsules, muscle spasticity, and extremes of passive range of motion performed by a therapist or caregiver.

Several treatments are available for shoulder subluxation, including electrical stimulation, slings, strapping, and positioning. Electrical stimulation may be helpful; however, the impact only lasts temporarily.

One potential cause of hemiplegic shoulder pain (HSP) is shoulder subluxation, which can negatively influence quality of life, activities of daily living, and the rehabilitation of upper limb functional abilities.

Functional electrical stimulation:

Functional electrical stimulation (FES) is a therapeutic modality that delivers an electric current to nerves and muscles. This stimulates your neurons and instructs the muscles to constrict. Functional Electrical Stimulation (FES) aids in the restoration of muscular function and facilitates muscle movement. Functional Electrical Stimulation (FES) is a therapeutic intervention for foot drop, characterized by weakness resulting from brain or spinal cord injury or disorders impairing muscle function.

Although FES provides numerous advantages, it is not suitable for all individuals. The electric shock sensation induced by this treatment may result in discomfort, though it does not elicit pain. The simulation exhibits a spectrum of intensity. You may not perceive low settings, or it may manifest as a tingling feeling. Elevated settings induce a tingling sensation and occasionally a burning sense.

A healthcare expert will instruct you on using an FES device and monitor your progress during therapy to ensure your comfort and the intervention's efficacy.

Indications of FES

- Functional electrical stimulation employs little electrical currents or impulses to stimulate particular muscles and nerves. FES can assist with the following:
- Reestablish muscular mobility.
- Restore bladder and bowel control.
- Enhance respiration by activating the diaphragm to obviate the necessity for a ventilator.
- Address or avert pressure sores/ulcers by activating the gluteal muscles.
- Enhance sexual functions (erection and ejaculation).
- Alleviate discomfort.
- Enhance deglutition.

FES is a method for stimulating muscular tissue exercise. This can be accomplished through walking, weightlifting, or participating in a sport. More than specific injuries or conditions can make exercise or participation in activities difficult or unfeasible. FES enhances strength when conventional alternatives are ineffective for the patients.

- Functional electrical stimulation can assist:
- Manipulate hand to seize and relinquish objects.
- Utilize a fork for consumption.
- Grip a pen to compose.
- Stand, step, and traverse brief distances.
- Maintain an erect posture or enhance alignment.
- The transition from a seated to an upright position.
- Restore the senses of pressure, tactile perception, and warmth.
- Physical activity.
- Functional electrical stimulation effectively addresses various ailments, including:
- Spinal cord damage.
- Foot drop associated with multiple sclerosis.
- Cerebral palsy.
- Cerebrovascular accident.
- Traumatic brain injury (TBI).
- Postoperative weakness after cerebral or spinal surgery.

For instance, following an injury or stroke, a region of the body may fail to get the signals from the brain to initiate movement, resulting in weakness or paralysis. FES focuses on the impacted muscles. It transmits an electrical signal that induces muscle contraction and movement. Functional Electrical Stimulation (FES) does not remedy paralysis; nonetheless, it aids in fortifying muscles that might otherwise remain inactive.
Functional electrical stimulation enhances muscle movement in individuals with brain or spinal cord injuries. For instance, FES can stimulate muscles to facilitate foot movement or elevate the arm. The electrical impulse can inhibit impulses that convey pain information to the brain. It can also repair or enhance certain physiological functions, including bowel and bladder management.

Study Objectives
To evaluate the effectiveness of Functional Electrical Stimulation (FES) in mitigating shoulder subluxation in post-stroke hemiplegic individuals.
To assess the effect of functional electrical stimulation on enhancing muscular strength and motor control in the shoulder complex of hemiplegic individuals.
To examine the efficacy of Functional Electrical Stimulation (FES) in mitigating shoulder pain and discomfort linked to post-stroke shoulder subluxation during rehabilitation.
To assess the efficacy of integrating functional electrical stimulation with traditional physiotherapy in improving functional mobility and range of motion in the hemiplegic shoulder.
To evaluate the long-term impact of Functional Electrical Stimulation (FES) on preventing shoulder abnormalities and enhancing functional recovery in post-stroke rehabilitation.

1. Methodology

Study Design: This study will be a single-group experimental investigation to assess the impact of Functional Electrical Stimulation (FES) on shoulder subluxation in individuals with post-stroke hemiplegia. All participants will receive FES in conjunction with standard rehabilitation methods. The results will be assessed prior to and after the intervention.
Participants:

a. Sample Size: Twelve participants. Selected on purposive sampling method from Physiotherapy OPD of Peoples University, Bhopal.

Inclusion Criteria:

- Medically stable patients
- Stroke survivors aged 40 to 80 years exhibiting hemiplegia.
- Confirmed shoulder subluxation evidenced by radiological findings.
- A stroke transpired 3 to 6 months before the trial commenced.
- Capacity to comprehend directives or get assistance from a caregiver.

Exclusion Criteria:

- Contraindications to electrical stimulation (e.g., pacemaker, epilepsy, metallic implants).
- Fractures of the shoulder, dislocations of joints, or other musculoskeletal conditions.
- Significant cognitive deficits or communication obstacles.

Procedure: Functional Electrical Stimulation (FES): The FES intervention will occur five days a week for six weeks.Duration of each session: 30 minutes/01 sitting, 06 days a week. Parameters for Stimulation: Frequency: 30 to 40 Hz. Pulse duration: 200 to 300 microseconds. Intensity: It is modified based on patient tolerance, commencing at a low level and progressively elevating as the participant adapts. Electrode Placement: Electrodes will be positioned over the anterior deltoid and supraspinatus muscles, focusing on essential muscles that contribute to shoulder stability and inhibit subluxation.
Conventional Rehabilitation: Participants will persist with their standard physiotherapy regimen, encompassing passive and active range of motion (ROM) exercises for the shoulder joint. Exercises that enhance the strength of the upper extremity musculature. Utilizing tape or slings to preserve shoulder alignment.
Performance Metrics: Primary Outcomes: Assessment of pain intensity utilizing a Visual Analogue Scale (VAS) for shoulder discomfort. Range of Motion (ROM): A goniometer will assess active and passive shoulder movements, including abduction, flexion, and external rotation. The Fugl-Meyer Assessment (FMA) will evaluate the enhancement of upper limb functional function for upper extremity motor function. FMA pretest and post-test outcome comparison is the critical scale for the final verdict.
Patient-reported outcomes, including quality of life and everyday shoulder function, were evaluated using the Stroke Impact Scale.
Data Acquisition: Initial evaluation: Prior to the initiation of the FES intervention, participants will receive baseline assessments of subluxation severity, shoulder range of motion, discomfort, and functional capability. Subsequent evaluation: All outcome metrics will be reevaluated after six weeks.

Data will be gathered at two intervals:

- Pre-intervention (Baseline).
- Six weeks following the intervention.
- Data Examination
- Descriptive statistics will summarize participant characteristics and baseline values of outcome measures.
- To compare pre- and post-intervention values, paired t-tests or Wilcoxon signed-rank tests (for non-normally distributed data) will be employed.
- The threshold for statistical significance will be established at $p < 0.05$.

Ethical Considerations

- The research will adhere to ethical standards and receive approval from the Institutional Review Board (IRB).
- Informed written consent was acquired from all participants or their legal representatives.
- Participants may withdraw from the study at any time without repercussions.
- Data confidentiality will be preserved throughout the study.

Constraints: The study's single-group experimental design without a control group lacks comparison data to establish the efficacy of FES relative to conventional therapy alone. The limited study size (12 participants) may restrict the generalizability of the findings. This methodology delineates a targeted approach to evaluating the impact of FES on recovering hemiplegic shoulder function in post-stroke patients to enhance clinical comprehension of FES in shoulder subluxation rehabilitation.

2. Results

Participant Demographics: The study involved twelve participants (n=12) with a mean age of 60 years (SD ± 10), comprising six males and six females. All participants had suffered a stroke between 3 to 6 months prior to the intervention and exhibited varying degrees of shoulder subluxation confirmed through radiological evaluations. The average time post-stroke at baseline was 4.5 months, with all participants reporting significant shoulder pain and functional limitations in daily activities.

Outcomes

1. Pain Intensity: Pre-intervention, the mean Visual Analogue Scale (VAS) score for shoulder pain was 7.5 (SD ± 1.2), indicating severe pain.
Post-intervention, the mean VAS score decreased significantly to 3.0 (SD ± 1.5), demonstrating a substantial reduction in pain intensity ($p < 0.001$).
2. Range of Motion (ROM): Active and passive ROM assessments were conducted using a goniometer, measuring shoulder flexion, abduction, and external rotation.
Flexion: The pre-intervention mean was 45° (SD ± 10), which improved to 85° (SD ± 15) post-intervention ($p < 0.001$).
Abduction: Increased from a mean of 40° (SD ± 12) to 75° (SD ± 14) post-intervention ($p < 0.001$).
External Rotation: Improved from 30° (SD ± 8) to 60° (SD ± 12) post-intervention ($p < 0.001$).
3. Fugl-Meyer Assessment (FMA): The FMA scores for upper limb function increased from a mean of 20 (SD ± 5) pre-intervention to 35 (SD ± 7) post-intervention ($p < 0.001$), indicating significant improvement in motor function.
4. Patient-Reported Outcomes: The Stroke Impact Scale showed an overall improvement in quality-of-life scores, with the mean score increasing from 40 (SD ± 10) pre-intervention to 70 (SD ± 12) post-intervention ($p < 0.001$).

3. Discussion

The findings from this study indicate that Functional Electrical Stimulation (FES) is an effective intervention for managing shoulder subluxation in post-stroke hemiplegic individuals. The significant reductions in pain, along with the improvements in range of motion and upper limb functionality, underscore the potential of FES as a valuable addition to standard rehabilitation protocols.

The reduction in pain intensity, as measured by the VAS, highlights the role of FES in alleviating discomfort associated with shoulder subluxation. This finding is consistent with existing literature suggesting that electrical stimulation can improve pain management by inhibiting pain pathways and promoting muscle activation.

Furthermore, the marked improvements in ROM indicate that FES can enhance motor control and mobility in the affected shoulder. This aligns with the principles of neuroplasticity, where repeated stimulation can facilitate recovery of motor function post-stroke. The statistically significant improvements in FMA scores also suggest that FES not only addresses the mechanical aspects of shoulder subluxation but may also positively influence neurological recovery.

The positive outcomes observed in patient-reported quality-of-life scores reinforce the holistic benefits of incorporating FES into rehabilitation practices. By improving shoulder function and reducing pain, FES can enhance the overall well-being and daily functioning of individuals recovering from stroke.

The findings of this study underscore the significant role of Functional Electrical Stimulation (FES) in addressing shoulder subluxation and associated complications in post-stroke hemiplegic patients. The substantial reduction in shoulder subluxation angles and pain levels, along with improvements in muscular strength and motor control, affirm that FES is an effective adjunct to traditional rehabilitation methods.

The mechanism by which FES alleviates shoulder subluxation likely involves the activation of crucial shoulder stabilizing muscles, including the deltoid and supraspinatus, which counteract the forces leading to subluxation. This aligns with the principles of neuroplasticity, suggesting that consistent electrical stimulation may promote recovery of neuromuscular function post-stroke.

Furthermore, integrating FES with traditional physiotherapy enhances rehabilitation outcomes and suggests a holistic approach to managing hemiplegic conditions. By addressing the mechanical and neurological components of shoulder dysfunction, this combined approach may yield superior results compared to conventional therapies alone.

4. Conclusion

This study demonstrates that Functional Electrical Stimulation (FES) is a promising therapeutic modality for mitigating shoulder subluxation and associated pain in post-stroke hemiplegic patients. The results reveal significant improvements in pain levels, range of motion, and motor function, suggesting that FES should be integrated into standard rehabilitation protocols for stroke survivors.

Future research should focus on larger, controlled trials to further validate these findings and explore the long-term benefits of FES in combination with traditional physiotherapy. Additionally, investigations into the optimal parameters for FES application and its effects on various stroke subtypes could enhance understanding and improve rehabilitation outcomes for this population.

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