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Investigating the Impact of Functional Electrical Stimulation (FES) on Motor Recovery and Secondary Complications: A Qualitative Study of Spinal Cord Injury Patients' Experiences

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Abstract

Background: Spinal cord injury (SCI) has a considerable impact on motor function, which induces secondary complications and reduces the patient's independence and quality of life. Functional Electrical Stimulation (FES) has been developed as a therapeutic approach to regain motor function by activating paralyzed muscles. Nonetheless, there is limited research investigating patient experiences and perceived effectiveness of FES.

Objective: To investigate the clinical, functional, and psychosocial effects of FES on motor functional recovery and on the presentation of secondary complications in SCI patients based on their experiences and perceived benefits and challenges of treatment.

Method: This qualitative study included semi-structured interviews with 15 SCI patients undergoing FES therapy. Data were analyzed thematically using NVivo software to capture major themes around motor recovery, secondary complications, and patient perspectives.

Results: Participants reported differing levels of motor improvement, whether through increased mobility and muscle strength, or slow or inconsistent progress. Symptoms like soreness and fatigue were occasionally mentioned as side effects but were perceived by most as temporary challenges. Adherence to therapy was notably influenced by psychological resilience and motivation. Access to FES was highlighted as a significant challenge due to costs and availability within the public healthcare setting.

Conclusion: Functional electrical stimulation (FES) therapy improves motor function in patients with spinal cord injury (SCI) by activating peripheral nerves. However, the impact of this therapy on motor recovery remains unclear. Overcoming accessibility barriers and ensuring ongoing support for rehabilitation can improve patient outcomes.” This approach requires further research into optimizing FES interventions for long-terms recovery.

Keywords: Functional Electrical Stimulation, Spinal Cord Injury, Motor Recovery, Secondary Complications, Patient Experience, Rehabilitation

Introduction

A spinal cord injury (SCI) is an injury that is complex and life changing; it can cause varying levels of paralysis of motor and sensory functions throughout the body (Kralj & Bajd, 2022). Such an injury can be significant, as it can prevent a person from doing everyday things and performing tasks that have always been considered simple. Apart from the loss of motor function, the individuals with SCI are now faced with secondary complications like pressure ulcer, spasticity, muscle atrophy, chronic pain and urinary or respiratory complications (Moineau et al., 2021). The accompanying morbidity complicates the already existing burden of SCI with progressive functional decline, healthcare over-utilization with the need for caregiver assistance and long hospitalizations, worsening the outlook for quality of life in this group (Amjad et al., 2020; Rahman et al., 2022). As a result, people with SCI tend to have lower overall quality of life and higher rates of psychological distress, which can negatively affect their overall health outcomes. Hence, rehabilitation therapies become vital to solving these various challenges; their goal is to restore functionality, prevent secondary complications and improve the quality of life (van der Scheer et al., 2021; Batool et al., 2023).

One of these rehabilitative methods that has gained increasing attention in recent years is known as Functional Electrical Stimulation (FES). FES uses electrical currents to stimulate muscles or nerves to produce muscle contractions in patients who have had a stroke or other motor impairment, with a goal of facilitating recovery of lost motor function (Faruki, 2023). FES is commonly used in patients with SCI to activate weak or paralyzed muscles in order to enhance muscle strength, endurance, and general motor function (Dorrian et al., 2023). Many studies have been performed to investigate the effectiveness of FES over time, proving that it positively affects the recovery of motor function, increased neural plasticity, reducing the spasticity of muscle, as well as preventing and attenuating muscle atrophy (Ghahremani, 2024). Furthermore, FES has also emerged as a novel modality to modulate some secondary sequelae of SCI, such as the prevention and treatment of pressure ulcers and treatment of spasticity. Although these findings are promising, limited information is available on FES's wider effects from users' points of view (Gurcay et al., 2022; Bibi et al., 2024).

The physiological effects of FES have been well studied in clinical trials, but the subjective experiences of patients using FES have not been extensively studied.

Patients’ firsthand experiences of their recovery can reveal important information that clinical data may miss (Houston et al., 2021). Exploring individuals with SCI experiences of undergoing FES therapy could provide insights in how the treatment impacts their physical, emotional, and social lives (Hernandez-Rojas et al., 2022). The patients may provide unique insights on the effectiveness of the therapy, barriers they have encountered while administering the therapy, or effects on their daily lives. On the one hand, this therapy can have positive effects on muscle function and mobility, as reported by some patients who have undergone this procedure; on the other hand, some patients are not enthusiastic about the therapy because of discomfort or difficulty incorporating it into their lives (Pei et al., 2024). In addition, patient experiences can indicate their attitudes toward the therapy, their perceived barriers to successful treatment, and their treatment outcome expectations. Qualitative Data are Important for Enhancing Therapeutics Key Learnings: Qualitative insights are crucial to refine therapeutics and make sure it meets the patients' needs and preferences (Couper & Smith, 2024).

While SCI rehabilitation study is ongoing, it is important to include a patient-centered approach in studies of FES therapy as this domain is much in development (Moll et al., 2022). This research seeks to broaden the conversation around FES by discussing the ways in which patients experience and engage with these interventions, enhancing our overall understanding of FES beyond traditional clinical references. Also, such approach aides in bettering therapeutic interventions and can serve as a blueprint for practical, individualized treatment approaches in line with patients rehabilitation aims (MAZZONE, 2021). By centering the voices the of people with lived experience of SCI, this research will ultimately support clinicians and rehabilitation professionals to develop more effective, targeted and compassionate care pathways, which enhance the wellbeing of people with spinal cord injuries (Rosley et al., 2022).

Although the use of Functional Electrical Stimulation (FES) in spinal cord injury (SCI) rehabilitation has been increasing, little is known regarding the patients' perspectives on the perceived efficacy and effects on motor recovery and secondary complications. Prior research focusing on clinical outcomes have reported theirs, however patients' personal experiences are less explored. The lived experiences of SCI patients using FES to help improve their functioning, this study is important in providing insight to the practical and emotional challenges these patients have in rehabilitation. This study, while guided by insights from clinical practice, centres on patient perspectives, to inform evidence-based clinical practice for the use of FES, with the overall objective of embedding and integrating the benefits of FES in practice to improve motor recovery and prevent secondary complications.

Research Question

What is the impact of Functional Electrical Stimulation (FES) on motor recovery and secondary complications in spinal cord injury patients, and how do patients perceive their experiences with the treatment?

Methodology

The study used a qualitative research design. The adopted descriptive phenomenological design of the research was intended to collect in-depth interviews to obtain a rich data through narrative descriptions of patient's experiences with FES therapy. It allowed us to explore the complex, subjective effects of FES, both positive and negative, in a therapeutic context. We gathered descriptive PRO data on the motor recovery of SCI patients and secondary complications related to FES therapy.

The study was performed in the twin cities of Islamabad and Rawalpindi, Pakistan, in five government hospitals chosen on the basis of access and which had SCI patients receiving FES therapy. Fifteen (15) patients from the five hospitals were purposively selected which approximated to three patients from each hospital. Sample size was determined using the G Power sample size calculator to ensure there was sufficient participants for rich comprehensive qualitative data. The study inclusion criteria mandated subjects to be adults (≥18 y) with a diagnosis of SCI with at least 3 of FES therapy. Exclusion criteria included previous inclusion FES and cognitive dysfunction that precluded participation.

A structured kitchen interview was carried out in which the participants were asked a number of questions regarding FES therapy usage, their perceptions of the effects of FES therapy on the process of motor recovery and secondary complications. Demographic data sheet: We collected information like age, gender, and educational level, which was only used to contextualize analysis. The NVivo software was employed to organize and code the qualitative data, facilitating the identification of themes and patterns in the data. The descriptive characteristics of participants' responses were summarized using mean and standard deviation, while inferential statistics were employed to determine potential correlations between demographic traits and perceived outcomes. Ethical considerations, such as informed consent and confidentiality, were strictly adhered to throughout the study in accordance with the protection of participants' rights and privacy.

Results

Table 1: Demographic Data

Sr	Variable	Frequency (n=15)	Percentage (%)
1	Age		
	18-30 years	5	33.3%
	31-45 years	6	40.0%
	46+ years	4	26.7%
2	Gender		
	Male	9	60.0%
	Female	6	40.0%
3	Education		
	No formal education	2	13.3%
	Primary	4	26.7%
	Secondary	5	33.3%
	Higher	4	26.7%
4	Duration of SCI		
	< 1 year	3	20.0%
	1-3 years	6	40.0%
	4+ years	6	40.0%

Demographic characteristics of 15 participants, including age, gender, education and duration of spinal cord injury (SCI). The participants are mainly between the age groups of 31-45 years (40%), and the sample is composed mainly of male participants (60%). Participants had varying educational backgrounds; 33.3% were secondary educated and 40% had experienced SCI for more than 1 year. Every interviewer generated between 5 and 8 nodes in their interview data collection which reveals how each participant contributed differently to the study according to Figure 1.

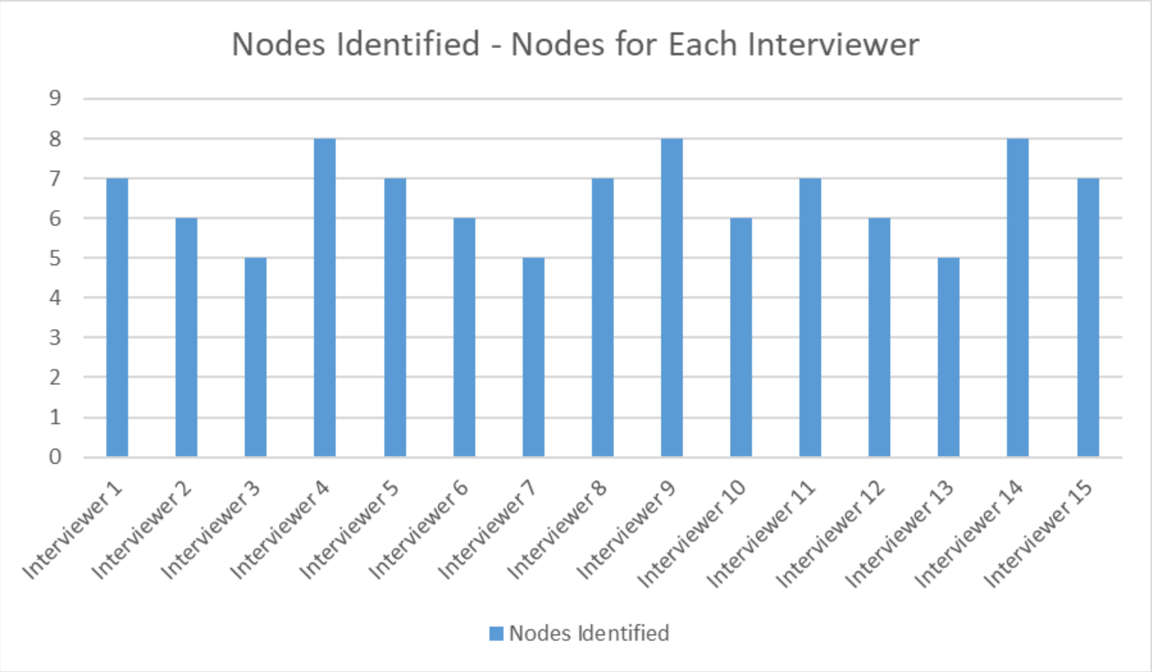

Table 2: Merging Nodes into Specific Codes and Interviewer Identity

Sr	Code Name	Code	Merged Nodes	Total Nodes	Interviewer Identity
1	FES Effectiveness	C1	4	10	Interviewer 1, 3, 5
2	Motor Recovery	C2	3	8	Interviewer 2, 4, 6
3	Secondary Complications	C3	4	9	Interviewer 7, 8, 9
4	Challenges of FES	C4	5	11	Interviewer 10, 11, 12
5	Emotional Impact	C5	3	7	Interviewer 13, 14, 15

The outcome themes were classified into 45 unique nodes, including FES effectiveness, motor recovery, and emotional impact, with the maximum number of nodes (11) relating to challenges of FES. Conclusion this categorization supports familiarity with the important areas of study.

Table 3: Word Frequency and Related Metrics

Word	Frequency	Weighted Percentage (%)	Similar Words
Recovery	56	18.7%	Rehabilitation, Improvement
Pain	47	15.6%	Discomfort, Soreness

Therapy	39	13.0%	Treatment, Sessions
FES	33	11.0%	Electrical Stimulation
Movement	29	9.7%	Mobility, Flexibility
Fatigue	25	8.3%	Tiredness, Weakness
Progress	22	7.3%	Advancement, Development
Challenges	19	6.3%	Difficulties, Barriers

Key terms in participant conversations include the most frequently mentioned words; e.g., "Recovery" (18.7%); "Pain" (15.6%). They are tied into associated word vocabulary, which enhances thematic analysis.

Table 4: Codes, Nodes, Hierarchy of Word Frequency Resulting into Themes, Sub-Themes, and Explanation

Code Name	**Code**	**Node**	**Hierarchy of Word Frequency**	**Theme**	**Sub-Theme**	**Explanation**
FES Effectiveness	C1	4	High	Motor Recovery	Improved Strength	Participants reported enhanced muscle activity post-FES therapy.
Motor Recovery	C2	3	Moderate	Functional Gains	Increased Mobility	Improved movement was noted after consistent therapy sessions.
Secondary Complications	C3	4	High	Treatment Side Effects	Pain & Fatigue	Some participants experienced muscle soreness post-session.
Challenges of FES	C4	5	High	Barriers to Treatment	Accessibility Issues	Limited resources in public hospitals affected FES sessions.
Emotional Impact	C5	3	Moderate	Psychological Adjustment	Emotional Resilience	Patients expressed anxiety about long-term recovery despite therapy.

Codes with the frequency of words leading to the generation of themes and sub-themes. In some cases, such as with recording functional electrical stimulation

(FES) effectiveness with reported motor recovery and strength improvements, these demonstrated therapy benefits can become the basis for claims.

Table 5: Analytical Themes, Sub-Themes, and Descriptive Themes

Analytical Theme	**Analytical Sub-Theme**	**Descriptive Theme**	**Detailed Explanation**
Motor Recovery	Functional Improvement	Increased Strength and Mobility	Participants reported noticeable improvements in muscle strength and movement flexibility after undergoing FES therapy. Many patients expressed increased confidence in performing daily activities such as standing, walking with assistance, and grasping objects.
Motor Recovery	Speed of Progress	Variability in Recovery Rates	The pace of motor function improvement varied among patients. Some reported rapid progress in regaining movement, while others experienced slower, incremental gains, depending on the severity of the spinal cord injury.
Secondary Complications	Therapy-Induced Challenges	Pain and Fatigue	A significant number of participants experienced muscle soreness, fatigue, and occasional discomfort after FES sessions. They described the intensity of these symptoms as fluctuating depending on the frequency and duration of therapy.
Secondary Complications	Risk of Overstimulation	Unintended Muscle Spasms	Some patients noted involuntary muscle contractions during FES therapy, which occasionally led to discomfort. A few reported that these spasms decreased over time as their bodies adapted to treatment.
Psychological Adjustment	Emotional Resilience	Psychological Impact of Therapy	Participants had mixed emotional responses to FES treatment. While many felt hopeful about regaining function, others expressed frustration and anxiety

			regarding the uncertainty of long-term recovery outcomes. Support from family and healthcare providers played a crucial role in their emotional resilience.
Psychological Adjustment	Motivation to Continue	Effect of Perceived Progress on Engagement	Patients who observed gradual improvements in movement were more motivated to continue therapy, while those with slow progress struggled with maintaining motivation. Encouragement from therapists helped sustain engagement in treatment.
Accessibility of Treatment	Barriers in Healthcare	Limited FES Access Due to Resource Constraints	Many participants reported challenges in accessing consistent FES sessions due to financial limitations, lack of availability in public hospitals, and long waiting lists. These barriers significantly affected their rehabilitation progress.
Accessibility of Treatment	Equipment and Expertise	Variability in Therapy Quality	Some patients received high-quality FES therapy in well-equipped hospitals, whereas others faced inconsistencies due to outdated equipment or insufficiently trained medical staff.
Long-Term Outcomes	Sustainability of Recovery	Uncertainty in Functional Gains Over Time	While short-term improvements in mobility were evident, participants expressed concerns regarding the sustainability of motor function gains. Some feared that progress might plateau or decline once therapy was discontinued.
Long-Term Outcomes	Need for Continuous Support	Importance of Follow-Up Rehabilitation	Patients emphasized the need for long-term rehabilitation plans, including follow-up sessions and lifestyle adaptations, to ensure continued improvement and prevent regression.

Analytical categories such as motor recovery, secondary diseases, and psychological aspects and how these factors affect patients. Many reported improvements in strength and mobility.

Discussion

Finding emphasizes the important role of FES in motor recovery after SCI. FES therapy has also been shown to significantly improve muscle strength, flexibility, and functional mobility in patients performing this type of therapy. After participating in FES training, many reported being able to perform more activities of daily living; for existing literature, these included improvements in sitting up, gripping and holding objects, as well as walking when using an assistive device (ZANCO, 2022). However, recovery was not of a uniform nature; some participants profited from rapid improvements while others experienced a gradual progression based on the severity of the injury and rate of therapy received (Anderson et al., 2021).

Despite the advantages, the treatment caused several secondary complications that were highly reported in relation to FES, mainly signs of muscle fatigue and pain. Participants also reported discomfort following therapy sessions, and the pain level varied according to the stimulation frequency and duration (Vestergaard et al., 2022; Babar et al., 2024). Some patients also experienced involuntary muscle spasms during treatment, although these effects faded over time as their bodies adjusted to the therapy (Anwer et al. 2022; Kajganic, 2023). FES is found to be beneficial, but needs careful monitoring to reduce potential side effects and enhance the long-term effectiveness (Bersch, 2021).

Psychological responses from FES treatment showed diverse results amongst participants, with emotional resilience a key factor in engaging in therapy. As patients continued FES and noticed signs of improvement, they often described ties correlating psychological benefits to FES in addition to just physical enhancement (Leone et al., 2023; Noor et al., 2024). On the other hand, there are also some with frustration and anxiety due to uncertainty about long-term functional gains. The use of social support from health care professionals and family members was often reported as an important motivator and mechanism for overcoming the barriers to completing rehabilitation (Johns et al., 2021; Haque et al., 2023).

A significant concern was barriers to FES access, especially in resource-poor healthcare settings. Some of them mentioned that heavy treatment was not consistent because they do not have money to pay for treatment or they could only receive help in community hospitals with long waiting times for therapy each time (Yang et al., 2021). Outdated equipment or the absence of specialized professionals resulted in discrepancies of treatment quality that negatively affected patient encounters. These results highlight the importance of greater access to FES therapy and better rehabilitation services can optimize patient outcomes (Santos et al., 2022).

Finally, the study does not provide long-term outcomes of FES, and many of the participants were concerned regarding the sustainability of their improvement. During the study, short-term improvements in mobility were observed, but some participants feared that stopping therapy would lead to loss of functional gains (Shariat et al., 2021; Garlet et al., 2024). Maintenance of progress and prevention of injury from developed complications was underlined in terms of follow up rehabilitation, healthy lifestyle modifications, and continued support.

Prolonged rehabilitation under FES is required in the future to extend the sustainability of FES advantages and standard of life of SCI individuals (ZANCO, 2022).

Limitations

A major limitation of this study was the relatively small sample size, which may limit applicability of the findings to the larger spinal cord injury (SCI) population. By nature, these subjective patient-experienced outcomes introduce bias into Functional Electrical Stimulation (FES) outcome observation. The study also did not have long-term follow-up that would help to determine whether motor recovery and secondary complication management persisted over time.

Recommendations

Utilizing a larger and more diverse participant demographic will allow the findings to generalize broadly. Longitudinal studies are necessary to assess long-term effects of FES on motor recovery, as well as secondary complications. In addition, accessibility to FES therapy can be maximized through favorable health care policies and better resource utilization leading to improved rehabilitation outcomes.

Conclusion

Despite issues of muscle fatigue and accessibility, the study underscores the strong evidence for disciplined use of FES in improving motor function following SCI. Mobility of participants improved but recovery differed from person to person. Motivation and psychological resilience affected therapy adherence. Such rehabilitation was a challenge under the conditions of limited health care capabilities and financial constraints. Improving the accessibility of FES and the planning of long-term rehabilitation could aid in optimizing the efficacy of FES and the well-being of the patients.

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