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Original Article

Comparison of Intensive Physical Therapy and Electrical Stimulation to Reduce Spasticity in Stroke

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ABSTRACT

Background: Stroke is a leading cause of disability worldwide, often resulting in spasticity that significantly impairs the functional recovery of individuals. The comparative efficacy of intensive physical therapy and electrical stimulation in mitigating post-stroke spasticity remains a critical area of research. Understanding the impacts of these treatments can guide clinicians in optimizing rehabilitation strategies for stroke survivors.

Objective: The study aimed to compare the effectiveness of intensive physical therapy and electrical stimulation in reducing spasticity among stroke patients, with an emphasis on how these interventions influence muscle tone and functional outcomes.

Methods: This quasi-experimental trial was conducted at Nishtar Hospital, Multan, over six months, involving 30 participants aged 50-65 years who had experienced a stroke. Participants were randomly assigned to receive either intensive physical therapy or electrical stimulation. Baseline and post-treatment assessments of spasticity were conducted using the Modified Ashworth Scale (MAS). Data were analyzed using SPSS version 25, focusing on changes in MAS scores before and after the interventions.

Results: Both interventions showed significant improvements in spasticity levels. The intensive physical therapy group exhibited notable reductions in MAS scores across various joints: shoulder flexors (from 3.13 ± 0.51 to 1.20 ± 0.41), shoulder extensors (from 3.00 ± 0.65 to 1.20 ± 0.67), and hip abduction (from 3.00 ± 0.65 to 1.33 ± 0.72). The electrical stimulation group also demonstrated significant improvements, with MAS scores in wrist flexion (from 2.73 ± 0.70 to 1.33 ± 0.61) and hip extension (from 2.80 ± 0.67 to 1.26 ± 0.45) showing notable reductions. However, no statistically significant differences were observed between the two groups in terms of overall effectiveness in reducing spasticity ($p > 0.05$).

Conclusion: Both intensive physical therapy and electrical stimulation are effective in reducing post-stroke spasticity, with no significant difference in their overall efficacy. This suggests that either treatment can be considered as part of a comprehensive rehabilitation strategy for stroke survivors, depending on individual patient needs, preferences, and specific functional goals.

Keywords: Stroke Rehabilitation, Spasticity, Intensive Physical Therapy, Electrical Stimulation, Modified Ashworth Scale, Quasi-Experimental Trial, Post-Stroke Recovery

INTRODUCTION

Cerebrovascular accidents (CVAs), widely recognized as strokes, have emerged as the principal cause of disability worldwide. Recent studies have alarmingly indicated that the incidence of strokes is significantly higher than previously estimated, with annual figures now approaching approximately 730,000 cases in the United States alone. This revised estimate suggests that the actual numbers could be even higher. A significant consequence of stroke is the development of post-stroke conditions such as spasticity, with a notable majority of survivors experiencing lasting impairments (1).

Intensive physical therapy (IPT) is designed to facilitate the rehabilitation process by engaging the brain and body in a coordinated effort to relearn movement patterns and activities through high repetitions within a condensed timeframe. This approach allows for

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a comprehensive focus on all areas of need simultaneously, thus accelerating the development of skills and strength. Among the innovative tools employed during IPT sessions is the Thera Suit, an external orthotic device that assists in realigning the body, normalizing gait patterns, and promoting neuromuscular re-education (2). Additionally, the Universal Exercise System is utilized to support functional weight-bearing exercises and gait training in a supportive environment. While upper limb interventions have been extensively tested, providing substantial benefits to the majority of stroke survivors, including those with significant residual motor deficits, interventions for the lower limb adopt a slightly different approach. This involves intensive practice of functional lower limb activities without the restriction of the affected limb, thereby facilitating rehabilitation in this patient population (3,4).

Spasticity, a common post-stroke complication, is characterized by an abnormal increase in muscle tone and exaggerated reflexes, occurring in approximately 20% to 30% of stroke survivors. It can lead to muscle contractures and significantly impair functional recovery (5). Recent advancements in treatment strategies have introduced neuromuscular electrical stimulation (NMES) as a promising option. NMES is theorized to induce specific neural plasticity within the spinal cord pathways (6), offering a valuable therapeutic approach to improve motor function. Previous studies on NMES have demonstrated enhancements in joint range of motion, finger strength, electromyography activity, and a reduction in muscle tone. Functional electrical stimulation (FES), a form of NMES, specifically targets peripheral sensory and motor nerves, facilitating the repetitive functional improvement of the paretic limb in individuals with hemiplegia or quadriplegia (7,8).

The application of NMES, including transcutaneous electrical nerve stimulation (TENS) and FES, has been explored in stroke rehabilitation for decades. These stimulation protocols have shown to improve lower limb motor function post-stroke (8). FES therapy combines preprogrammed electrical stimulation with manual joint movement assistance by a therapist, enabling patients to perform functional arm movements. This therapy involves a variety of task-specific multi-joint movements, integrated with manually assisted passive movements, tailored to enhance the patient's ability to perform functional tasks (9,10).

FES stands out as an effective model for rehabilitation, providing substantial sensorimotor input to the central nervous system. It holds the potential for continued use even after the conclusion of formal rehabilitation programs. Simplifying the application of FES, for instance, through the use of neuroprosthetics, could further amplify its benefits by seamlessly integrating essential sensorimotor input with functional activities. This approach underscores the evolving landscape of stroke rehabilitation, where innovative therapies like IPT and NMES/FES are pivotal in enhancing the quality of life for stroke survivors.

MATERIAL AND METHODS

This quasi-experimental trial was conducted at Nishtar Hospital in Multan over a period of six months, employing a non-probability purposive sampling technique to recruit participants. A total of 30 participants, aged between 50 and 65 years and experiencing post-stroke balance disturbances, were enrolled in the study. These participants met the inclusion criteria of having suffered a stroke at least six months prior to the study, possessing normal vestibular and visual functions, and demonstrating the ability to understand testing procedure instructions. Exclusion criteria encompassed individuals outside the specified age range, those with psychiatric disorders or dementia, any neurological or orthopedic conditions affecting balance, pre-existing neurological disorders, the presence of metallic or cardiac pacemaker implants, and unwillingness to participate in the study.

Participants were divided into two groups, each comprising 15 individuals, through simple randomization procedures. Informed consent was obtained from all participants, detailing the trial's safe nature and their right to withdraw at any time. The treatment group received electric stimulation, whereas the control group was subjected to intensive physical therapy. For the treatment group, Transcutaneous Electrical Nerve Stimulation (TENS) was applied to the upper and lower limb muscles for 30-40 minutes at a frequency of 100 Hz and a pulse width of 200 microseconds, adjusted to two to three times the sensory threshold. This threshold was meticulously measured for each participant before the experiment to ensure the electrical stimulation was administered at appropriate intensities, ranging from 0.01 mA until the stimulation was felt (11). The control group underwent a regimen of intensive physical therapy, starting with moist heat application for 10-15 minutes, followed by muscle stretching and range of motion exercises, muscle strengthening exercises, manual therapy, proximal trunk stability exercises, as well as balance, coordination, and gait training (12).

Data collection was carried out using standardized tools and methods to ensure the reliability and validity of the results. Ethical considerations were a paramount aspect of this study. It adhered strictly to the Declaration of Helsinki principles regarding human research ethics, ensuring the protection of participant rights, safety, and well-being throughout the trial. Additionally, the study protocol was reviewed and approved by the institutional review board of Nishtar Hospital, Multan.

For data analysis, the statistical package SPSS version 25 was utilized. The analysis included descriptive statistics to characterize the study population and inferential statistics to examine the differences between the treatment and control groups' outcomes. This comprehensive approach to data handling aimed to ensure the robustness and scientific validity of the findings, thereby contributing

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valuable insights into the comparative efficacy of electric stimulation and intensive physical therapy in reducing post-stroke balance disturbances.

RESULTS

In the conducted quasi-experimental trial at Nishter Hospital Multan, a total of 30 participants were enrolled, evenly divided by gender into two groups with 16 males and 14 females. The distribution of participants based on the affected body side was balanced, with 16 individuals experiencing right-side effects and 14 on the left side, as detailed in Table 1. This demographic setup provided a comprehensive overview for analyzing the effects of the treatments administered to both groups.

The between-group comparison of Modified Ashworth Scale (MAS) scores before and after treatment revealed significant findings. Initially, the experimental group, which received electric stimulation, and the control group, which underwent intensive physical therapy, showed comparable baseline MAS scores across various joint movements (Table 2). Notably, after 3 weeks of treatment, both groups exhibited substantial improvements in spasticity levels; however, the magnitude of improvement varied between the two treatment modalities.

For shoulder flexors, the experimental group's MAS scores improved from a mean of 3.13 ± 0.51 to 1.20 ± 0.41, while the control group's scores improved from 2.73 ± 0.70 to 1.53 ± 0.51. Although both groups showed significant improvements, the difference was not statistically significant ($p = .061$), indicating that both treatments were effective in reducing shoulder flexor spasticity. Similar trends were observed in shoulder extensors, abductors, and adductors, with both groups showing improvements, but the most significant change was noted in shoulder adductors MAS scores post-treatment, where the experimental group improved to 1.33 ± 0.48 compared to the control group's 1.13 ± 0.63, yielding a statistically significant difference ($p = .021$).

Elbow flexion and extension, along with wrist movements, also demonstrated notable improvements. Wrist flexion MAS scores after treatment showed a significant difference, with the experimental group reaching 1.33 ± 0.61 and the control group at 1.40 ± 0.73 ($p = .001$), highlighting the efficacy of electric stimulation in reducing spasticity more than intensive physical therapy in this specific area.

Table 1: Gender Distribution of Participants by Affected Body Side

Gender	Right Side	Left Side	Total
Male	8	8	16
Female	8	6	14
Total	16	14	30

Table 2: Between-Group Comparison of Modified Ashworth Scale (MAS) Scores

Joint Movement	Group	Before Treatment Mean ± SD	After 3 Weeks Treatment Mean ± SD	P value
Shoulder Flexors MAS	Experimental	3.13 ± 0.51	1.20 ± 0.41	.061
	Control	2.73 ± 0.70	1.53 ± 0.51	
Shoulder Extensors MAS	Experimental	3.00 ± 0.65	1.20 ± 0.67	.072
	Control	2.86 ± 0.63	1.33 ± 0.61	
Shoulder Abductors MAS	Experimental	2.66 ± 0.61	1.06 ± 0.70	.089
	Control	3.06 ± 0.70	1.46 ± 0.74	
Shoulder Adductors MAS	Experimental	2.80 ± 0.56	1.33 ± 0.48	.021
	Control	2.80 ± 0.67	1.13 ± 0.63	
Elbow Flexion MAS	Experimental	2.80 ± 0.56	1.33 ± 0.48	.057
	Control	3.06 ± 0.59	1.53 ± 0.51	
Elbow Extension MAS	Experimental	2.86 ± 0.63	1.20 ± 0.56	.087
	Control	3.20 ± 0.67	1.40 ± 0.73	
Wrist Flexion MAS	Experimental	2.73 ± 0.70	1.33 ± 0.61	.001
	Control	3.00 ± 0.65	1.40 ± 0.73	
Wrist Extension MAS	Experimental	2.53 ± 0.74	1.20 ± 0.77	.050
	Control	2.73 ± 0.79	1.06 ± 0.59	
Hip Flexion MAS	Experimental	2.66 ± 0.61	1.33 ± 0.61	.071
	Control	2.93 ± 0.70	1.40 ± 0.73	

Joint Movement	Group	Before Treatment Mean ± SD	After 3 Weeks Treatment Mean ± SD	P value
Hip Extension MAS	Experimental	2.80 ± 0.67	1.26 ± 0.45	.001
	Control	2.80 ± 0.56	1.33 ± 0.72	
Hip Abduction MAS	Experimental	3.00 ± 0.65	1.33 ± 0.72	.052
	Control	2.93 ± 0.70	1.46 ± 0.63	
Hip Adduction MAS	Experimental	2.86 ± 0.74	1.33 ± 0.61	.085
	Control	3.00 ± 0.65	1.53 ± 0.83	
Knee Flexion MAS	Experimental	2.93 ± 0.59	1.46 ± 0.74	.091
	Control	2.93 ± 0.59	1.46 ± 0.51	
Knee Extension MAS	Experimental	2.93 ± 0.59	1.06 ± 0.59	.065
	Control	2.40 ± 0.91	1.13 ± 0.63	
Ankle Dorsal Flexion MAS	Experimental	3.00 ± 0.65	1.40 ± 0.73	.059
	Control	3.00 ± 0.65	1.46 ± 0.63	
Ankle Plantar Flexion MAS	Experimental	3.00 ± 0.65	1.40 ± 0.53	.021
	Control	2.73 ± 0.79	1.33 ± 0.61	

Lower limb spasticity, measured through hip, knee, and ankle MAS scores, followed a similar pattern of significant improvement. The hip extension MAS scores after treatment were particularly noteworthy, with the experimental group showing an average score of 1.26 ± 0.45 compared to the control group's 1.33 ± 0.72, marking another significant difference ($p = .001$) between the treatments.

DISCUSSION

This research aimed to evaluate the efficacy of intensive physical therapy versus electrical stimulation in reducing spasticity among stroke patients. The study specifically investigated the relationship between patient demographics such as age, gender, and the affected side of the body in individuals aged 50-65 years, excluding those with pacemakers or an inability to follow instructions. Baseline measurements were taken, followed by a subsequent assessment after three weeks of treatment in two distinct groups: one receiving intensive physical therapy and the other undergoing electrical stimulation (13, 14).

The analysis revealed that both interventions led to improvements in spasticity as measured by the Modified Ashworth Scale, particularly noted in shoulder flexion, shoulder extension, and hip abduction. The mean scores in these areas showed significant reductions post-treatment, indicating a decrease in muscle spasticity. However, no significant differences were observed between the two groups when baseline measurements were compared, suggesting that both interventions were equally effective at the outset of the study (15, 16).

The lack of significant difference in baseline measures, with $p > 0.05$, implies that the initial conditions of spasticity in both groups were comparable, allowing for a fair comparison of the treatment effects. Electrical nerve stimulation's mechanism, believed to release GABA or opiates that inhibit neurotransmitters at the spinal cord level, mirrors analgesic effects by producing rapid vibrations in the surrounding muscles and increasing acetylcholine production, which aids in muscle contraction (13). This biological response underscores the potential of electrical stimulation in facilitating muscle relaxation and reducing spasticity (17-19).

The study highlights the importance of task-specific exercises and functional activities in rehabilitation. Repetitive tasks and functional activities in a real-world context were shown to be crucial for patients recovering from brain injury, suggesting that electrical stimulation alone may not suffice to enhance task training in affected limbs. Functional stimulation, particularly when combined with targeted exercises, could potentially yield more specific improvements by engaging major muscle groups through a closed-loop control system (20).

The research acknowledges several strengths, including the rigorous methodological approach and the focused comparison of two prevalent therapeutic interventions for stroke-induced spasticity. However, it also faces limitations, such as the small sample size and the short duration of the intervention, which may not capture the long-term effects of the treatments. Additionally, the study's exclusion criteria limited the generalizability of the findings to a broader stroke patient population.

CONCLUSION

In conclusion, the study suggests that intensive physical therapy may offer slight advantages over electrical stimulation in reducing spasticity among stroke patients, although both treatments demonstrated efficacy. These findings contribute to the growing body of evidence supporting tailored rehabilitation strategies that incorporate both physical therapy and electrical stimulation to optimize recovery outcomes. Future research should aim to explore the long-term effects of these interventions, potentially incorporating

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larger and more diverse patient populations, to further understand the mechanisms underlying their effectiveness. Moreover, integrating new technologies and personalized rehabilitation protocols could enhance the precision and impact of stroke rehabilitation, addressing the unique needs of each patient and ultimately improving their quality of life.

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