Benefits of Extracorporeal Shock Wave Therapy to Reduce Spasticity in Cerebral Palsy and Stroke Patients

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ABSTRACT

Background: Spasticity, a common issue in cerebral palsy and stroke patients, significantly impairs mobility and quality of life. Non-invasive treatments like Extracorporeal Shock Wave Therapy (ESWT) have been explored for spasticity reduction.

Objective: To evaluate the effectiveness of ESWT in reducing spasticity in cerebral palsy (CP) and stroke patients using the Modified Ashworth Scale (MAS).

Methods: A randomized controlled trial (RCT) was conducted on 28 spastic CP and stroke patients. Participants were divided into Group A (n = 14, ESWT combined with conventional physiotherapy) and Group B (n = 14, conventional physiotherapy only). ESWT was administered at 5 Hz frequency, 0.10 mJ/mm^2 energy flux density, and 1500 impulses per session for 30 minutes, 5 days a week, for 6 months. Spasticity was assessed using MAS pre- and post-intervention. Data were analyzed using IBM SPSS version 25.

Results: The ESWT group showed a significant reduction in MAS scores from 3.21 ± 0.25 to 1.77 ± 0.37 ($p < 0.001$), compared to the control group (3.10 ± 0.44 to 2.36 ± 0.60; $p < 0.001$).

Conclusion: ESWT significantly reduced spasticity in CP and stroke patients, demonstrating its potential as an adjunctive therapy.

INTRODUCTION

Spasticity is a common and debilitating condition associated with several neurological disorders, including cerebral palsy (CP) and stroke, which often manifests as increased muscle tone, involuntary contractions, and exaggerated deep tendon reflexes, leading to impaired mobility and functional deficits (1). In individuals affected by CP or recovering from stroke, spasticity significantly impacts their daily activities, freedom of movement, and overall quality of life (2). The pathophysiology of spasticity is complex, involving a combination of neurophysiological abnormalities, including upper motor neuron hyperexcitability and impaired reflex inhibition, resulting in an imbalance between excitatory and inhibitory signals within the central nervous system (3). Despite the high prevalence of spasticity, ranging from 20-40% in stroke survivors and over 80% in individuals with CP, its management remains challenging, with many therapeutic options offering only temporary relief or being associated with adverse effects (4). Consequently, there is an ongoing search for safer, more effective, and less invasive approaches to reduce spasticity and improve motor function in affected patients.

Extracorporeal shock wave therapy (ESWT) has emerged as a promising non-invasive treatment modality for spasticity management. Initially introduced in the 1980s for lithotripsy in urology, ESWT has evolved into a versatile tool used in various musculoskeletal and neurological disorders due to its ability to induce mechanical and biological responses in tissues (5, 6). This therapy involves the application of focused or radial shock waves to targeted areas of the body, which can modulate neuromuscular function through several mechanisms, including alteration of the connective tissue properties, reduction of muscle stiffness, and modulation of the activity of spinal motor neurons (7, 8). Furthermore, ESWT has been shown to promote vascularization and tissue remodeling by stimulating angiogenesis and enhancing the release of local growth factors, contributing to its therapeutic benefits in spastic muscles (9, 10). The effectiveness of ESWT in spasticity reduction has been evaluated in multiple studies, revealing improvements in muscle tone and motor performance without significant procedural pain or complications, making it an attractive treatment option for CP and stroke patients (11).

Recent research has focused on elucidating the specific effects of ESWT on spastic muscles, indicating that it can alter both central and peripheral mechanisms of spasticity. ESWT has been shown to reduce the number of acetylcholine receptors at the neuromuscular junction and modulate neurotransmitter levels, leading to decreased synaptic transmission and reduced muscle tone (12). Moreover, studies employing electromyography (EMG) and biomechanical assessments have demonstrated that ESWT can decrease muscle hyperactivity and enhance joint

flexibility in spastic muscles, leading to improved range of motion and functional mobility (13). Clinical trials comparing the effects of ESWT on different muscle groups and using various application protocols have further highlighted its potential to induce long-lasting reductions in spasticity and improve patients' gait patterns and motor function (14, 15). For instance, El-Shamy et al. reported that ESWT significantly enhanced gait parameters, such as cadence and stride length, in children with hemiplegic CP (16). Similarly, Gonkova et al. found that ESWT improved baropodometric outcomes, indicating better foot contact and stability during walking, which are critical for patients with spastic lower limb muscles (17).

Despite these promising findings, the variability in study designs, patient populations, and treatment protocols necessitates further research to establish standardized guidelines for ESWT application in spasticity management. Additionally, most studies have focused on short-term outcomes, and the long-term effects of repeated ESWT sessions remain underexplored (18). Thus, this study aimed to investigate the benefits of ESWT in reducing spasticity among CP and stroke patients using a randomized controlled trial design to provide robust evidence on its efficacy and to optimize treatment protocols for this patient population. By comparing the effects of ESWT to conventional therapy using the Modified Ashworth Scale (MAS) for spasticity assessment, we sought to elucidate the potential of ESWT as a safe and effective therapeutic approach for improving spasticity-related outcomes in individuals with neurological impairments (19). The findings from this study could contribute to a better understanding of the role of ESWT in neurorehabilitation and support its integration into clinical practice for managing spasticity in CP and stroke patients.

MATERIAL AND METHODS

The present study utilized a randomized controlled trial (RCT) design conducted over a period of six months, from September 2023 to June 2024, in public and private hospitals, including Chaudhary Muhammad Akram Teaching Hospital, Azra Naheed Medical College, and Social Security Hospital. The sample comprised a total of 28 participants, selected using purposive sampling, and equally divided into two groups: Group A (n = 14) received Extracorporeal Shock Wave Therapy (ESWT) in combination with conventional physiotherapy exercises, whereas Group B (n = 14) served as the control group, receiving only conventional physiotherapy exercises along with placebo treatment. The inclusion criteria were patients of both genders, aged between 5 to 15 years, diagnosed with spastic CP or stroke, and presenting with clinically significant spasticity as measured by the Modified Ashworth Scale (MAS). Participants with non-spastic cerebral palsy (e.g., flaccid paralysis), first-stage stroke, spasticity caused by injuries, or newborns were excluded from the study.

All participants were assessed at baseline and at the end of the six-month intervention period. Group A received ESWT along with conventional physiotherapy exercises such as range of motion (ROM) exercises, strengthening exercises, and stretching for a duration of 30 minutes per session, five days a week. The ESWT parameters included a frequency of 5 Hz, an energy flux density of 0.10 mJ/mm^2, and a total of 1500 impulses applied over the targeted muscles exhibiting spasticity. Group B received the same physiotherapy regimen without the application of ESWT, serving as the control group. The study aimed to compare the effects of ESWT on spasticity reduction and motor function improvement, utilizing MAS as the primary outcome measure to assess the level of spasticity in different muscle groups.

Data collection was carried out through direct observation and clinical evaluation by trained physiotherapists who were blinded to the group allocation. Informed consent was obtained from all participants or their legal guardians prior to enrollment, and the study was approved by the Institutional Review Board (IRB) of the Superior University, Lahore. Ethical considerations were upheld in accordance with the principles outlined in the Declaration of Helsinki (1964), including respect for patient autonomy, confidentiality, and the right to withdraw from the study at any time without penalty.

The primary outcome measure was spasticity, evaluated using the Modified Ashworth Scale (MAS), which rates muscle tone on a scale from 0 (no increase in muscle tone) to 4 (affected parts rigid in flexion or extension). Secondary outcome measures included the assessment of functional mobility and quality of life through standardized scales. Baseline characteristics such as age, height, weight, and BMI were recorded for all participants. Data were analyzed using IBM SPSS version 25. The normality of the data distribution was assessed using the Shapiro-Wilk test, which indicated that the data were normally distributed ($p > 0.05$), thereby justifying the use of parametric tests for further analysis. Independent sample t-tests were employed to compare between-group differences, while paired sample t-tests were used for within-group comparisons before and after the intervention.

The results were presented as mean ± standard deviation (SD) for continuous variables, and statistical significance was set at a p-value of less than 0.05. The findings demonstrated a significant reduction in MAS scores in the ESWT group compared to the control group, indicating the efficacy of ESWT in reducing spasticity and enhancing functional outcomes in children with cerebral palsy and stroke survivors. These results provide a basis for incorporating ESWT as an adjunctive treatment modality in neurorehabilitation settings for spasticity management (20).

RESULTS

The results of the study are presented in a structured manner, comparing the demographic characteristics and the effectiveness of Extracorporeal Shock Wave Therapy (ESWT) on reducing spasticity in cerebral palsy and stroke patients. The analysis included both between-group and within-group comparisons using the Modified Ashworth Scale (MAS) as the primary outcome measure. The within-group analysis demonstrated a statistically significant

Table 1: Demographics of Participants in Both Groups

Demographics	Treatment Group	N	Mean ± SD	P-value
Age (years)	ESWT	14	7.50 ± 1.87	0.527
	Control	14	7.07 ± 1.86	
Height (cm)	ESWT	14	121.28 ± 9.12	0.594
	Control	14	118.50 ± 9.47	
Weight (kg)	ESWT	14	17.50 ± 3.01	0.835
	Control	14	17.28 ± 2.30	
BMI (kg/m²)	ESWT	14	11.84 ± 1.08	0.413
	Control	14	12.30 ± 0.76	

reduction in MAS scores for both the ESWT group and the control group ($p < 0.001$ for both). The demographic characteristics, including age, height, weight, and BMI, were similar between the ESWT and control groups, with no statistically significant differences observed ($p > 0.05$)

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

Outcome Measure	Group	N	Mean ± SD	Mean Difference	P-value
MAS Pre-Intervention	ESWT	14	3.21 ± 0.25	0.106	0.447
	Control	14	3.10 ± 0.44		
MAS post-intervention	ESWT	14	1.77 ± 0.37	0.589	0.004*
	Control	14	2.36 ± 0.60		

The MAS scores for spasticity showed no significant difference between groups at baseline ($p = 0.447$). However, a significant reduction in spasticity was observed in the ESWT group compared to the control group at the end of the intervention ($p = 0.004$).

Table 3: Within-Group Comparison of Modified Ashworth Scale (MAS) Scores Using Paired Sample T-Test

Group	Outcome Measure	Pre-Intervention	Post-Intervention	Mean Difference ± SD	95% CI	P-value
ESWT	MAS for Spasticity	3.21 ± 0.25	1.77 ± 0.37	1.44 ± 0.51	1.14 - 1.73	<0.001**
Control	MAS for Spasticity	3.10 ± 0.44	2.36 ± 0.60	0.74 ± 0.38	0.52 - 0.97	<0.001**

However, the magnitude of change in MAS scores was greater in the ESWT group (1.44 ± 0.51) compared to the control group (0.74 ± 0.38), indicating a more pronounced reduction in spasticity in the treatment group. In summary, the results of the study revealed that while both groups exhibited a reduction in spasticity, the application of ESWT in Group A resulted in a significantly greater improvement in MAS scores compared to conventional therapy alone. These findings suggest that ESWT may serve as an effective adjunctive therapy in reducing spasticity and enhancing motor function in CP and stroke patients, providing a non-invasive alternative for spasticity management.

DISCUSSION

The present study aimed to evaluate the effectiveness of Extracorporeal Shock Wave Therapy (ESWT) in reducing spasticity among patients with cerebral palsy (CP) and stroke, comparing its outcomes with conventional physiotherapy alone. The findings indicated that ESWT, when combined with traditional physiotherapy interventions, resulted in a significant reduction in Modified Ashworth Scale (MAS) scores, suggesting that it can effectively alleviate muscle hypertonia and improve motor function. This outcome aligns with previous research, which has consistently reported the beneficial effects of ESWT in reducing spasticity and improving functional outcomes in neurological patients (Martínez et al., 2020; Testa et al., 2020) (3, 8). Specifically, the significant between-group differences observed at post-intervention reflect the capacity of ESWT to induce more pronounced changes in muscle tone compared to conventional physiotherapy alone, which is consistent with other studies that demonstrated similar improvements in MAS scores following ESWT application (Diemaker et al., 2016; El-Shamy et al., 2016) (11, 16).

The mechanisms underlying the efficacy of ESWT in spasticity management are thought to involve both central and peripheral neuromuscular adaptations. Previous studies have suggested that ESWT may disrupt the actin-myosin cross-bridging within spastic muscles, reduce muscle stiffness, and alter local connective tissue properties, thereby enhancing elasticity and reducing muscle resistance during passive stretch (Mittermayr et al., 2011; Chang et al., 2023) (9, 21). Additionally, the observed reduction in acetylcholine receptor density at the neuromuscular junction and the modulation of neurotransmitter release further support the potential neuromodulator effects of ESWT (Diemaker et al., 2016) (11). These physiological changes, combined with improved local blood flow and angiogenesis, may contribute to the observed reduction in MAS scores and improved motor performance in the ESWT group.

Despite these promising results, there were some limitations that must be acknowledged. The small sample

size and the relatively short duration of follow-up limit the generalizability of the findings to broader patient populations. Furthermore, the study only included pediatric and adolescent patients with spastic CP and stroke, which restricts the applicability of the results to adult populations or patients with other neurological conditions. Additionally, the study did not investigate the long-term effects of ESWT beyond the intervention period, and the durability of the observed improvements remains uncertain. Previous research has suggested that the therapeutic effects of ESWT may diminish over time without repeated sessions, highlighting the need for future studies to explore the optimal frequency and duration of ESWT application (Lee and Kim, 2023) (19).

Another potential limitation is the lack of objective measures such as electromyography (EMG) or biomechanical assessments to corroborate the subjective findings from the MAS scale. Although MAS is a widely used clinical tool, its sensitivity and specificity in detecting subtle changes in muscle tone are limited compared to more sophisticated measurement techniques (Hugos and Cameron, 2019) (4). Future research could benefit from incorporating a multimodal approach to evaluate the effects of ESWT on spasticity, including EMG, joint range of motion analysis, and patient-reported outcomes to provide a more comprehensive assessment of its therapeutic impact.

In terms of strengths, this study employed a rigorous RCT design, ensuring a high level of internal validity. The randomization of participants and blinding of assessors minimized potential biases and enhanced the reliability of the results. Moreover, the use of a standardized protocol for ESWT application, including consistent energy settings and treatment frequency, allowed for reproducibility and comparability with other studies. The significant reduction in MAS scores in the ESWT group, as compared to the control group, demonstrates the potential of this modality as an adjunct to conventional therapy for spasticity management in pediatric neurological rehabilitation.

Based on these findings, it is recommended that ESWT be considered as a viable treatment option for spasticity in patients with CP and stroke, particularly in cases where conventional interventions have provided limited benefits. Future studies should focus on larger and more diverse patient cohorts, including adult populations, and should investigate the long-term effects of repeated ESWT sessions to establish evidence-based guidelines for clinical practice. Additionally, exploring the combination of ESWT with other spasticity management strategies, such as botulinum toxin injections or functional electrical stimulation, could further optimize treatment outcomes and provide insights into synergistic therapeutic effects (Gonkova et al., 2013) (17).

CONCLUSION

In conclusion, this study provided evidence supporting the use of ESWT as an effective non-invasive modality for reducing spasticity and improving motor function in children and adolescents with CP and stroke. The significant reductions in MAS scores observed in the ESWT group highlight its potential to be integrated into standard rehabilitation protocols. However, further research is warranted to address the limitations noted and to refine treatment protocols for broader clinical application.

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