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"THE EFFECTS OF RADIAL EXTRACORPOREAL SHOCKWAVE THERAPY AND ANTIGRAVITY TREADMILL TRAINING ON DYNAMIC BALANCE IN INDIVIDUALS WITH SPASTIC CEREBRAL PALSY"

JESSICA RUTH CHRISTINA
MEENAKSHI COLLEGE OF PHYSIOTHERAPY

DR. SUGASRI SURESHKUMAR
MEENAKSHI ACADEMY OF HIGHER EDUCATION AND RESEARCH, CHENNAI

ABSTRACT

BACKGROUND: Spasticity is the most common motor problem in cerebral palsy (CP), and its treatment is difficult, offering a considerable challenge to the rehabilitation team. Radial extracorporeal shock wave therapy (rESWT) has developed in recent years as an effective, non-invasive, and low-risk option for managing spasticity in CP patients, with very mild side effects such as small bruises or soreness during administration. Most of the children with cerebral palsy (CP) are not able to walk or can walk in incorrect pattern and are dependent on assistive devices. Recently an antigravity treadmill has been found to be beneficial as a new therapeutic approach. Thus, the study is done to investigate the effects of antigravity treadmill training (AlterG) along with radial extracorporeal shockwave therapy (rESWT) in improving dynamic balance in spastic cerebral palsy.

OBJECTIVE: The purpose of this study is to determine whether prolonging the duration between rESWT sessions could help patients with CP benefit from therapy for prolonged spasticity. Furthermore, how antigravity treadmill training helps cerebral palsy sufferers with their walking, balance, and fall prevention.

METHODOLOGY: 30 patients will be included in the study. Enrolment is based upon inclusion/exclusion criteria. Participants will be randomized in 2 groups. **GROUP A**: (experimental group) Each patient will receive 2000 impulses in the Triceps Sural muscle (distributed by all the plantar flexor muscles: soleus and gastrocnemius), at a 2.2 Bars pressure and a frequency of 8 Hz. There will be a 3-week gap between each session. They also underwent antigravity treadmill training (20 minutes per day, three days per week) in addition to conventional physical treatment throughout the course of three months. **GROUP B: (**control group) received only traditional physical therapy such as stretching their spastic lower limb muscles, range of motion exercises, strengthening exercises, constraint-induced movement therapy (CIMT), and gait training on parallel bars and treadmill. Outcomes as Muscle tone and Dynamic balance were measured at baseline and after 6 months and 2 weeks of intervention.

RESULT: Radial extracorporeal shockwave and antigravity treadmill training improve the dynamic balance of children with spastic cerebral palsy

CONCLUSION: Shock wave therapy could serve as an effective method for diminishing spasticity, enhancing the ability to isolate and manage movement, and thereby, promoting better balance and gross motor skills in children with unilateral cerebral palsy. The clinical significance is that Antigravity treadmill training may be viewed as a therapeutic approach for achieving a lasting enhancement in postural stability for children with spastic cerebral palsy.

KEYWORDS: Radial extracorporeal shock wave therapy rESWT, spasticity, cerebral palsy, antigravity treadmill training, constraint induced movement therapy.

1. INTRODUCTION

Cerebral palsy refers to a set of chronic conditions that have an effect on bodily mobility, posture, and muscle coordination. These disorders are caused by non-progressive defects in the developing fetal or newborn brain that usually occur before birth, during delivery, or in the early postnatal period [46]. Affecting roughly two to three out of each 1,000 live births international, cerebral palsy is most of the most customarily occurring motor disabilities in youngsters. [41]. Making up between 70 and 80 percentage of all instances, spastic cerebral palsy is a maximum normal style of cerebral palsy. Increased muscular tone (hypertonia), muscle stiffness, and exaggerated reflexes (spasticity) are the hallmarks of spastic cerebral palsy (CP), which can cause aberrant posture, trouble moving, and problems with balance and coordination [21].

Spasticity in CP is caused by damage in upper motor neurons, resulting in an imbalance of excitatory and inhibitory impulses in the central nervous system. Clinically, this presents as resistance to passive stretching dependent of the speed of movement, which can greatly impact a child's motor skills and daily functioning. [20]. Spasticity mostly affects the lower legs, resulting in equinus foot deformity, scissoring gait, and difficulties walking and standing. Over time, persistent spasticity can lead to muscular contractures, joint abnormalities, and other functional impairments [1]. Treating spasticity is difficult, and usually a challenge to the rehabilitation team. Treatment of spastic cerebral palsy mostly centers on enhancing balance and postural control. Functional motions like walking, jogging, and position changes demand dynamic balance, which is the capacity to keep the body's centre of gravity (COG) inside the base of support (BOS) while in movement. Impaired balance in children with spastic CP is caused by the combination of neuromuscular impairments, such as decreased selective motor control, poor muscle coordination, altered muscle tone, and disrupted sensory integration [4]. These deficits can raise the risk of falls, limit participation in physical activities, and reduce independence, lowering the child's quality of life. Traditionally, the management of spasticity and balance deficits in CP has relied on a combination of physical therapy, pharmacological treatments (e.g., oral antispastic agents, botulinum toxin injections), orthotic devices, and in some cases, surgical interventions such as selective dorsal rhizotomy [40]. Many treatments have shown different degrees of efficacy, but many are restricted by negative effects, invasiveness, expensive price, or short-term results. As a result, there is an increasing interest in alternative and complementary therapies that are non-invasive, safe, and successful in treating spasticity and functional impairment.

RADIAL EXTRACORPOREAL SHOCKWAVE THERAPY (RESWT)

Radial extracorporeal shockwave therapy is one such new technique. High-energy acoustic waves produced outside the body and sent to the affected muscles through the skin are applied using this approach. It is thought that rESWT's therapeutic effects result from mechanically stimulating tissues, which alters them at the cellular and molecular level. These benefits include improved blood flow, decreased muscle rigidity, altered neuromuscular junction activity, and tissue regeneration [33]. [19]. rESWT is increasingly being explored in the context of musculoskeletal and neurological illnesses, including as tendinopathies, myofascial pain syndrome, and, most recently, spasticity in neurological pathologies.

A number of studies have shown that rESWT helps persons with CP have decreased muscle stiffness. For example, in their study "treatment of spasticity in cp" [50], Vidal et al. observed a considerable decrease in spasticity in the gastrocnemius muscle, as evaluated by the Modified Ashworth Scale (MAS). In a similar vein, Abd-el-kafy et al. discovered that children with spastic diplegia had a wider passive range of motion and less resistance to stretching in their study "Effects of postural balance training in cp" [3]. According to these findings, rESWT could be a useful non-invasive supplement to standard therapy for CP patients' spasticity.

ANTIGRAVITY TREADMILL TRAINING (AGT)

Another potential strategy that has sparked interest in juvenile neurorehabilitation is antigravity treadmill (AGT) training. AGT technology, such as the AlterG treadmill, employs lower-body positive pressure to reduce the user's effective body weight, allowing for partial weight bearing ambulation. This helps children with motor disabilities to practice walking in a safe setting, reducing joint and muscle strain. AGT exercise optimizes gait symmetry, improves neuromuscular reeducation, and boosts endurance and mobility confidence [32].

AGT can help kids with cerebral palsy because it can give them repetitive, task-specific gait training without making their spasticity or fatigue worse. Alwhaibi found that AGT training made adults with spastic cerebral palsy walk faster, take longer steps, and be more mobile in general. This was part of a study on AGT for kids with cerebral palsy [2]. Also, after AGT sessions, people were better at shifting their weight and their lower limb muscles were more active [20]. Gains in freedom and balance in day-to-day tasks can result from these advantages. There has been limited study comparing or combining rESWT and AGT training to assess their combined effects on dynamic balance, despite the fact that both have shown individual efficacy in enhancing motor function and spasticity in CP. AGT improves motor learning and functional performance, while rESWT lessens hypertonicity. These treatments may work in concert when combined. This combination may have significant positive effects on ambulation and dynamic balance in children with spastic cerebral palsy.

MODIFIED TARDIEU SCALE (MTS)

The efficacy of these treatments is dependent on an accurate assessment of balance and spasticity. The Modified Tardieu Scale (MTS), which measures muscular reaction to passive stretch at increasing speeds, is widely known for distinguishing between contracture and spasticity [22]. The MTS is better suited for identifying improvements after intervention because it offers both a qualitative (degree of spasticity) and quantitative (angle of muscle reaction) evaluation, unlike the Modified ashworth scale.

PEDIATRIC BALANCE SCALE (PBS)

The Pediatric Balance Scale is frequently used to assess dynamic balance. The 14 items on the PBS, which was adapted from the Berg Balance Scale, assess functional balance tasks like standing, sitting, reaching, and turning. In pediatric groups with neurological abnormalities, it has shown outstanding validity and reliability [28]. PBS

scores are a useful outcome measure in CP research since they have been linked to have improved functional mobility and a reduced the risk of falls.

The goal of this study is to evaluate the effects of antigravity treadmill training and Radial extracorporeal shockwave therapy on dynamic balance in children with spastic cerebral palsy. This study will demonstrate the effectiveness of these innovative therapies, individually and in combination, by assessing improvements in spasticity and balance using Modified Tardieu scale and Pediatric balance scale as outcome measures.

This study has the potential to affect clinical practice by identifying effective, non-invasive, and child-friendly therapies for improving balance and treating spasticity in kids with cp. Given CP's lifetime nature and influence on functional independence, early and successful rehabilitation treatments are critical for optimizing results and improving the quality of life for afflicted persons and their families. As healthcare moves toward more individualized and integrative models of care, research like this is critical in directing evidence-based, multidimensional approaches to pediatric rehabilitation. This study also adds to a growing body of literature that highlights the significance of combining therapeutic modalities to attain holistic results by examining the interaction between functional and neuromuscular therapies. The results might also guide upcoming studies on the long-term impacts, cost-effectiveness, and creation of standardized procedures for incorporating rESWT and AGT into the regular clinical treatment of youngsters with spastic CP.

Hence, cerebral palsy represents a complex neurodevelopmental condition with profound implications for motor function, balance, and quality of life. Spasticity and dynamic balance impairments are among the most challenging aspects of CP management. Radial extracorporeal shockwave therapy and antigravity treadmill training are innovative, non-invasive approaches that hold promise for addressing these issues. By rigorously evaluating their effects and providing robust clinical data, the present study endeavours to contribute meaningfully to the field of pediatric neurorehabilitation and support the development of comprehensive, patient-centered care strategies for children with spastic CP.

2. METHODOLOGY AND MATERIALS

2.1 STUDY DESIGN: Pretest and posttest experimental study design
STUDY SETTING: Braintree hospital (Vadapalani, Chennai) & pride hospital (Perambur, Chennai)
SAMPLE METHOD: Convenient sampling method
SAMPLE SIZE AND DURATION: 30 patients [15-control group and 15-experiemental group] with time period of 6 months and 2 weeks.
Statistical Analysis: Paired t-test is to evaluate the effectiveness of the program, independent t-test is to compare the effectiveness of the posttest values of both the groups of the program.

This randomized controlled study's goal is to find out how antigravity treadmill (AGT) training and radial extracorporeal shockwave therapy (rESWT) affect the dynamic balance of people with spastic cerebral palsy (CP). After being chosen based on set inclusion and exclusion criteria, the participants were randomly put into intervention groups.

INCLUSION CRITERIA

- Patients who presented with spastic cerebral palsy (CP)
- Patients belonged to both sexes
- Age group between 4 to 30 years
- Spasticity presented in the triceps surae muscle
- Patients with a gross motor classification (GMFCS) of level 1 and 2
- Patients with either unilateral or bilateral involvement
- Must have Cognition and perception ability to understand simple instructions
- Modified Ashworth grade of above 1
- Ability to move, at least when using a walker.

EXCLUSION CRITERIA

- Any history of treatment in the six months before the trial for the triceps sural or any other lower extremity muscle.
- History of receiving, within the six months before the research, targeted intramuscular therapy with phenol or alcohol, or botulinum toxin, in the triceps sural or any other lower limb muscle.
- History of tumor (those in the cerebellopontine angle (CPA) region).
- History of patients who had undergone any surgical procedures for orthopedic foot deformities in the past year.
- Observable abnormalities of ankle joint
- Myopathy or neuropathy present

2.2 INTERVENTION PROTOCOL

Participants were separated into two groups: Group A received radial extracorporeal shockwave therapy (rESWT), and antigravity treadmill (AGT) training along with traditional physical treatment. Whereas group B received only traditional physical therapy.
Both interventions were conducted over a period of 6 months and 2 weeks, with sessions scheduled three times per week.

EXPERIEMENTAL GROUP-1

Group 1 was given radial extracorporeal shockwave along and antigravity treadmill training along with traditional physiotherapy.

Radial Extracorporeal Shockwave Therapy (rESWT)

- Patient position: prone lying
- Radial shockwave therapy was applied using a standard rESWT device, focusing on the gastrocnemius and soleus muscles.
- Based on previously known procedures that have been demonstrated to improve motor function and lower muscular tone in spastic CP, the application used energy flux densities ranging from 0.03 to 0.25 mJ/mm² at a frequency of 10–15 Hz [35, 50].
- The therapy was administered for 5 minutes per session, targeting the myotendinous junction where spasticity predominantly manifests.
- The radial nature of the shockwaves enables dispersion through superficial layers, reducing tissue stiffness and promoting neuromodulation of spasticity-related pathway [18].

Antigravity Treadmill (AGT) Training

- The Antigravity Treadmill training was conducted using a zero-gravity physical therapy equipment, which allows users to exercise with a reduced body weight load.
- Patient Positioning: made to Stand in the middle of the treadmill belt. Avoiding them from leaning too far forward or backward.
- Participants began with 60–70% body weight support and progressed to lower support levels over time, based on tolerance and clinical response.
- The patient was fastened into a harness. The patient's spastic CP improved their ability to move their legs by "offloading" 30 pounds using zero-gravity physical therapy equipment.
- Wearing a gait belt around the waist helped prevent falls during the 20-30 minute sessions, which focused on gait patterning, balance correction, and neuromuscular coordination (32).
- The lower stress environment improved joint alignment and motor control, avoiding the strain associated with regular overground walking. [20].

EXPERIEMENTAL GROUP-2

During the same time period, the control group received only conventional physical therapy such as stretching their spastic muscles, range of motion (ROM) exercises, strengthening exercises, constraint-induced movement therapy (CIMT), and gait training on parallel bars and treadmill.

Stretching Exercises

People with cerebral palsy, particularly those who experience stiffness, need to do stretching exercises. These exercises promote joint flexibility, reduce muscular tension, and prevent contractures. Common stretches recommended include:

- Hamstring Stretch: the patient was instructed to sit on the floor with their legs extended and gently reach towards their toes to stretch the muscles in the back of their legs.
- Calf Stretch: the patient was taught to stand with one foot positioned behind the other and lean forward to stretch the calf muscles at the back of the leg.
- Frequency and duration: three times a week for 10 minutes.
- Daily stretching was recommended to help improve the range of motion and alleviate discomfort caused by tight muscles. [18]

Strengthening Exercises

Increasing muscle strength is crucial for bettering everyday functioning, mobility, and posture. Arms, legs, and the core are frequently the focus of strengthening workouts.
The following strengthening exercises were provided:

- Bridges: the patient is instructed to lie on their back with their feet flat on the ground and their knees bent. then instructed to engage the glutes and core by lifting the hips toward the ceiling.
- Seated Leg Lifts: this technique involves having the patient sit on a stool with their feet flat on the floor. Participants were instructed to strengthen their thighs by lifting one leg at a time while maintaining its straight position.
- Frequency and duration: three times a week for 10 minutes. [18]

Balance and Coordination Exercises

To improve motor skills and prevent falls, balance and coordination must be improved. The following balance exercises were included:

- Single-Leg Stand: the patient was required to stand on one leg while gripping a chair for support, with the duration of the exercise being increased gradually.
- In order to increase stability, the patient is required to walk heel-to-toe, putting one foot in front of the other in a straight line.
- Balance Board Exercises: There was a balance board.as well as challenging the patient to stand on it and balance themselves initially both with and without assistance. followed my minimal upper limb activity while maintain their balance on the board.
- Frequency and duration: 3 times per week for about 10 mins.[3]

Gait Training

Improved posture and walking patterns are the main goals of gait training for those with CP who are ambulatory. The exercises provided are:

- Treadmill Walking: Using a treadmill to walk for ten minutes or so, usually with harness support, to develop steady steps and increase endurance.
- Step-Ups: To build leg muscles and enhance balance, alternately step up and down on a step or low platform. Walking on your toes or heels might help you strengthen your feet and enhance your gait.
- parallel bar training were given for gait training.[3]

Constraint induced movement therapy

The stronger leg is limited (not completely blocked, but usage is reduced), so the weaker leg gets more practice. Having the child do activities that force them to use the weaker leg (like)

1. Stepping over obstacles with the weaker leg
2. Balancing games using the weaker leg
3. Kicking a ball with the weaker leg
4. Walking on different surfaces

- Devices or setups were used that encouraged weight bearing and movement on the weaker side.
- **Frequency:** 3 days per week **Duration per day:** 30 mins. [6]

2.3 OUTCOME MEASURES

1. Muscle tone
2. Dynamic balance

TOOLS USED:

1. Modified Tardieu Scale (MTS)
2. Pediatric Balance Scale (PBS)

PROCEDURAL FRAMEWORK: Each participant underwent a baseline assessment before the first intervention session. Follow-up assessments were conducted at the end of the 6 months and 2 week intervention period. All sessions were supervised. The assessors, unaware of the intervention type received by participants, ensured unbiased evaluation of tone and balance. Adherence and any adverse effects were monitored regularly. Informed consent were secured from patient's parents or legal guardians of all participants.

3. RESULTS

The changes in the experimental group are examined using a paired t-test.

From the table I, the descriptive statistics mean, standard deviation, t-value has been obtained using t- test of pre-test and post-test. The statistical results support the application of Antigravity treadmill training along with radial extracorporeal shockwave therapy is effective in spastic cerebral palsy patients.

- From the table 1, The descriptive statistics, including mean, standard deviation, and t-value, were calculated using a t-test comparing pre-test and post-test results. The statistical findings indicate that the use of Antigravity treadmill training is beneficial for individuals with spastic cerebral palsy.
- From table 1, The descriptive statistics, including mean, standard deviations, and t value, were calculated using a t-test comparing pre-test and post-test results. The statistical findings provide evidence that the use of radial extracorporeal shockwave therapy is effective for treating spastic cerebral palsy.
- From table 5, the descriptive statistics for the experimental group's pre-test dynamic balance values, t-test value is 33.47 dynamic balance <0.05 with the mean value is 31.6.
- From table 5, the descriptive statistics for the experimental group's pre-test muscle tone values, t-test value is 30.16-muscle tone <0.05 with the mean value is 6.6.
- From table 6, the descriptive statistics of post-test value of dynamic balance in experimental Group t-test value is 33.47 dynamic balance <0.05 with the mean value is 31.8.
- From table 6, the descriptive statistics of post-test value of muscle tone in experimental Group t- value is 30.16-muscle tone <0.05 with the mean value is 6.7. Changes within control Group is analyzed using paired t test

- The descriptive statistics—mean, standard deviation, and t-value—were derived from the t-test of the pre-test and post-test as shown in Table 2. The statistical findings demonstrate the differences between the pre-test and post-test values in the control group.
- The descriptive statistics, including the mean, standard deviations, and t value, were derived from Table 2 using the t-test for the pre-test and post-test. The statistical results demonstrate that conventional therapeutic exercises are effective for spastic cerebral palsy.
- From table 7, the descriptive statistics of pre-test value of dynamic balance in control Group, t-test value is 39.35 dynamic balance <0.05 with the mean value is 36.8.
- From table 7, the descriptive statistics of pre-test value of muscle tone in control Group, t-test value is 30.85 muscle tone <0.05 with the mean value is 3.33
- From table 8, the descriptive statistics of post-test value of dynamic balance in control Group t-test value is 39.35 dynamic balance <0.05 with the mean value is 36.
- From table 8, the descriptive statistics of post-test value of muscle tone in control Group t- value is 30.85- muscle tone <0.05 with the mean value is 3.73.

Experimental group

Dynamic balance

- Mean value of pre-test is 31.6 and post-test is 36.8.
- For fourteen degrees of freedom and at 5% degree of importance
- The table value is 4.140
- Calculated t value is 33.47 which is greater than the table value of 4.140
- Because the alternative hypothesis is accepted, the experimental group shows enhanced dynamic balance.

Muscle tone

- Mean value of pre-test is 6.6 and post-test is 3.33
- For fourteen degrees of freedom and at 5% degree of importance
- The table value is 4.140
- Calculated t value is 30.16 which is greater than the table value of 4.140
- Since alternate hypothesis is accepted, there is an improvement in muscle tone in experimental Group.

Control group

Dynamic balance

- Mean value of pre-test is 31.8 and post-test is 36.
- For fourteen degrees of freedom and at 5% degree of importance
- The table value is 4.140
- Calculated t value is 39.35 which is greater than the table value of 4.140
- Because the alternative hypothesis is accepted, the control group shows enhanced dynamic balance.

Muscle tone

- Mean value of pre-test is 6.7 and post-test is 3.7
- For fourteen degrees of freedom and at 5% degree of importance
- The table value is 4.140
- Calculated t value is 30.85 which is greater than the table value of 4.140
- Since alternate hypothesis is accepted, there is an enhancement in muscle tone in control Group.

The statistical results supports the Application of Antigravity treadmill training along with radial extracorporeal shockwave therapy is much effective in spastic cerebral palsy patients.

2.4 STATISTICAL ANALYSIS

TABLE 1 VARIABLE MEASURED IN EXPERIMENTAL GROUP 1 (ANTIGRAVITY TREADMILL TRAINING AND RADIAL EXTRACORPOREAL SHOCKWAVE THERAPY)

MUSCLE TONE (PEDIATRIC BALANCE SCALE)			DYNAMIC BALANCE (MODIFIED TARDIEU SCALE)	
S.NO	PRE-TEST	POST-TEST	PRE-TEST	POST TEST
1	29	34	7	4
2	32	37	7	4
3	32	38	6	2
4	31	36	7	3
5	30	35	7	4
6	30	35	6	3

7	30	35	6	3
8	31	36	7	3
9	32	39	7	4
10	32	37	6	3
11	33	39	7	4
12	32	37	7	4
13	33	38	6	3
14	32	38	7	3
15	33	38	6	3

TABLE 2 VARIABLE MEASURED IN EXPERIMENTAL GROUP 2 (TRADITIONAL PHYSIOTHERAPY INTERVENTION)

MUSCLE TONE (PEDIATRIC BALANCE SCALE)			**DYNAMIC BALANCE (MODIFIED TARDIEU SCALE)**	
S.NO	**PRE-TEST**	**POST-TEST**	**PRE TEST**	**POST TEST**
1	31	36	7	4
2	32	36	7	4
3	33	37	7	4
4	32	36	6	3
5	32	36	7	4
6	33	38	7	3
7	31	35	7	5
8	31	35	6	3
9	31	35	7	4
10	32	36	7	4
11	31	35	7	4
12	32	36	7	4
13	33	38	7	4
14	32	36	6	3
15	31	35	6	3

TABLE 3: COMPARISON OF PRE AND POST TEST VALUE OF EXPERIMENTAL GROUP 1

S.NO	**VARIABLE**	**DAYS**	**MEAN PRE**	**T VALUE**	**LEVEL OF SIGNIFICANCE**
1	Dynamic balance (PBS)	day 1	31.6	33.47	P<0.05
		Day 198	36.8		
2	Muscle tone (MTS)	day 1	6.6	30.16	P<0.05
		Day 198	3.33		

TABLE 4: COMPARISON OF PRE AND POST TEST VALUES OF EXPERIMENTAL GROUP 2

S.NO	VARIABLE	DAYS	MEAN PRE-TEST	T VALUE	LEVEL OF SIGNIFICANCE
1	Dynamic balance (PBS)	Day 1	31.8	39.35	P<0.05
		Day 198	36		
2	Muscle tone (MTS)	Day 1	6.7	30.85	P<0.05
		Day 198	3.7		

TABLE 5: COMPARISON OF PRE TEST VALUE IN PBS AND MTS IN EXPERIEMENTAL GROUP 1

GROUP 1	EXPERIEMENTAL PRE-TEST	t-VALUE	LEVEL OF SIGNIFICANCE
Dynamic balance (PBS)	31.6	33.47	P<0.05
Muscle tone (MTS)	6.6	30.16	P<0.05

TABLE 6: COMPARISON OF POST TEST VALUE OF PBS AND MTS IN EXPERIMENTAL GROUP 1

GROUP 1	EXPERIMENTAL POST TEST	t-VALUE	LEVEL OF SIGNIFICANCE
Dynamic balance (PBS)	31.8	33.47	P<0.05
Muscle tone (MTS)	6.7	30.16	P<0.05

TABLE 7: COMPARISON OF PRE TEST VALUE IN PBS AND MTS IN EXPERIMENTAL GROUP 2

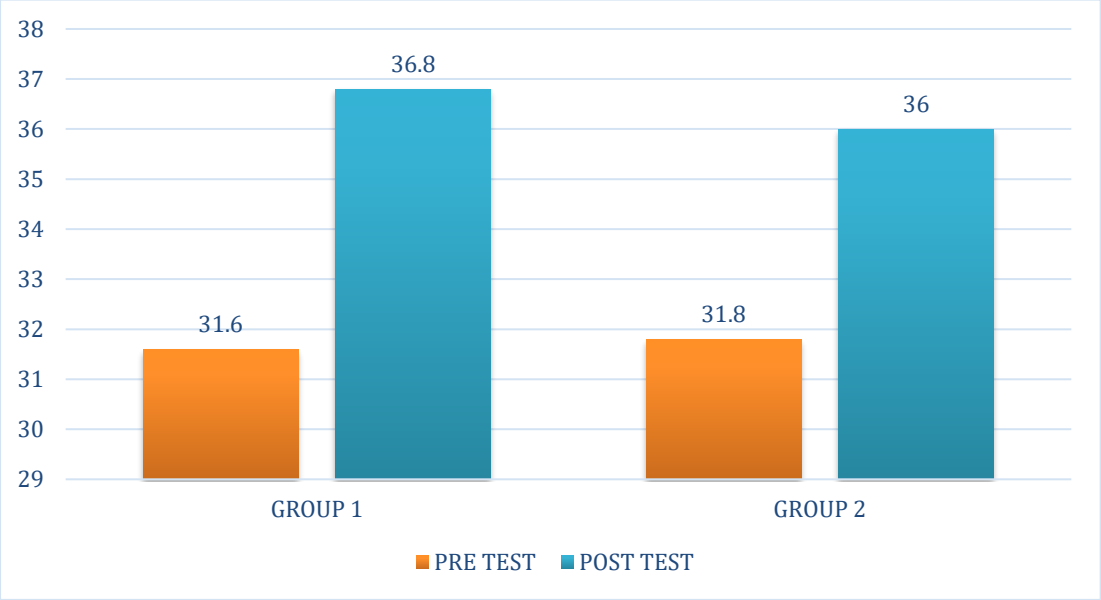
GROUP 2	EXPERIMENTAL PRE-TEST	t- VALUE	LEVEL OF SIGNIFICANCE
Dynamic balance (PBS)	36.8	39.35	P<0.05
Muscle tone (MTS)	3.33	30.85	P<0.05

TABLE 8: COMPARISON OF POST TEST VALUE IN PBS AND MTS IN EXPERIMENTAL GROUP 2

GROUP 2	EXPERIMENTAL POST TEST	t- VALUE	LEVEL OF SIGNIFICANCE
Dynamic balance (PBS)	36	39.35	P<0.05
Muscle tone (MTS)	3.73	30.85	P<0.05

GRAPHICAL REPRESENTATION

GRAPH 1 : COMPARISON OF PRETEST AND POST TEST VALUES OF THE PEDIATRIC BALANCE SCALE BEFORE AND AFTER ANTIGRAVITY TREADMILL TRAINING AND RADIAL EXTRACORPOREAL SHOCKWAVE THERAPY VS CONVENTIONAL PHYSIOHERAPY



GRAPH 2: COMPARISON OF THE PRE TEST AND POST TEST VALUES OF MODIFIED TARDIEU SCALE BEFORE AND AFTER ANTIGRAVITY TREADMILL TRAINING AND RADIAL EXTRACORPOREAL SHOCKWAVE THERAPY VS CONVENTIONAL PHYSIOHERAPY.

The graphical representation 1 compares the pediatric balance scales of the experimental group and control groups before and after the intervention of Group-1 Antigravity treadmill training and radial extracorporeal shockwave therapy, Group-2 stretching, strengthening, CIMT, balance and gait training, Compared to the control group, experimental group 1 exhibits greater progress in post value representation.
The graphical representation 2 compares the Modified Tardieu scales of the experimental group and control groups before and after the intervention of Group-1 Antigravity treadmill training and radial extracorporeal shockwave therapy, Group-2 stretching, strengthening, cimt, balance and gait training, compared to the control group, experimental group 1 exhibits greater progress in post value representation demonstrating decrease in spasticity.

4. DISSCUSSION

This current study assessed the combined impacts of antigravity treadmill (AGT) training and radial extracorporeal shockwave therapy (rESWT) on spasticity and dynamic balance in children with spastic cerebral palsy (CP). The findings clearly show that the experimental group that received both treatments had statistically significant enhancements in both the Pediatric Balance Scale (PBS) and the Modified Tardieu Scale (MTS) scores.

The results deepen the clinical insight of integrative, non-invasive approaches for pediatric neurorehabilitation while also supporting previous literature.

Statistical Overview and Clinical Impact

In the experimental group (Group 1), the PBS score improved from the pre-test mean of 31.6 to a post-test mean of 36.8, yielding a t-value of 33.47 ($p < 0.05$). Simultaneously, the MTS score decreased from 6.6 to 3.33, with a t-value of 30.16 ($p < 0.05$). These changes reflect a clear improvement in functional balance and a reduction in spasticity.

In contrast, the control group (Group 2), which received only traditional physiotherapy, also showed improvement but with lesser magnitude: PBS scores increased from 31.8 to 36 ($t = 39.35$, $p < 0.05$) and MTS scores reduced from 6.7 to 3.7 ($t = 30.85$, $p < 0.05$). Although statistically significant, the gains were not as profound as those observed in the combined-intervention group.

The combination of rESWT and AGT training produces higher functional outcomes than standard physiotherapy alone, as this data demonstrates.

Mechanistic and Therapeutic Rationale

There has been a lot of research on how rESWT works to lower spasticity. It is thought to
change spinal reflex pathways, increase vasodilation, and modulate neuromuscular activity [50, 18]. Giving the Triceps Surae muscles 2000 shocks at 8 Hz greatly reduced hypertonia, as shown by a drop in MTS scores [49]. This decrease probably made it easier to move around, made joints less stiff, and made AGT training more effective.

Since the Modified Tardieu Scale (MTS) can measure both dynamic and static aspects of muscle tone, we selected it over the Modified Ashworth Scale (MAS) [47]. According to this study, the experimental group's average improvement on the MTS was between 6.6 and 3.33 points. This demonstrates the significance of rESWT in treating velocity-dependent hypertonia, a prevalent condition in spastic cerebral palsy.

The Paediatric Balance Scale revealed significant gains in dynamic balance, which is a crucial aspect of being able to walk with CP. The experimental group's average score increased from 31.6 to 36.8, supporting the notion that AGT training enhances neuromuscular control and postural stability. The AGT training component, which began with 60-70% body weight support, allowed for safe, regular gait training by lowering joint stress and muscle fatigue. Participants reported improved motor control and posture symmetry as they reduced weight support. These are both essential for achieving dynamic balance. This aligns with findings from "Impact of Antigravity Treadmill Training on Gait, Balance, and Fall Risk in Diplegic Cerebral Palsy Patients" by **El- shamy, Dadashi** et al [25, 17], who emphasized AGT's role in gait normalization and balance improvement. This also echoes findings by **Grabowski AM**.in his study "Metabolic and biomechanical effects of using a lower-body positive pressure device for walking with weight and speed support." [30], who reported improved gait kinetics and kinematics in paediatric patients training under reduced load conditions.

The PBS score gains in Group 1 signify more than balance improvement—they reflect functional independence, with children showing enhanced ability to perform tasks such as standing, turning, and transferring. Improvements in MTS indicate neural plasticity and muscle tone normalization, contributing directly to smoother, controlled movements.

Synergistic Impact of rESWT and AGT Training

Previous studies have often looked at these modalities separately, but this study gives new evidence that rESWT's ability to reduce spasticity may make AGT training more effective. This synergistic effect is especially important in children and teenagers, where neuroplasticity, motivation, and the timing of interventions are all very important for therapy to work [20].

The results of the study support the notion that combining neuromodulatory and motor learning-based techniques results in larger functional gains. Emara Hamah et al. [26] found that dynamic balance and motor function were enhanced in patients with spastic diplegia who received therapies that targeted both spasticity and postural control. This implies that while regular physiotherapy is still helpful when used in conjunction with rESWT and AGT, it can greatly speed up functional recovery and improve dynamic posture control. The synergistic model for CP rehabilitation is based on non-invasive therapies that correct weaknesses and promote participation and functionality.

Clinical and Functional Relevance

Because of its non-invasiveness, safety record, and kid-friendly design, the combination of rESWT with AGT has showed promise in clinical trials. To reduce the danger of tiredness or overuse injuries, AGT sessions were carried out under strict supervision utilizing progressive
loading procedures. To allow for neuromuscular adaptation cycles, rESWT sessions were spaced out by three weeks. Better ability in everyday tasks like walking, reaching, and transferring—all essential for children with cerebral palsy to become self-sufficient—are functionally indicated by higher PBS scores. These changes have significant implications for social interaction, educational inclusion, and quality of life; they are not merely statistical [52].

Comparison with Control Group

The experimental group experienced a greater change in PBS and MTS scores than the control group, despite the latter displaying statistically significant gains. This suggests that frequent physiotherapy can significantly enhance functional recovery and dynamic posture control, even when combined with rESWT and AGT. This is congruent with the findings of Aras B and Yasar E [7], who reported that AGT improved CP mobility and balance more effectively than normal treadmill therapy. This synergistic technique in CP rehabilitation represents a paradigm shift toward multimodal, non-invasive therapies that address deficits while simultaneously fostering engagement and functionality.

5. CONCLUSION

In conclusion, this study provides convincing evidence that radial extracorporeal shockwave therapy and antigravity treadmill training can enhance dynamic balance and reduce stiffness in children with spastic cerebral palsy. Significant changes in PBS and MTS scores (p-values < 0.05) indicate statistical and clinical success. When combined, these therapies provide a comprehensive, research-based strategy for improving motor function, independence, and quality of life in young children receiving neurorehabilitation. This study suggests a viable technique for improving results in spastic cerebral palsy as rehabilitation shifts to multimodal and patient-centered treatment. Potentially setting a new standard for function-driven, tailored care for children with cerebral palsy.

6. LIMITATION AND RECOMMENDATION

- The longer therapy sessions for the experimental group may have yielded superior results, introducing bias. Furthermore, the small sample size limits statistical power and generalizability.
- Replicating the study with a bigger sample size and a longer recovery period may benefit future research. This technique will allow us to precisely measure improvement and maintain consistency in the rehabilitation program for cerebral palsy patients, which will have both short- and long-term benefits.
- Spastic cerebral palsy is diagnosed by assessing range of motion, muscle strength, length, and postural control, as well as dynamic balance and muscle tone. These subjects could be the focus of future research.
- In addition to the Pediatric Balance Scale and the Modified Tardieu Scale, the Gross Motor Function Classification System (GMFCS), the Pediatric Evaluation of Disability Inventory (PEDI), and the Modified Ashworth Scale can be used to assess dynamic balance and muscle tone in children with spastic cerebral palsy.

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