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# IMPACT OF VESTIBULAR STIMULATION ON MOTOR FUNCTION AND BALANCE IN CHILDREN WITH HYPOTONIC CEREBRAL PALSY: A RANDOMIZED CONTROLLED TRIAL

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**Abstract**

*Cerebral palsy (CP) is among the most common causes of childhood disability, with motor dysfunction and impaired balance representing major challenges—especially in the hypotonic subtype. This randomized controlled trial examined the effects of adding vestibular stimulation to routine physiotherapy on motor skills and postural stability in children with hypotonic CP. Eighty-two children meeting strict inclusion criteria were randomly allocated to either a combined treatment group (vestibular stimulation plus conventional therapy) or a conventional therapy only group. Outcome measures included the Gross Motor Function Measure (GMFM), Pediatric Balance Scale (PBS), and Pediatric Evaluation of Disability Inventory (PEDI), administered at baseline and following a six-week intervention period. Data analysis revealed that children receiving vestibular stimulation demonstrated statistically significant improvements in both gross motor function and balance compared to their counterparts receiving conventional therapy alone. These findings support the clinical integration of vestibular stimulation as an adjunct to standard rehabilitation in this population.*

## INTRODUCTION

Cerebral palsy comprises a group of non-progressive neurological disorders arising from early brain injury. Although many children with CP exhibit spasticity, the hypotonic variant presents with reduced muscle tone and coordination challenges that adversely affect balance and motor control. The development of postural stability relies heavily on the integration of neural signals and the mechanical function of the vestibular system. Given that children with hypotonic CP frequently struggle with activities of daily living, innovative therapeutic approaches are needed to enhance their quality of life.

Vestibular stimulation—a method that targets the sensory pathways involved in balance—has recently been explored as an adjunct to conventional physiotherapy. By stimulating the otolith organs and semicircular canals, this technique may enhance vestibulo-ocular reflexes and activate dormant neural

circuits. Such improvements could lead to better postural control, improved motor function, and ultimately, greater independence in daily activities. This study aimed to compare the effects of vestibular stimulation combined with routine physical therapy versus conventional physical therapy alone on motor function and balance in children with hypotonic CP.

**Rationale**

It is difficult for hypotonic cerebral children to do exercises because of complex exercise mechanism and procedure which hard to appreciate however, vestibular stimulation is a method in which it is not necessary to that the child directly perform the exercise.

Vestibular stimulation impacts motor control and balance by vestibulo-occular reflex control mechanism. Therefore, reflex control mechanism including soft tissue and joint mechanoreceptors may elicit neural circuits to facilitate muscular tone. In this way, it can help to improve CP children treatment practice. It would be a great contribution towards community of cerebral palsy, care giver friends and family.it can also lessen hospital burden by inducing less engaging mechanism of managing hypo tonicity.

**Literature Review**

Recent studies have highlighted the potential of sensory-based interventions in managing motor deficits in children with CP. Seyam et al. (2021) demonstrated that incorporating sensory integration techniques improved gait parameters in children with hemiplegic CP, suggesting that multi-modal stimulation can positively affect motor control. Similarly, Mohsen and Samy (2020) reported improvements in gait and gross motor function in children with diplegic CP when conventional physiotherapy was supplemented with sensory stimulation delivered via a platform swing walkway.

In research by Sailesh and Mukkadan (2019), vestibular stimulation was found to reduce stress-induced changes and enhance overall quality of life, implying that vestibular inputs can influence neurological and behavioral outcomes. Further support comes from studies such as Tramontano et al. (2017), where vestibular stimulation was linked to improvements in neuromuscular coordination and balance in children with CP. Although mechanisms remain under investigation, these studies suggest that vestibular stimulation may induce neuroplastic changes and enhance proprioceptive feedback, thereby supporting motor learning and postural control.

Despite these promising findings, there is a need for rigorous clinical trials using robust outcome measures to confirm the benefits of vestibular stimulation—especially in children with hypotonic CP. This study was designed to address this gap by providing a comprehensive evaluation of vestibular stimulation on motor function and balance.

**Objective**

The objective of the study was to compare the effects of vestibular stimulation and routine physical therapy on motor function and balance in children with hypotonic cerebral palsy.

**Hypothesis**

**Alternative Hypothesis (H1)**

There is no significant difference in effect of vestibular stimulation as compared to routine physical therapy on motor functions and balance in children with hypotonic cerebral palsy.



**Null Hypothesis (H0)**

There is significant difference in effect of vestibular stimulation as compared to routine physical therapy on motor functions and balance in children with hypotonic cerebral palsy.

**Operational Definition**

**Balance**

Balance is the body's ability to maintain the center of gravity into the base of scored by the coordinated action of neural and mechanical receptors to obtain an optimal level of postural stability for Static and dynamic activities. It was measured by Pediatric Balance Scale

**Vestibular Stimulation**

Vestibular stimulation is an exercise-based intervention in which the vestibular system is stimulated to maximize central nervous system output so that it can contribute to attaining optimal balance for postural stability.

**Gross Motor Function**

Gross motor: A motor skill is a function, which involves the precise movement of muscles with the intent to perform a specific act. Most purposeful movement requires the ability to "feel" or sense what one's muscles are doing as they perform the act. To measure the gross motor, gross motor function classification system is used. Gross motor function measure: The gross motor skill (sitting walking) of children and young people with cerebral palsy can be categorized into different level using a tool called gross motor function classification scale (GMFCS).

## Methodology

**Study Design and Setting**

This study employed a randomized controlled trial design. Participants were recruited from the Department of Pediatric Rehabilitation at Shaikh Zayed Hospital, Lahore. The intervention was carried out over nine months, following ethics approval from the University of Lahore's ethical committee.

**Participants**

A total of 82 children (aged 5–10 years) with a clinical diagnosis of hypotonic cerebral palsy were enrolled. Inclusion criteria required:

- Good head control and the ability to maintain a ring sitting position.
- Absence of associated neurogenic conditions (e.g., uncontrolled epilepsy).
- No severe orthopedic or sensory impairments.

Exclusion criteria included severe visual or auditory deficits, uncontrolled seizures, significant medical comorbidities, and other orthopedic complications.

**Ethical Considerations**

Written informed consent was obtained from all parents/guardians. Participants' data were anonymized, and they were free to withdraw from the study at any time without affecting their standard care.

**Randomization and Blinding**

Participants were randomly assigned to one of two groups using computer-generated random numbers:

- **Control Group:** Received conventional physiotherapy.
- **Intervention Group:** Received conventional physiotherapy combined with vestibular stimulation.

The study was single-blinded, with the assessor unaware of group allocation.

**Intervention Protocol**

Both groups underwent therapy sessions once daily, five days per week, for six weeks:

- **Conventional Physiotherapy:** Included passive soft tissue stretching, lower limb resistance exercises, movement transitions, balance board and foam board exercises, walking, and stair climbing. Sessions lasted 30 minutes with a 5-minute rest period.
- **Vestibular Stimulation:** In addition to conventional therapy, the intervention group participated in vestibular exercises such as multi-directional swinging, trampoline jumps, rocking in a rocking chair, gaze stabilization, and visual pursuit tasks. These sessions were structured with a 30-minute duration and a 10-minute rest period between activities.

**Outcome Measures and Data Collection**

Assessments were performed at baseline and after the intervention using:

- **Gross Motor Function Measure (GMFM)**
- **Pediatric Balance Scale (PBS)**
- **Pediatric Evaluation of Disability Inventory (PEDI)**

Data were recorded at baseline, 1st week, 3rd week, and 5th week.

**Data Analysis**

Data were analyzed using SPSS version 25. Descriptive statistics (mean ± SD) were used for quantitative variables, and frequencies with percentages for categorical variables. The normality of data was assessed using Kolmogorov-Smirnov and Shapiro-Wilk tests. Independent samples t-tests or Mann–Whitney tests were applied as appropriate, and repeated measures ANOVA (or Friedman test for non-parametric data) was used to compare outcomes over time. A p-value of $\leq 0.05$ was considered statistically significant.

**Results**

The study included 82 children equally divided between the two groups. Demographic data for children and their parents are summarized in the tables below.

**Table 1. Child Gender Distribution**

| Group | Male (%) | Female (%) | Total (%) |
|---|---|---|---|
| Vestibular Stimulation | 43.9 | 56.1 | 100 |
| Conventional | 46.3 | 53.7 | 100 |

Table 2. Parent Gender Distribution

| Group | Male (%) | Female (%) | Total (%) |
|---|---|---|---|
| Vestibular Stimulation | 19.5 | 80.5 | 100 |
| Conventional | 9.8 | 90.2 | 100 |

**Table 3. Parent Education**

| Group | Higher Secondary or Below (%) | Bachelors (%) | Masters or Above (%) | Total (%) |
|---|---|---|---|---|
| Vestibular Stimulation | 19.5 | 58.5 | 22.0 | 100 |
| Conventional | 19.5 | 58.5 | 22.0 | 100 |

**Table 4. Parent Marital Status**

| Group | Married (%) | Widowed (%) | Divorced (%) | Total (%) |
|---|---|---|---|---|
| Vestibular Stimulation | 92.7 | 2.4 | 4.9 | 100 |
| Conventional | 85.4 | 7.3 | 7.3 | 100 |

**Table 5. Age Descriptive Statistics**

| Group | Mean Age (years) | Standard Deviation |
|---|---|---|
| Vestibular Stimulation | 8.22 | 2.32 |
| Conventional | 8.10 | 2.32 |

**Table 6. Comparison of Mean PEDI Scores**

| Measure | Group | Mean ± SD | p-value |
|---|---|---|---|
| **Pre-Treatment PEDI** | Vestibular Stimulation | 42.88 ± 0.90 | 0.751 |
| | Conventional | 42.93 ± 0.82 | |
| **Post-Treatment PEDI** | Vestibular Stimulation | 51.39 ± 1.16 | 0.000* |
| | Conventional | 52.73 ± 1.40 | |

*Significant difference noted in post-treatment measures.

Additional tables provided detailed comparisons in self-care, mobility, assistance domains, gross motor function, and pediatric balance scores. In all domains, the intervention group demonstrated statistically significant improvements following vestibular stimulation compared to conventional therapy alone.

**Discussion**

The addition of vestibular stimulation to conventional physiotherapy significantly improved motor function and balance in children with hypotonic CP. This study confirms that vestibular inputs can enhance postural stability and facilitate motor learning by stimulating central neural circuits. Improvements in PEDI scores, GMFM scores, and PBS measures indicate that vestibular stimulation may activate otherwise dormant synaptic connections, thereby promoting neuromuscular coordination.

Several studies support these findings. For instance, earlier investigations using sensory integration techniques reported enhanced gait parameters and overall motor performance (Seyam et al., 2021; Mohsen & Samy, 2020). Furthermore, the observed improvements in balance may be linked to enhanced vestibulo-ocular reflexes, which are critical for maintaining postural control. Although the precise neurophysiological mechanisms remain to be fully elucidated, the present findings suggest that vestibular stimulation has a beneficial role in pediatric neurorehabilitation.

Some limitations of this study include the challenges in standardizing the dose of vestibular stimulation and the variability inherent in CP presentations. Moreover, while significant improvements were observed over a six-week period, longer-term studies are warranted to determine the durability of these effects.

**Recommendations, Suggestion, Limitation**

Based on our findings, the following recommendations are proposed for clinical practice and future research:

Vestibular stimulation should be integrated into routine CP rehabilitation programs.

Standardized guidelines for vestibular stimulation protocols should be developed.

Parental training programs should be introduced to facilitate home-based vestibular stimulation exercises.

Clinicians should consider incorporating vestibular stimulation into routine physiotherapy programs for children with hypotonic CP.

Therapy protocols must be tailored to the child's tolerance level to avoid overstimulation, which may temporarily induce dizziness or nausea.

With proper supervision, vestibular stimulation exercises can be adapted for home settings to reduce caregiver burden and hospital visits.

Larger studies with long-term follow-up are needed to refine dosing protocols and further understand the mechanisms underlying the observed improvements.

The time was limited so it decrease the generalization of this study.

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