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PREVALENCE OF BALANCE AND SENSORY IMPAIRMENTS AND THEIR CORRELATION WITH GROSS MOTOR FUNCTION IN CHILDREN WITH SPASTIC DIPLEGIC CEREBRAL PALSY

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ABSTRACT

Background

Cerebral Palsy is one of the most common causes of physical disability in children. Children with spastic diplegic cerebral palsy commonly present with impairments in balance, sensory processing, and gross motor function, which affect their functional independence and quality of life. Balance and sensory impairments may significantly influence postural control, gait, and motor performance in these children.

Aim

To determine the prevalence of balance and sensory impairments and their correlation with gross motor function in children with spastic diplegic cerebral palsy.

Objectives

1. To assess balance impairments using the Pediatric Berg Balance Scale.
2. To evaluate sensory impairments using the Sensory Profile.
3. To assess gross motor function using the Gross Motor Function Measure and Gross Motor Function Classification System.
4. To analyze the correlation between balance, sensory impairments, and gross motor function.

Methodology

A cross-sectional study was conducted among 109 children diagnosed with spastic diplegic cerebral palsy aged between 5–12 years. Participants were selected based on inclusion and exclusion criteria. Balance was assessed using the Pediatric Berg Balance Scale, sensory impairments were evaluated using the Sensory Profile, and gross motor function was assessed using the GMFM and GMFCS. The collected data were statistically analyzed using Pearson's and Spearman's correlation tests.

Results

The study demonstrated a strong positive correlation between Pediatric Berg Balance Scale scores and GMFM scores (Pearson $r = 0.828$, $p < 0.001$; Spearman rho = 0.854, $p < 0.001$). A very strong positive correlation was observed between Pediatric Berg Balance Scale scores and Sensory Profile scores (Pearson $r = 0.955$, $p < 0.001$; Spearman rho = 0.953, $p < 0.001$). Similarly, GMFM scores showed a very strong positive correlation with Sensory Profile scores (Pearson $r = 0.946$, $p < 0.001$; Spearman rho = 0.948, $p < 0.001$).

Conclusion

The study concluded that balance and sensory impairments are highly prevalent in children with spastic diplegic cerebral palsy and are significantly correlated with gross motor function. Better balance and sensory processing abilities were associated with improved gross motor performance. Early assessment and targeted rehabilitation focusing on balance and sensory integration may help improve functional outcomes in children with spastic diplegic cerebral palsy.

KEYWORDS: Cerebral palsy, spastic diplegia, balance impairment, sensory impairment, gross motor function, GMFM, Pediatric Berg Balance Scale, Sensory Profile.

INTRODUCTION

Due to non-progressive disorders in the developing fetus or infant brain, a group of persistent illnesses known as cerebral palsy (CP) restrict movement and posture and limit activities. It is among the most frequent reasons why children develop physical disabilities. The most common subtype of cerebral palsy

is spastic diplegic, which is primarily characterized by lower limb spasticity and motor impairment rather than upper limb impairment. Balance, coordination, posture, gait, and functional mobility issues are frequent in children with spastic diplegia, and these issues have a substantial impact on their everyday activities and quality of life.[1,2]

One of the most prevalent causes of physical disability in children worldwide is cerebral palsy. It is a collection of long-term conditions that impact posture, movement, and motor function as a result of non-progressive damage to the developing fetus or infant brain.[1,2] Cerebral palsy's incidence, prevalence, risk factors, distribution, and related disabilities are all included in its epidemiology.[45]

It is estimated that there are two to three incidences of cerebral palsy for every 1000 live births worldwide. Because the developing brain is more vulnerable in preterm and low birth weight babies, the prevalence is higher.[45] Although survival rates for preterm infants have increased due to advancements in neonatal intensive care, many survivors are still at risk for neurological abnormalities, such as cerebral palsy.Nearly 70–80% of cases are of spastic cerebral palsy, which is the most prevalent kind.[2,44] Spastic diplegia is one of the most common spastic kinds, especially in premature newborns with periventricular white matter damage.[2] The lower limbs are the primary site of motor dysfunction in children with spastic diplegic cerebral palsy, which impacts posture, walking, balance, and functional mobility.[6,36]

The ability to keep the center of gravity of the body within the base of support during both static and dynamic activity is known as balance.[15]" The integration of ocular, vestibular, and somatosensory signals with the proper neuromuscular responses is necessary for proper balance regulation.[23,24] Balance dysfunction is frequently caused by abnormalities in muscle tone, muscle weakness, aberrant postural reflexes, and poor sensory integration in children with spastic diplegic cerebral palsy.[6,14]" These disabilities may result in decreased participation in social and functional activities, an elevated risk of falls, and instability when standing and walking.[9,36]

Children with cerebral palsy frequently have sensory abnormalities. Postural control and movement coordination may be hampered by deficiencies in proprioception, tactile feeling, vestibular processing, and visual perception.[25,26] Sensory dysfunction may exacerbate motor deficits and have a detrimental effect on a child's capacity to carry out gross motor tasks effectively.[27,50] Functional independence in children with spastic diplegia can be significantly impacted by disruptions in the balance and sensory systems, which cooperate to maintain posture and mobility.[39]Activities requiring vast muscle groups, such sitting, standing, walking, sprinting, and jumping, are referred to as gross motor function.[6,23]The Classification System for Gross Motor Function and Gross Motor Function Measures are frequently used to evaluate children with cerebral palsy's functional mobility and motor skills.[3,4]Poor balance control and sensory deficiencies are often linked to limitations in gross motor function.[6,36] Maintaining posture, shifting weight, walking independently, and executing coordinated motions are all common challenges for kids with poor balance and sensory processing[18,50]

Research on the prevalence of balance and sensory abnormalities in children with spastic diplegic cerebral palsy has grown in importance since these impairments have a substantial impact on functional outcomes and motor performance.[45,46]Physiotherapists and rehabilitation specialists can create more successful treatment plans targeted at enhancing mobility, independence, and quality of life by knowing how balance deficits, sensory impairments, and gross motor function are related.[40,41]

In compared to typically developing children, children with spastic diplegic cerebral palsy have been shown in numerous studies to have reduced postural stability, delayed balance reactions, impaired sensory integration, and decreased motor control.[6,8,9] Additionally, muscle spasticity, contractures, weakness, and abnormal gait patterns contribute to reduced gross motor abilities and impaired balance.[13,14]Inadequate lower limb sensory feedback might also impact posture corrections and body awareness when moving.[24 ,37]

When managing children with spastic diplegia through physiotherapy, assessment of balance and sensory deficits is crucial. Postural control, sensory processing, and motor performance are frequently assessed using clinical instruments as the Pediatric Berg Balance Scale, Berg Balance Scale (BBS), Functional Reach Test (FRT), Sensory Profile, and Gross Motor Function Measure.[10,11,22] Planning customized rehabilitation programs that emphasize balance training, sensory integration treatment, gait training, strengthening exercises, and functional mobility enhancement might be aided by early detection of these deficiencies.[31 ,41]

Many children with spastic diplegic cerebral palsy nevertheless have functional impairments because of ongoing balance and sensory problems, even with breakthroughs in therapy.[40,42] In order to improve treatment approaches and functional outcomes, it is crucial to investigate the incidence of these deficits and examine how they relate to gross motor function.[18,50]

NEED OF THE STUDY

The need of the study is to determine the prevalence of balance and sensory impairments and their correlation with gross motor function in children with spastic diplegic cerebral palsy, as these

impairments significantly affect mobility, posture, coordination, and performance of daily activities. Children with spastic diplegic cerebral palsy commonly experience difficulties in maintaining balance and processing sensory information, which may further limit their gross motor abilities and functional independence.

Understanding the prevalence and relationship between balance deficits, sensory impairments, and gross motor function will help in early identification and assessment of these problems. This study may also contribute to planning effective physiotherapy and rehabilitation interventions aimed at improving functional mobility, balance control, sensory integration, and overall quality of life in children with spastic diplegic cerebral palsy.

REVIEW OF LITERATURE

1. **Radhika Mittal et al. (2024)** conducted a systematic review and meta-analysis on the impact of sensory-based therapy on balance and posture problems in children with cerebral palsy. The objective of the study was to evaluate the effectiveness of Sensory Integration Therapy (SIT) in improving postural control and balance dysfunctions in children with cerebral palsy. A systematic literature search was carried out using databases such as PubMed, Web of Science, Google Scholar, and Scopus. The review included studies conducted on children below 18 years with cerebral palsy. The study followed PRISMA guidelines, and methodological quality was assessed using the PEDro scale and Cochrane Risk of Bias tool.Seven randomized controlled trials involving 203 children with cerebral palsy were included in the review. The findings showed that sensory-based interventions significantly improved gross motor skills, balance, postural control, and functional mobility. These therapies also enhanced participation in daily activities and overall quality of life.The study concluded that sensory-based therapy is effective in improving balance and posture in children with cerebral palsy. It recommended incorporating sensory integration therapy into rehabilitation programs to improve functional independence and developmental outcomes in children with cerebral palsy.
2. **Mi-Soo Lim et al. (2025)** conducted a systematic review and meta-analysis on the effects of trunk intervention on gross motor function, balance, and spasticity in children with cerebral palsy. The objective of the study was to evaluate the effectiveness of trunk-focused interventions in improving trunk control, balance, gross motor function, and spasticity in children with cerebral palsy. A systematic search was conducted using databases such as PubMed, Embase, Web of Science, MEDLINE, and CINAHL. Fifteen randomized controlled trials involving 454 children with cerebral palsy were included in the review. The methodological quality of the studies was assessed using the PEDro scale. The results showed that trunk-based interventions significantly improved trunk control and gross motor function in children with cerebral palsy. Balance also improved, especially when the interventions were performed more than four times per week. However, limited evidence was found regarding improvement in spasticity.The study concluded that trunk-focused interventions are effective in improving trunk control and gross motor function in children with cerebral palsy. It also emphasized the importance of including trunk rehabilitation exercises in physiotherapy programs to improve balance, functional mobility, and overall motor performance.
3. **Guojun Yun et al. (2022)** conducted a study on the correlation between selective motor control, gross motor ability, functional balance, and gait performance in ambulant children with bilateral spastic cerebral palsy. The study included 36 children aged 5–16 years with Gross Motor Function Classification System (GMFCS) levels I and II. Selective motor control was assessed using the Selective Control Assessment of the Lower Extremity (SCALE). Gross motor function was measured using GMFM-88, balance was evaluated using the Pediatric Balance Scale (PBS) and Timed Up and Go Test (TUG), and gait performance was assessed using the Edinburgh Visual Gait Score (EVGS) and 10-Meter Walk Test (10MWT). The results showed a strong positive correlation between selective motor control and gross motor function, balance, and walking speed. Reduced selective motor control was associated with poor balance, severe gait deviations, and decreased walking speed in children with bilateral spastic cerebral palsy. The study concluded that deficits in selective motor control significantly affect gross motor ability, balance, and gait performance in children with cerebral palsy. It also emphasized that physiotherapy interventions should focus on improving selective motor control to enhance overall functional ability and mobility.
4. **Guojun Yun et al. (2023)** conducted a study on the association between selective motor control (SMC) and functional outcomes in ambulant children with bilateral spastic cerebral palsy. A correlational study design was used with standardized assessment tools to evaluate SMC, gross motor function, balance, and gait performance. The study found a significant positive correlation between selective motor control and functional outcomes. Children with poor SMC showed reduced gross motor function, impaired balance, gait deviations, and slower walking speed.The study concluded that impaired selective motor control negatively affects posture, balance, and gait efficiency in children with cerebral palsy. It also emphasized the importance of SMC-focused physiotherapy interventions to improve functional independence and motor performance.

5. **Isabelle Poitras et al. (2021)** conducted a systematic review on the impact of sensory deficits on upper limb motor performance in individuals with cerebral palsy. The objective of the study was to examine the relationship between sensory impairments and upper limb motor function in individuals with cerebral palsy. A systematic review was conducted using five databases, and 33 articles were included in the study. The reviewed studies assessed tactile, proprioceptive, and visual sensory functions along with unimanual and bimanual motor functions in individuals with cerebral palsy.The findings showed that tactile sensory deficits had a moderate to strong association with impaired upper limb motor performance. However, evidence regarding proprioceptive and visual sensory deficits was inconclusive due to variability among studies.The study concluded that sensory impairments significantly influence motor performance in individuals with cerebral palsy. It also emphasized the need for comprehensive assessment of both sensory and motor functions to improve rehabilitation outcomes and functional abilities.
6. **Atahan Turhan and Melek Güneş Yavuzer(2025)** conducted a controlled experimental study on the effects of Sensory Integration Therapy (SIT) and Conventional Therapy Programme (CTP) in children with spastic diplegic cerebral palsy. The aim of the study was to determine the effect of SIT on spasticity, balance, motor function, and functional independence. The study included 22 children aged 4–17 years with spastic diplegic cerebral palsy. Both groups received conventional therapy for 45 minutes, three times a week for 8 weeks, while the intervention group additionally received 15 minutes of sensory integration therapy. Spasticity was assessed using the Modified Ashworth Scale (MAS), balance using the Pediatric Berg Balance Scale (PBBS), motor function using GMFM-88, and functional independence using WeeFIM.The results showed significant improvement in hamstring spasticity, balance, and functional independence in the intervention group compared to the control group. Both groups also showed improvement in triceps surae spasticity.The study concluded that sensory integration therapy combined with conventional therapy is more effective than conventional therapy alone in improving balance, reducing spasticity, and enhancing functional independence in children with spastic diplegic cerebral palsy .
7. **Amira H. Mohammed et al. (2023)** conducted a randomized controlled trial on the correlation between selective motor control of the lower extremities and balance in children with spastic hemiplegic cerebral palsy. The aim of the study was to evaluate the effect of mirror therapy on selective motor control and balance in children with hemiplegic cerebral palsy. The study included 47 children with hemiplegic cerebral palsy. The control group received conventional physiotherapy, while the intervention group received conventional physiotherapy along with bilateral lower extremity mirror therapy. Selective motor control was assessed using the Selective Control Assessment of Lower Extremity (SCALE), and balance was assessed using the Pediatric Balance Scale (PBS).The results showed significant improvement in selective motor control and balance in both groups, with greater improvement observed in the intervention group receiving mirror therapy.The study concluded that mirror therapy is an effective adjunct to physiotherapy for improving selective motor control and balance in children with hemiplegic cerebral palsy. It also suggested that mirror therapy is simple, cost-effective, and beneficial for enhancing motor performance and balance abilities.
8. **Vaishnavi B. Warutkar et al(2023)**. conducted a study on the effectiveness of Sensory Integration Therapy (SIT) on functional mobility in children with spastic diplegic cerebral palsy. The aim of the study was to evaluate the effect of SIT combined with conventional physiotherapy on functional mobility in children with spastic diplegic cerebral palsy. The study included 40 children with spastic diplegic cerebral palsy who were divided into two groups. Group A received sensory integration therapy along with conventional physiotherapy, while Group B received only conventional physiotherapy for four weeks. Outcome measures included the Short Sensory Profile (SSP), Gross Motor Function Classification System (GMFCS), Pediatric Mini-Mental State Examination (MMSE), and Modified Ashworth Scale.The results showed significant improvement in sensory function, gross motor function, and functional mobility in both groups. However, greater improvement was observed in the group receiving sensory integration therapy along with conventional physiotherapy.The study concluded that sensory integration therapy combined with conventional physiotherapy is more effective in improving functional mobility and motor performance in children with spastic diplegic cerebral palsy.
9. **Sapna Tiwari et al.(2024)** conducted a study on the correlation between trunk control and balance in children with bilateral spastic cerebral palsy. The aim of the study was to examine the relationship between trunk control and different components of balance in children with cerebral palsy. The study included 30 children with bilateral spastic cerebral palsy with Gross Motor Function Classification System (GMFCS) levels I to III. Trunk control was assessed using the Trunk Control Measurement Scale (TCMS), and balance was evaluated using the Kids-Mini-BESTest. The results showed a moderate positive correlation between trunk control and balance in children with bilateral spastic cerebral palsy. Static sitting balance, dynamic selective motor control, and reaching ability were significantly associated with balance components such as anticipatory control, gait stability, and sensory orientation. The study concluded that trunk control is closely associated with balance performance in children with bilateral

spastic cerebral palsy. It emphasized the importance of trunk control training in rehabilitation programs to improve balance and functional mobility in children with cerebral palsy.

10. **Christopher Morris and Doreen Bartlett (2019)** conducted a review on the impact and utility of the Gross Motor Function Classification System (GMFCS) in children with cerebral palsy. The study aimed to evaluate the usefulness, reliability, and clinical application of the GMFCS in assessing movement disability in children with cerebral palsy. The GMFCS was developed as a standardized system to classify gross motor function into five levels based on self-initiated movement abilities, sitting, walking, and the need for assistive devices. Children in Level I have minimal limitations, while children in Level V have severe limitations in posture and voluntary movement control.The review analyzed publications, journal articles, and conference abstracts related to GMFCS. The findings showed that the GMFCS is a reliable and widely accepted tool for classifying functional ability in children with cerebral palsy. It has been extensively used in research, clinical practice, and education to understand motor disability and functional limitations.The study concluded that GMFCS is an effective and standardized classification system for evaluating gross motor function in children with cerebral palsy. It also emphasized its importance in treatment planning, prognosis, rehabilitation, and research related to cerebral palsy.
11. **Shraddha Diwan etal. (2019)** conducted a cross-sectional analytical study on the correlation between gross motor functions and quality of life in children with cerebral palsy in Ahmedabad, Gujarat. The aim of the study was to determine the relationship between gross motor function and quality of life in children with different types and levels of cerebral palsy. The study included 52 children with cerebral palsy aged 5–18 years across all GMFCS levels and clinical types. Gross motor function was assessed using the Gross Motor Function Measure-88 (GMFM-88), and quality of life was evaluated using the Caregiver Priorities and Child Health Index of Life with Disabilities (CPCHILD) questionnaire.The results showed a moderate to strong positive correlation between gross motor function and quality of life. Children with better gross motor abilities and lower GMFCS levels demonstrated higher quality of life scores compared to non-ambulatory children.The study concluded that improved gross motor function is associated with better quality of life in children with cerebral palsy. It emphasized the importance of physiotherapy interventions aimed at enhancing gross motor abilities to improve functional independence and overall well-being.
12. **Babu Roshan et al. (2018)** conducted a pilot study on the association between upper limb function and functional balance in children with spastic cerebral palsy. The aim of the study was to determine the correlation between upper extremity function and functional balance in children with spastic cerebral palsy. The study included 20 children aged 5–12 years with spastic cerebral palsy and GMFCS levels I–III. Functional balance was assessed using the Pediatric Balance Scale (PBS), and upper limb function was evaluated using the Quality of Upper Extremity Skill Test (QUEST).The results showed a strong positive correlation between upper limb function and functional balance. Children with better balance demonstrated improved upper limb motor performance and functional abilities.The study concluded that functional balance and upper limb function are closely associated in children with spastic cerebral palsy. It emphasized that interventions focusing on trunk control and balance training may help improve upper limb function and overall motor performance.
13. **Mustafa Cemali et al. (2022)** conducted a single-blind randomized controlled trial on the effectiveness of sensory integration interventions on motor and sensory functions in infants with cortical vision impairment and cerebral palsy. The aim of the study was to examine the effect of sensory integration therapy on sensory processing, motor function, and oculomotor skills in infants with cerebral palsy. The study included 34 infants aged 12–18 months with cortical vision impairment and cerebral palsy. The intervention group received sensory integration therapy along with conventional physiotherapy, while the control group received only conventional physiotherapy for eight weeks. Sensory processing was assessed using the Test of Sensory Functions in Infants (TSFI), and motor function was evaluated using the Alberta Infant Motor Scale (AIMS). The results showed significant improvement in sensory processing functions in the intervention group compared to the control group. Both groups showed improvement in motor function, but greater sensory improvement was observed in the group receiving sensory integration therapy. The study concluded that sensory integration therapy combined with conventional physiotherapy is effective in improving sensory processing skills in infants with cerebral palsy and cortical vision impairment. It also emphasized the importance of early sensory-based interventions in rehabilitation programs.
14. **Kate Himmelmann and Christos P. Panteliadis (2025)** discussed the clinical characteristics of cerebral palsy in a review chapter. The study described cerebral palsy as the most common motor disability in childhood, affecting movement, posture, and balance due to early brain injury. The review highlighted that cerebral palsy is often associated with impairments in cognition, sensation, perception, communication, behavior, and epilepsy. It emphasized the importance of assessing muscle tone, strength, selective motor control, posture, balance, contractures, and gross motor impairment in children with cerebral palsy.The chapter also explained the classification of cerebral palsy into spastic, dyskinetic, and ataxic types, with spastic cerebral palsy being the most common form. Bilateral spastic cerebral palsy

was identified as a major subtype associated with balance and motor impairments.The study concluded that comprehensive clinical assessment is essential for identifying motor and sensory impairments in children with cerebral palsy. It also emphasized the importance of early rehabilitation and multidisciplinary management to improve functional abilities and participation in daily activities.

15. Fatema Ghasia, et al (2008) conducted an observational cross-sectional study on the frequency and severity of visual sensory and motor deficits in children with cerebral palsy according to the Gross Motor Function Classification System (GMFCS). The objective of the study was to determine whether children with different severities of cerebral palsy showed different types and degrees of visual dysfunction. A representative cohort of 50 children with cerebral palsy, with a mean age of 5.6 years, was included in the study. Neurological and masked ophthalmic assessments were performed to evaluate visual sensory and motor deficits. The results showed that children with higher GMFCS levels had a greater likelihood of severe visual deficits, regardless of gestational age. Children with GMFCS level 5 had the highest risk of high myopia, absence of binocular fusion, dyskinetic strabismus, severe gaze dysfunction, optic neuropathy, and cerebral visual impairment (CVI). In contrast, these deficits were rare in children with GMFCS level 1. The study also found that children with diplegic and spastic cerebral palsy were more commonly hyperopic and esotropic, whereas children with quadriplegic and mixed cerebral palsy showed higher prevalence of high myopia, CVI, dyskinetic strabismus, and gaze dysfunction. The study concluded that visual deficits vary according to the severity of cerebral palsy, with children having severe motor impairment demonstrating more serious visual sensory and motor dysfunctions.

16. Hua-Fang Liao et al (2003) conducted a study on the relationship between balance function and gross motor ability in children with cerebral palsy. The objective of the study was to investigate the association between balance function and gross motor performance in children with cerebral palsy. A total of 15 children with cerebral palsy aged between 5 and 12 years participated in the study. Balance function was assessed using the Smart Balance Master System and various clinical balance tests, while gross motor ability was evaluated using the Motor Age Test. The results showed that postural stability under eyes-open, eyes-closed, and swaying-vision conditions, as well as one-leg standing duration and heel-to-toe standing duration, were significantly correlated with gross motor ability. Among these factors, postural stability in the eyes-closed condition was identified as the strongest predictor, explaining 64% of the variability in gross motor ability. The study concluded that balance function, particularly postural stability without visual input, is strongly associated with gross motor ability in children with cerebral palsy, and highlighted the need for further research on balance training interventions to improve motor function.

17. Serhat Erkek and Çiğdem Çekmece (2023) conducted a study on the relationship between sensory-processing skills and motor functions in children with cerebral palsy. The objective of the study was to examine the relationship between sensory-processing skills, gross motor functions, bimanual motor functions, and balance in children with cerebral palsy. A total of 47 children aged between 3 and 10 years diagnosed with cerebral palsy were included in the study from a physical therapy and rehabilitation unit. Sensory Profiling (SP), Assisting Hand Assessment (AHA), Gross Motor Function Measure-66 (GMFM-66), and Pediatric Berg Balance Scale (PBBS) were used for evaluation. The Gross Motor Function Classification System (GMFCS) and the Manual Ability Classification System (MACS) were also used to classify the children according to functional abilities and manual dexterity. The results showed statistically significant relationships between sensory-processing skills and AHA, PBBS, and GMFM-66 scores ($p < 0.05$). The study found that children with cerebral palsy experience sensory-processing disorders that affect motor functions and balance. The study concluded that sensory evaluations should be included as an important component of rehabilitation programs for children with cerebral palsy.

18. Hua-Fang Liao and Ai-Wen Hwang (2003) conducted a study on the relationship between balance function and gross motor ability in children with cerebral palsy. The objective of the study was to investigate the association between balance function and gross motor performance in children with cerebral palsy. A total of 15 children with cerebral palsy aged between 5 and 12 years participated in the study. Balance function was assessed using the Smart Balance Master System and various clinical balance tests, while gross motor ability was evaluated using the Motor Age Test. The results showed that postural stability under eyes-open, eyes-closed, and swaying-vision conditions, as well as one-leg standing duration and heel-to-toe standing duration, were significantly correlated with gross motor ability. Among these factors, postural stability in the eyes-closed condition was identified as the strongest predictor, explaining 64% of the variability in gross motor ability. The study concluded that balance function, particularly postural stability without visual input, is strongly associated with gross motor ability in children with cerebral palsy, and highlighted the need for further research on balance training interventions to improve motor function.

19. Sergio Montero Mendoza,et al.(2015) conducted a correlational study in Spain on the association between gross motor function and postural control in sitting among children with cerebral palsy. The objective of the study was to analyse the relationship between the Gross Motor Function Classification System (GMFCS) and the Level of Sitting Scale (LSS), and to examine how the Surveillance of Cerebral Palsy in Europe (SCPE) classification relates to sitting abilities and gross motor function. A total of 139

children with cerebral palsy aged between 3 and 18 years from 24 educational centres participated in the study. Information regarding age, gender, CP classification according to SCPE, GMFCS level, and LSS level was collected and assessed by an experienced physiotherapist. The results showed a significant inverse relationship between GMFCS and LSS levels ($r_s = -0.86$, $p = 0.00$), indicating that better sitting ability was associated with higher gross motor function. The study also found that 45.3% of children who could lean in any direction and re-erect the trunk independently (Level VIII on LSS) were able to walk without limitations (Level I on GMFCS). Significant differences were observed in GMFCS and LSS distributions according to the type and distribution of spasticity ($p < 0.01$). The study concluded that GMFCS and LSS are valuable tools for describing functional abilities and limitations in children with cerebral palsy, particularly in relation to sitting balance and mobility, and that classification based on spasticity distribution and gross motor function provides important clinical information regarding prognosis and development.

20. **Duygu Korkem Yorulmaz, et al.(2025)** conducted a randomized controlled study comparing balance, foot posture, functionality, and gait speed among children with spastic cerebral palsy according to Gross Motor Function Classification System (GMFCS) levels and typically developing children. The objective of the study was to evaluate differences in balance, foot posture, functional ability, and gait speed across varying GMFCS levels in children with spastic cerebral palsy and compare them with typically developing peers. A total of 80 children aged between 7 and 16 years participated in the study, including 40 children with spastic cerebral palsy and 40 typically developing children. Gross motor functions were assessed using the Gross Motor Function Measure (GMFM), while balance, foot posture, functionality, and gait speed were evaluated using clinical assessment tools including the 10-meter walk test. Randomization ensured equal distribution of children with cerebral palsy across GMFCS levels I to III. The results showed that children with spastic cerebral palsy had significantly lower gross motor function, balance, and foot functionality scores compared to typically developing children, although no significant difference was observed in foot posture. Increasing GMFCS severity was associated with poorer motor function, reduced balance, and slower gait speed, with children at GMFCS level III demonstrating the greatest impairments. The study concluded that spastic cerebral palsy negatively affects gross motor function, balance, and gait performance, and these impairments increase with higher GMFCS levels. The authors emphasized the importance of early and comprehensive evaluation for planning individualized rehabilitation interventions and improving therapeutic outcomes.

21. **Amira H. Mohammed,et al (2023)** conducted a randomized controlled trial on the correlation between selective motor control of the lower extremities and balance in children with spastic hemiplegic cerebral palsy. The objective of the study was to evaluate the effect of mirror feedback therapy on lower extremity selective motor control and balance in children with hemiplegic cerebral palsy and to understand the relationship between selective motor control and balance. A total of 47 children of both sexes diagnosed with hemiplegic cerebral palsy participated in the study. The participants were divided into two groups: the control group received conventional physical therapy, while the intervention group received conventional physical therapy along with bilateral lower extremity mirror therapy. Selective motor control was assessed using the Selective Control Assessment of Lower Extremity Scale (SCALE), and balance was evaluated using the Pediatric Balance Scale (PBS). The results showed significant improvements in both SCALE and PBS scores in both groups after treatment, with the intervention group demonstrating significantly greater improvement compared to the control group. The study concluded that mirror therapy is an effective, simple, and low-cost adjunct to conventional rehabilitation for children with hemiplegic cerebral palsy, and that it may significantly improve selective motor control and balance in these children.

22. **Myoung-Ok Park (2017)** conducted a study on the relationship between sensory processing abilities and gross and fine motor capabilities in children with cerebral palsy. The objective of the study was to investigate the differences and relationships between sensory processing abilities, gross motor function, and fine motor abilities in children with cerebral palsy. A total of 104 children with cerebral palsy participated in the study. Sensory processing abilities were assessed using the Short Sensory Profile (SSP), while gross motor and fine motor abilities were evaluated using the Gross Motor Function Classification System (GMFCS) and the Manual Ability Classification System (MACS), respectively. The results showed significant correlations between SSP scores and both GMFCS ($R = .72$, $p < .00$) and MACS ($R = .77$, $p < .00$) levels. Significant differences were also observed in gross motor and fine motor levels according to sensory processing ability levels. Subdomains of sensory processing, including tactile sensitivity, movement sensitivity, auditory filtering, and low energy/weakness, demonstrated significant correlations with both gross motor and fine motor performance. Multiple regression analysis further showed that higher GMFCS and MACS levels were associated with higher SSP total scores (adjusted $R^2 = .62$). The study concluded that sensory processing abilities are closely related to gross and fine motor capabilities in children with cerebral palsy, and that better motor abilities are associated with improved sensory processing skills.

23. Sigrid Østensjø et al. (2004) conducted a study on the distribution of motor impairments and their relationship with gross motor function and daily activities in children with cerebral palsy. The study included 95 children with different types and severities of cerebral palsy. Standardized tools such as the Modified Ashworth Scale (MAS), range of motion assessment, Selective Motor Control scale, Gross Motor Function Measure (GMFM), and Pediatric Evaluation of Disability Inventory (PEDI) were used. The study found that loss of selective motor control had a stronger association with reduced gross motor function than spasticity and range of motion limitations. It also showed that daily activities were more influenced by gross motor ability than by motor impairments alone. The study concluded that selective motor control and gross motor function play an important role in functional independence in children with cerebral palsy. It emphasized the need for comprehensive rehabilitation programs focusing on improving gross motor function and daily activity participation.

24. Karin Sandström, Johan Alinder and Birgitta Öberg (2004) conducted a study to describe functioning and health status and to explore the usefulness of the Gross Motor Function Classification System (GMFCS) in adults with cerebral palsy. The study included 48 adults with cerebral palsy selected from a cohort of 199 individuals. Structured interviews and functional assessments were carried out to evaluate activities of daily living (ADL), motor function, range of motion (ROM), pain, and general health status. Standardized assessments related to functional independence and motor ability were used along with GMFCS classification. The study found that nearly one-third of the participants showed deterioration in functional ability from adolescence to adulthood according to GMFCS levels. Most participants were independent in personal ADL activities such as feeding and dressing, but many required assistance in instrumental ADL activities including household work, transportation, and community participation. Walking difficulties, limited joint range of motion, and pain were commonly observed across all GMFCS levels. General health status was lower when compared with the general population. The study also demonstrated that GMFCS had good validity in adults with cerebral palsy because it correlated well with measures of motor function and dependence in daily activities.

25. Susan M. Reid, et al.(2011) conducted a study to describe the distribution and patterns of motor severity in individuals with cerebral palsy using the Gross Motor Function Classification System (GMFCS). The study also examined temporal trends in motor severity and reviewed the distribution of GMFCS levels across cerebral palsy registries worldwide. Data were collected from the Victorian Cerebral Palsy Register involving 3312 individuals with non-postneonatally acquired cerebral palsy born between 1970 and 2003. The sample included 1852 males and 1460 females with a mean age of 21 years. Logistic regression analysis was used to assess trends over time, and a systematic review of international cerebral palsy registries was also performed to compare GMFCS distributions globally. The study found that the proportion of individuals with mild motor impairment classified under GMFCS Levels I and II increased from 54% in the 1970s to 61% in the 2000s, indicating improved survival and early management of milder forms of cerebral palsy. Across nine cerebral palsy registries worldwide, the average distribution of GMFCS levels from I to V was reported as 34.2%, 25.6%, 11.5%, 13.7%, and 15.6% respectively. Considerable variability was observed between registries, particularly in Levels I and II, while Level III showed relatively consistent classification across studies.The study concluded that the GMFCS is a reliable and useful system for describing motor severity patterns in cerebral palsy populations. However, variability between registries suggests possible uncertainty in distinguishing between mild functional levels, especially Levels I and II. The authors emphasized the need for additional clinical information and standardized assessment procedures to improve the reliability and consistency of GMFCS classification across different populations and registries.

26. Sapna Dhiman,et al.i (2025) conducted a study to examine the psychometric properties of the Child Sensory Profile-2 (CSP-2) among children with spastic cerebral palsy. The purpose of the study was to determine the validity and reliability of CSP-2 as a standardized tool for assessing sensory processing deficits in children with spastic cerebral palsy. The study included 230 children with spastic cerebral palsy aged between 3 and 14 years who were referred from various pediatric rehabilitation centres in the Delhi-NCR region between April 2021 and September 2023. Data were collected using the Child Sensory Profile-2 caregiver questionnaire through a snowball sampling method. The study assessed both validity and reliability of the CSP-2 questionnaire. Face validity and content validity were evaluated by experts, who reported that the questionnaire design and organization were appropriate for children with spastic cerebral palsy. The items in the questionnaire were found to be simple, understandable, and suitable for caregivers to complete. Reliability was assessed using Cronbach's alpha coefficient to measure internal consistency. The internal consistency value for the total 86 items of the questionnaire was 0.898, indicating excellent reliability and strong consistency among the questionnaire items.The study concluded that the Child Sensory Profile-2 is a valid and reliable assessment tool for evaluating sensory processing difficulties in children with spastic cerebral palsy. The authors emphasized that CSP-2 can be effectively used in clinical and rehabilitation settings to identify sensory processing deficits and to support accurate assessment and intervention planning for children with spastic cerebral palsy.

27. Sapna Dhiman, et al. (2025) conducted a systematic review to identify sensory processing assessment tools and explore sensory processing issues in children with cerebral palsy. The review aimed

to provide a comprehensive overview of sensory processing deficits and highlight the importance of sensory assessment in children with cerebral palsy. A detailed literature search was carried out up to September 2024 using scientific databases including PubMed, Scopus, Web of Science, and Google Scholar. The review found that the Child Sensory Profile-2 (CSP-2) was the most commonly used assessment tool for evaluating sensory processing abilities in children with cerebral palsy. The Sensory Outcome Measure (SOM) was also identified as a valid and reliable tool with strong content validity, face validity, and concurrent validity for assessing sensory deficits in this population. The review reported that sensory processing difficulties affect approximately 55–83% of children with spastic cerebral palsy. Visuospatial attention deficits were observed in nearly 60% of children with spastic cerebral palsy. The "Registration" pattern of sensory modulation and impairments in vestibular and body position processing were highly affected across all types of cerebral palsy. Children with hemiplegic cerebral palsy showed greater difficulties in the "Avoiding" sensory modulation pattern compared to children with diplegic cerebral palsy. Somatosensory deficits such as impaired proprioception, stereognosis, tactile discrimination, and two-point discrimination were also common, particularly in children with hemiplegic cerebral palsy. Additionally, children with cerebral palsy were found to be less sensitive to mechanical and heat stimuli but more responsive to painful mechanical stimuli compared to healthy children.The review concluded that sensory processing deficits are highly prevalent in children with cerebral palsy and significantly influence functional performance and participation. The authors emphasized the importance of including sensory processing assessments in routine clinical evaluation and rehabilitation programs for children with cerebral palsy. The study recommended that pediatric neurologists, physiotherapists, occupational therapists, and rehabilitation professionals should consider early identification and management of sensory processing deficits to improve functional outcomes and quality of life in children with cerebral palsy.

AIMS AND OBJECTIVES

AIM OF THE STUDY

The aim of this study is to determine the prevalence of balance and sensory impairments and to identify their correlation with gross motor function in children with spastic diplegic cerebral palsy.

OBJECTIVES OF THE STUDY

1. To assess balance impairments in children with spastic diplegic cerebral palsy by using the Pediatric Berg Balance Scale (PBS).
2. To evaluate sensory impairments in children with spastic diplegic cerebral palsy by using the Sensory Profile.
3. To assess gross motor function in children with spastic diplegic cerebral palsy by using the Gross Motor Function Measure (GMFM) and Gross Motor Function Classification System (GMFCS).
4. To determine the prevalence of balance and sensory impairments among children with spastic diplegic cerebral palsy.
5. To analyze the correlation between balance impairments and gross motor function in children with spastic diplegic cerebral palsy.
6. To analyze the correlation between sensory impairments and gross motor function in children with spastic diplegic cerebral palsy.

HYPOTHESIS

NULL HYPOTHESIS

There will be no significant prevalence of balance and sensory impairments and no significant correlation with gross motor function in children with spastic diplegic cerebral palsy.

ALTERNATE HYPOTHESIS

There will be a significant prevalence of balance and sensory impairments and a significant correlation with gross motor function in children with spastic diplegic cerebral palsy.

METHODOLOGY

- **STUDY DESIGN:** Prevalence study
- **TYPE OF STUDY:** Cross-sectional study
- **STUDY SETTING:** VKM SPECIAL SCHOOL,VALANCHERY,MALAPPURAM,KERALA
- **SAMPLE SIZE :**109

- **STUDY SAMPLING:** Convenience sampling technique

- **STUDY DURATION:** 3 Months

METHOD OF DATA COLLECTION

- Subjects who fulfill the inclusion and exclusion criteria will be selected for the study.
- Informed consent will be obtained from the parents/guardians before participation.
- Demographic data such as age, gender, diagnosis, and Gross Motor Function Classification System level will be recorded.
- Balance assessment will be conducted using the Pediatric Berg Balance Scale.
- Sensory impairments will be assessed using the Sensory Profile.
- Gross motor function will be evaluated using the Gross Motor Function Measure.
- The collected data will be tabulated and statistically analyzed to determine the prevalence of balance and sensory impairments and their correlation with gross motor function in children with spastic diplegic cerebral palsy.

POPULATION

- Participants / Children diagnosed with spastic diplegic cerebral palsy and Age between 5–16 years

CRITERIA FOR SAMPLE SELECTION

INCLUSION CRITERIA

- Gender – male and female
- Children diagnosed with spastic diplegic cerebral palsy
- Age between 5–16 years
- Children classified under Gross Motor Function Classification System levels II–IV
- Children able to follow simple verbal instructions
- Willingness of parents/guardians to allow participation in the study

EXCLUSION CRITERIA

- Children with other types of cerebral palsy apart from spastic diplegia
- History of recent orthopedic surgery
- History of botulinum toxin injection within the last 6 months
- Presence of severe visual, hearing, or cognitive impairments affecting assessment
- Children with uncontrolled seizures or other neurological disorders
- Unwillingness of child or parents/guardians to participate in the study

PROCEDURE

A total of 109 children with spastic diplegic cerebral palsy were selected based on the inclusion and exclusion criteria. The participants were recruited from pediatric physiotherapy centers and special schools. Children belonging to the age group of 3–16 years and classified under Gross Motor Function Classification System levels II–IV were included in the study.

The purpose and procedure of the study were explained to the parents or guardians, and informed consent was obtained prior to participation. Demographic details such as age, gender, diagnosis, and GMFCS level were recorded.

Gross motor function was assessed using the Gross Motor Function Measure. Balance impairments were evaluated using the Pediatric Berg Balance Scale. Sensory impairments were assessed using the Sensory Profile through parent or caregiver responses.

All assessments were carried out in a comfortable and safe environment under the supervision of the investigator. The collected data were tabulated and statistically analyzed to determine the prevalence of balance and sensory impairments and their correlation with gross motor function in children with spastic diplegic cerebral palsy.

OUTCOME MEASURES

1. Gross Motor Function Measure – To assess gross motor function in children with spastic diplegic cerebral palsy.
2. Gross Motor Function Classification System – To classify the severity of gross motor impairment.
3. Pediatric Berg Balance Scale – To assess balance impairments.
4. Sensory Profile – To assess sensory impairments and sensory processing abilities.

MATERIALS REQUIRED

- Assessment couch or chair
- Step stool
- Stopwatch
- Measuring tape
- Balance assessment equipment
- Pen and assessment sheets
- Gross Motor Function Measure score sheet
- Pediatric Berg Balance Scale score sheet
- Sensory Profile questionnaire forms
- Stationery items
- Consent forms

DATA ANALYSIS AND INTERPRETATION

The collected data were organized, tabulated, and analyzed using appropriate statistical methods. Descriptive statistics such as mean, standard deviation, frequency, and percentage were used to determine the prevalence of balance and sensory impairments in children with spastic diplegic cerebral palsy.

The scores obtained from the Gross Motor Function Measure, Pediatric Berg Balance Scale, and Sensory Profile were statistically analyzed to identify the relationship between balance impairment, sensory impairment, and gross motor function.

Correlation analysis was performed using appropriate statistical tests such as Pearson's correlation test or Spearman's correlation test. The level of statistical significance was set at $p < 0.05$.

WITHIN GROUP ANALYSIS

Within-group analysis was performed to analyze the relationship between balance impairment, sensory impairment, and gross motor function among children with spastic diplegic cerebral palsy within the same study group.

RESULTS

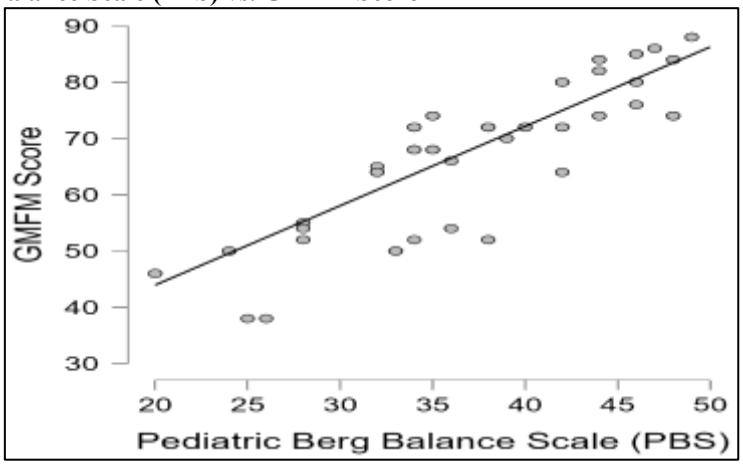
Correlation

Correlation Table

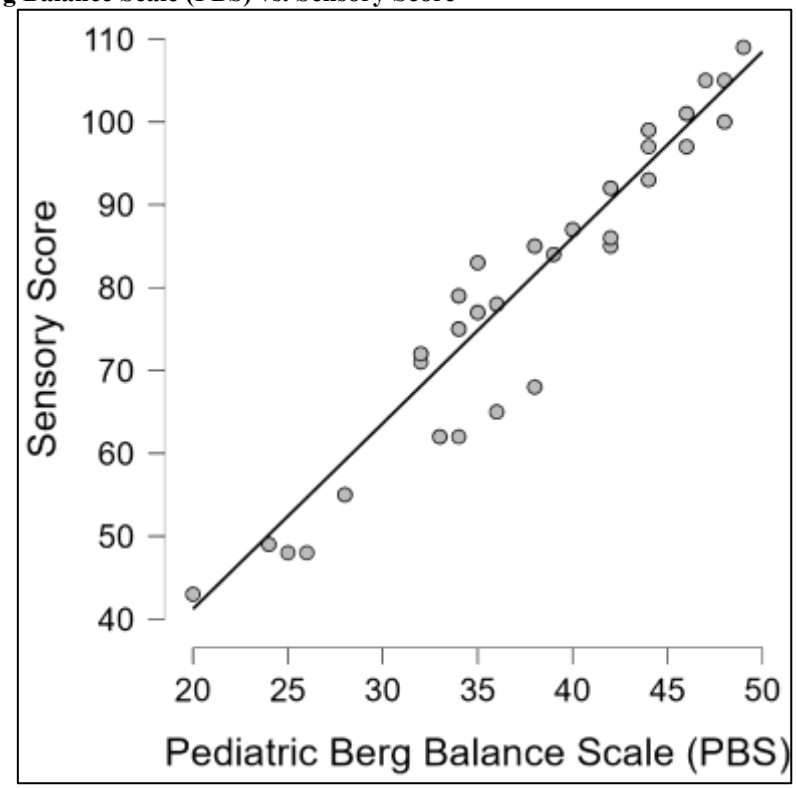
			Pearson		Spearman	
			r	p	rho	p
Pediatric Berg Balance Scale (PBS)	-	GMFM Score	0.828	< .001	0.854	< .001
Pediatric Berg Balance Scale (PBS)	-	Sensory Score	0.955	< .001	0.953	< .001
GMFM Score	-	Sensory Score	0.946	< .001	0.948	< .001

Scatter plots

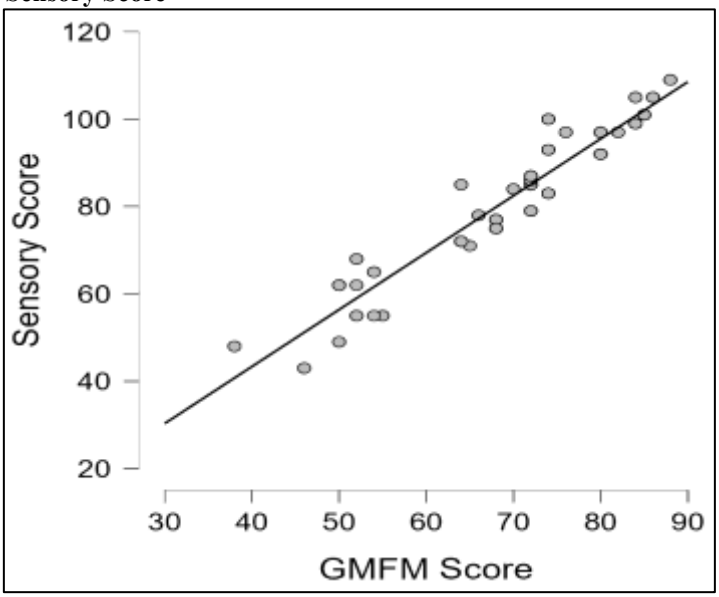
Pediatric Berg Balance Scale (PBS) vs. GMFM Score



Pediatric Berg Balance Scale (PBS) vs. Sensory Score



GMFM Score vs. Sensory Score



RESULT EXPLANATION

The collected data were analyzed using Pearson's correlation test and Spearman's correlation test to determine the relationship between balance impairment, sensory impairment, and gross motor function in children with spastic diplegic cerebral palsy.

The correlation analysis between the Pediatric Berg Balance Scale score and Gross Motor Function Measure score showed a strong positive correlation (Pearson $r = 0.828$, $p < 0.001$; Spearman rho = 0.854, $p < 0.001$). This indicates that children with better balance performance demonstrated better gross motor function.

The correlation analysis between the Pediatric Berg Balance Scale score and the Sensory Profile score revealed a very strong positive correlation (Pearson $r = 0.955$, $p < 0.001$; Spearman rho = 0.953, $p < 0.001$). This finding suggests that improved sensory processing abilities are strongly associated with improved balance performance in children with spastic diplegic cerebral palsy.

The analysis between the GMFM score and Sensory Score also demonstrated a very strong positive correlation (Pearson $r = 0.946$, $p < 0.001$; Spearman rho = 0.948, $p < 0.001$). This indicates that children with better sensory function tend to have better gross motor abilities.

The scatter plots further supported these findings by showing a positive linear relationship between:

- Pediatric Berg Balance Scale and GMFM score
- Pediatric Berg Balance Scale and Sensory score
- GMFM score and Sensory score

Since all p-values were less than 0.001, the results were found to be statistically highly significant. Therefore, the study findings indicate that balance impairment and sensory impairment are strongly correlated with gross motor function in children with spastic diplegic cerebral palsy.

DISCUSSION

The present study was conducted to determine the prevalence of balance and sensory impairments and their correlation with gross motor function in children with spastic diplegic cerebral palsy. The findings of the study demonstrated a strong positive correlation between balance, sensory function, and gross motor performance.

The correlation between the Pediatric Berg Balance Scale and Gross Motor Function Measure scores showed a statistically significant positive relationship. This indicates that children with better balance abilities exhibited improved gross motor function. Balance plays an important role in maintaining posture, performing functional activities, and controlling movements during walking and other daily activities. Children with spastic diplegic cerebral palsy often experience impaired postural control due to muscle spasticity, weakness, and poor coordination, which negatively affect their gross motor abilities.

The study also revealed a very strong positive correlation between balance performance and sensory function assessed using the Sensory Profile. Sensory processing is essential for maintaining body awareness, postural stability, and movement control. Impairments in sensory integration, proprioception, tactile processing, and vestibular function can lead to difficulty in balance and coordinated movements in children with cerebral palsy. The results suggest that children with better sensory processing abilities tend to demonstrate better balance control.

Furthermore, the findings showed a highly significant positive correlation between sensory function and gross motor function. This indicates that sensory impairments may directly influence the motor performance of children with spastic diplegic cerebral palsy. Proper sensory input is necessary for planning, initiating, and executing motor activities. Deficits in sensory processing may therefore limit functional mobility and independence.

The scatter plot analysis further supported the presence of a positive linear relationship between Pediatric Berg Balance Scale scores, GMFM scores, and Sensory Profile scores. As balance and sensory scores increased, gross motor function scores also increased correspondingly.

The results of the present study are consistent with previous studies which reported that impairments in balance and sensory processing significantly affect motor performance in children with cerebral palsy. The findings emphasize the importance of including balance training and sensory integration approaches in physiotherapy rehabilitation programs to improve functional outcomes in children with spastic diplegic cerebral palsy.

Overall, the study concludes that balance and sensory impairments are highly prevalent in children with spastic diplegic cerebral palsy and are strongly associated with gross motor function. Early assessment and targeted therapeutic interventions may help improve balance, sensory processing, and functional mobility in these children.

LIMITATIONS OF THE STUDY

1. The study included only children with spastic diplegic cerebral palsy; therefore, the results cannot be generalized to other types of cerebral palsy.
2. The study was limited to a specific age group of children, which may influence the applicability of the findings to other age groups.
3. Sensory assessment was mainly based on caregiver responses using the Sensory Profile, which may include subjective bias.
4. Environmental, psychological, and motivational factors affecting balance and motor performance were not considered during the study.
5. The study design was cross-sectional in nature; therefore, causal relationships between balance, sensory impairments, and gross motor function could not be established.

SUGGESTIONS

1. Similar studies can be performed among different types of cerebral palsy for comparison.
2. Longitudinal studies can be carried out to evaluate changes in balance, sensory function, and gross motor function over time.
3. Advanced assessment tools and objective sensory evaluation methods may be included in future research.

4. Intervention-based studies focusing on balance training and sensory integration therapy can be conducted to identify effective rehabilitation strategies.

5. Future studies may include children from different age groups and functional levels to obtain broader clinical findings.

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