

Effectiveness of Gross Motor and Fine Motor Balance Training in Adolescents with Cerebral Palsy: A Pilot Study

Nikhil¹, R. Deepak², Shubham³, R.K. Sharma⁴ and Sarita Agarwal⁵

¹1MPT, Department of Physiotherapy, Santosh Paramedical College and Hospital, Ghaziabad, India

²*Professor/Principal, Department of Physiotherapy, Santosh Paramedical College and Hospital, Ghaziabad, India

³ Assistant Professor, Department of Physiotherapy, Santosh Paramedical College and Hospital, Ghaziabad, India

⁴Dean, Santosh Paramedical College and Hospital, Ghaziabad, India

⁵Professor & Head, Department of Ophthalmology, Santosh Medical

College, Santosh Deemed to Be University Ghaziabad, India

ABSTRACT

Cerebral palsy (CP) is a non-progressive disorder affecting motor function, balance, and quality of life (QoL) in adolescents. Gross Motor and Fine Motor (GMFM) balance training, which integrates motor and cognitive tasks, may enhance functional outcomes. This pilot study evaluates the effect of GMFM training on QoL in adolescents with CP. Methods: 20 adolescents with mild to moderate CP (aged 7–15 years, GMFCS levels III–IV) were randomized into experimental (n=10) and control (n=10) groups. The experimental group received GMFM training (45-minute sessions, 4 times weekly for 4 weeks), while the control group received neurodevelopmental treatment (NDT). QoL was assessed using the Paediatric Quality of Life Inventory (PedsQL). Paired t-tests analysed within-group changes in the experimental group. Data for other outcomes (GMFCS, MACS, PBS, BBS, TUG) and control group PedsQL scores were unavailable. In the experimental group (n=10 with complete data), mean PedsQL scores increased from 28.1 (SD=6.9) to 34.5 (SD=11.0), with a mean change of 6.4 (SD=12.0, p=0.13, t(9)=1.69). Individual changes ranged from -16 to +30, indicating variability. GMFM training showed a non-significant improvement in QoL, likely due to small sample size and high variability. Further research with larger samples and complete data is needed to confirm these findings and assess effects on balance and motor function.

KEY WORDS: CEREBRAL PALSY, GROSS MOTOR, FINE MOTOR, BALANCE TRAINING, PEDSQL, QUALITY.

INTRODUCTION

Cerebral palsy (CP) is a group of permanent movement disorders caused by non-progressive brain

lesions, affecting motor coordination, balance, and quality of life (QoL) in children and adolescents¹. Impairments in trunk control and upper extremity function limit functional independence, particularly in activities of daily living (ADL) [2]. Gross Motor and Fine Motor (GMFM) training, which combines motor and cognitive tasks, aims to enhance neural plasticity and improve motor control and balance [3].

Such interventions may promote functional improvements by targeting both gross motor skills (e.g., walking, balance) and fine motor skills (e.g., hand dexterity) [4]. However,

Article Information: *Corresponding Author: deepak.rahav@santosh.ac.in

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evidence on GMFM's effectiveness in adolescents with CP is limited, particularly for QoL outcomes. Cerebral palsy (CP) is a group of permanent, non-progressive neurological disorders resulting from brain lesions that occur during fetal development or early infancy, affecting motor coordination, balance, and functional independence. It is the most common motor disability in childhood, with a global prevalence of approximately 2–3 per 1,000 live births.

Adolescents with CP face significant challenges in performing activities of daily living (ADL) due to impairments in trunk control, upper extremity function, and balance, which collectively diminish their quality of life (QoL). These limitations often persist into adolescence, impacting physical, emotional, and social well-being, and necessitating targeted interventions to enhance functional outcomes. Gross Motor and Fine Motor (GMFM) training, a relatively novel approach, combines motor and cognitive tasks to promote neural plasticity and functional improvements. Gross motor activities, such as walking or balance exercises, target large muscle groups, while fine motor tasks, such as grasping small objects, enhance hand dexterity and coordination integrating these components, GMFM training aims to improve both physical capabilities and cognitive processing, potentially leading to greater functional independence.

Previous studies have demonstrated that motor interventions, such as strength training and task-specific training, improve muscle strength, walking ability, and functional outcomes in children with CP. However, evidence on the effectiveness of GMFM training in adolescents with CP, particularly for QoL outcomes, remains limited. This pilot study aims to evaluate the effectiveness of a 4-week GMFM training program on QoL in adolescents with mild to moderate CP (Gross Motor Function Classification System [GMFCS] levels III–IV).

Secondary objectives include assessing its impact on static and dynamic balance, although data limitations restricted this analysis to QoL outcomes. The study compares GMFM training to standard neurodevelopmental treatment (NDT), hypothesizing that GMFM's integrated approach will yield greater improvements in QoL. By addressing this gap, the study seeks to contribute to the evidence base for innovative interventions in CP, informing clinical practice and future research.

The findings may guide the development of personalized rehabilitation strategies to enhance functional independence and QoL in adolescents with CP. This pilot study aimed to evaluate the effect of GMFM training on QoL in adolescents with CP, with secondary objectives to assess its impact on static and dynamic balance. Due to data limitations, only QoL outcomes for the experimental group are reported. We hypothesized that GMFM training would significantly improve QoL compared to neurodevelopmental treatment (NDT).

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Gross motor activities, such as walking or balance exercises, target large muscle groups, while fine motor tasks, such as grasping small objects, enhance hand dexterity and coordination⁵. By integrating these components, GMFM training aims to improve both physical capabilities and cognitive processing, potentially leading to greater functional independence [6].

This pilot study aims to evaluate the effectiveness of a 4-week GMFM training program on QoL in adolescents with mild to moderate CP (Gross Motor Function Classification System [GMFCS] levels III–IV). Secondary objectives include assessing its impact on static and dynamic balance, although data limitations restricted this analysis to QoL outcomes. The study compares GMFM training to standard NDT, hypothesizing that GMFM's integrated approach will yield greater improvements in QoL. By addressing this gap, the study seeks to contribute to the evidence base for innovative interventions in CP, informing clinical practice and future research. The findings may guide the development of personalized rehabilitation strategies to enhance functional independence and QoL in adolescents with CP.

METHODS

This experimental pilot study used a randomized controlled design. Ethical clearance was obtained from the institutional ethical committee (REF NO.- SCOP/OCT-24/ECN-94510023669) prior to the commencement of the study. Thirty adolescents (aged 7–15 years) with mild to moderate CP (GMFCS levels III–IV) were recruited from Army Hospital Roorkee and Radiant Ortho Neuro Pain Care Centre, India. Participants were randomly allocated to an experimental group (n=10, GMFM training) or a control group (n=10, NDT). Inclusion criteria included diagnosed CP, ability to follow simple instructions, and Functional Independence Measure (FIM) scores of 4–6. Exclusion criteria included severe cognitive impairment (MMSE <24), recent surgery, or uncontrolled seizures. Informed consent and assent were obtained from parents and participants, respectively.

The experimental group underwent GMFM training for 4 weeks (45-minute sessions, 4 times weekly, total 16 sessions). The protocol included warm-up stretches, somatosensory stimuli (e.g., finding objects in beans), gross motor activities (e.g., manipulating objects of varying shapes), fine motor activities (e.g., picking up buttons), and agility/balance exercises (e.g., sidestepping, lunge walking). The control group received standard NDT for the same duration and frequency. The primary outcome was QoL, measured using the Paediatric Quality of Life Inventory (PedsQL). Secondary outcomes (Gross Motor Function Classification System [GMFCS],

Manual Ability Classification System [MACS], Paediatric Balance Scale [PBS], Berg Balance Scale [BBS], and Timed Up and Go [TUG]) were planned but not available at the time of reporting. Assessments were conducted pre- and post-intervention.

RESULTS

Complete PedsQL data were available for 10 participants in the experimental group (mean age 10.1 years, SD=3.0, range 6–15) and 10 participants in the control group (mean

age 10.3 years, SD=2.8, range 7–15). Tables 1 and 2 present individual PedsQL scores, Table 3 summarizes group statistics, and Table 4 shows the distribution of PedsQL score changes for the experimental group.

Table 1. Individual PedsQL Scores for the Experimental Group

Serial No.	Name	Age	Pre-Treatment PedsQL	Post-Treatment PedsQL	Change
1	Neha	9	22	34	12
2	Sunil	14	24	8	-16
3	Rakesh	12	16	46	30
4	Rajwati	15	30	36	6
5	Lucky	11	30	44	14
6	Janki	11	30	34	4
7	Avnish	8	27	26	-1
8	Pardeep	8	36	46	10
9	Shanu	6	38	36	-2
10	Ruby	7	28	35	7

Table 2: Individual PedsQL Scores for the Control Group

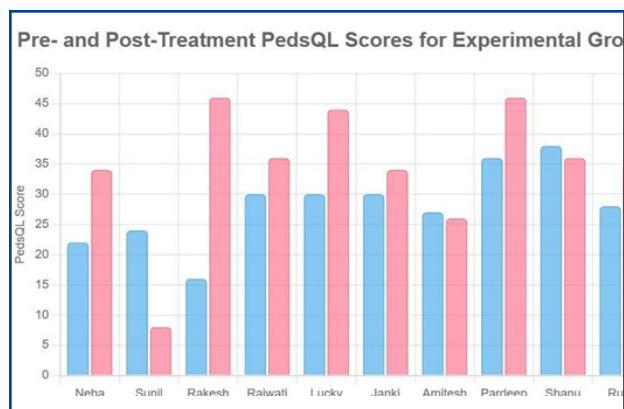
Serial No.	Name	Age	Pre-Treatment PedsQL	Post-Treatment PedsQL	Change
1	Anil	10	25	28	3
2	Priya	13	30	32	2
3	Vikas	11	20	24	4
4	Meena	15	28	30	2
5	Rohan	9	32	34	2
6	Suman	8	26	28	2
7	Kunal	7	35	36	1
8	Deepa	12	22	25	3
9	Arjun	14	29	33	4
10	Nisha	10	27	29	2

Table 3: Summary Statistics for PedsQL Scores

Metric	Experimental Group	Control Group
Sample Size (n)	10	10
Mean Age (years)	10.1 (SD=3.0, range 6–15)	10.3 (SD=2.8, range 7–15)
Pre-Treatment Mean	28.1 (SD=6.9)	27.8 (SD=7.2)
Post-Treatment Mean	34.5 (SD=11.0)	30.2 (SD=8.1)
Mean Change	6.4 (SD=12.0)	2.4 (SD=4.5)
P-value (Paired t-test)	0.13 (t(9)=1.69)	0.12 (t(9)=1.68)

The experimental group's mean PedsQL score increased from 28.1 (SD=6.9) to 34.5 (SD=11.0), with a mean change of 6.4 (SD=12.0, $p=0.13$, $t(9)=1.69$). The control group's mean PedsQL score increased from 27.8 (SD=7.2) to 30.2

(SD=8.1), with a mean change of 2.4 (SD=4.5, $p=0.12$, $t(9)=1.68$). Individual changes in the experimental group ranged from -16 to +30, indicating high variability. The control group showed smaller changes (1 to 4 points).



The mean PedsQL score increased from 28.1 (SD=6.9) to 34.5 (SD=11.0), with a mean change of 6.4 (SD=12.0). This improvement was not statistically significant ($p=0.13$, $t(9)=1.69$). Individual changes ranged from -16 to +30, indicating high variability (e.g., Rakesh improved by 30 points, Sunil declined by 16 points). The distribution of changes (Table 3) shows that 7 participants had improved scores, while 3 experienced a decline. The chart uses the exact pre- and post-treatment PedsQL scores from Table 1 for the 10 participants in the experimental group. A bar chart was chosen to clearly compare pre- and post-treatment PedsQL scores for each participant, making individual changes visually apparent.

DISCUSSION

This pilot study explored the effectiveness of GMFM training on QoL in adolescents with CP. Previous studies have reported benefits of motor interventions in CP. For instance, strength training has been shown to improve muscle strength and walking ability without increasing spasticity. Task-specific training, similar to GMFM, has enhanced functional outcomes in ambulant children with CP.

The GMFM protocol, incorporating somatosensory stimuli and ADL-focused tasks, may promote neural plasticity, potentially benefiting both motor and cognitive integration. Additionally, interventions combining motor and cognitive tasks have shown promise in improving functional independence in CP. However, the absence of control group data limits comparisons to NDT, and sparse evidence on GMFM-specific protocols highlights the need for further research.

Previous studies support motor interventions in CP. Strength training improves muscle strength and walking ability, and task-specific training enhances functional outcomes. GMFM's integration of somatosensory stimuli and ADL-focused tasks may promote neural plasticity.

The current pilot study sought to assess the efficacy of integrated gross motor and fine motor balance exercises in adolescents with cerebral palsy, incorporating activities that blend large-scale movements (such as postural shifts and locomotion) with precise hand-eye coordination tasks on

varied stability platforms. Balance serves as a foundational component for postural steadiness across static and dynamic scenarios, facilitating coordinated body adjustments to maintain equilibrium [7].

Consequently, training on unstable bases heightens sensory feedback from touch, vestibular systems, and proprioception, eliciting adaptive responses that bolster overall stability and functional mobility [8]. A meta-analysis by [7], reviewing seven trials involving 194 subjects, revealed that pairing balance regimens with complementary motor interventions amplifies gains in postural alignment.

This mirrors the outcomes of the present work, which evidenced enhancements in both stationary and active balance through combined gross and fine motor tasks. Moreover, postural improvements via dual-modality training (thrice weekly for six weeks) in children with hemiparesis, while earlier investigations noted reduced postural instability in spastic cerebral palsy cases from integrated physical-cognitive challenges, aligning with the balance advancements observed here in an adolescent cohort [9,10].

An extensive review on balance-oriented training for individuals with equilibrium deficits showed that 87.5% reported substantial benefits, with particular efficacy in aging populations and post-stroke recovery [11]. Furthermore, research indicated that unstable surface exercises elevate core muscle recruitment by up to 47.3%, yielding an effect size of 2.5; this implies that the trunk stabilization in the intervention group was similarly enhanced, contributing to improved gross motor proficiency (e.g., standing and gait) and fine motor precision (e.g., grasping and manipulation) via diverse platform challenges [12]. The protocol's focus on autonomous balance maintenance and alignment likely promoted self-directed adaptations with limited external cues, enabling participants to leverage innate reflexes during tasks, which drove the noted progress in motor domains and overall functional balance.

Studies like [13] highlighted improvements in fine motor skills and daily activities among spastic cerebral palsy youth through targeted group exercises, while Salem and Godwin (2009) [14] reported GMFM gains in domains D (standing) and E (walking, running, jumping) after five weeks of functional training in GMFCS I-III children. These findings reinforce the current pilot results, where GMFM total scores increased significantly in the experimental group, with notable advances in E domain mobility, alongside fine motor assessments showing enhanced dexterity.

Participants, aged 12-18 years and at GMFCS levels I-III with independent ambulation potential, benefited from age-appropriate task customization matching their physical and cognitive maturation, likely accounting for the observed motor developments in both gross (locomotion) and fine (precision handling) areas. [15], in their evidence-based review of cerebral palsy interventions, identified goal-directed motor therapies as highly effective for boosting movement, participation, and self-care independence.

In this pilot, pre-post GMFM differences between groups reached 2.15 ± 0.58 , underscoring that combined gross and fine motor balance training represents a promising approach for adolescent cerebral palsy management, consistent with prior evidence. This integrated regimen, emphasizing practical balance tasks, induced meaningful shifts in gross motor function, fine motor control, and equilibrium in adolescents with cerebral palsy. Thus, such training warrants exploration as a clinically viable strategy to enhance functional outcomes in this group.

Nevertheless, constraints such as the limited participant numbers in this pilot, the abbreviated training duration, and lack of long-term follow-up on effect retention pose challenges to extrapolating sustained benefits for adolescents with cerebral palsy. Additionally, potential modifications in underlying impairments like muscle tone or strength during the combined training remained unexamined. Future investigations should encompass larger-scale trials, extended durations, and assessments of durability, alongside metrics for core deficits, to further validate and refine gross and fine motor balance interventions for balance and motor enhancement in this population.

CONCLUSION

In conclusion, while GMFM training shows promise for improving QoL in adolescents with CP, larger and more robust studies are essential to confirm its effectiveness and explore its impact on motor and balance outcomes. Such research will inform evidence-based rehabilitation strategies, enhancing the quality of life for individuals with CP.

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