Original Article

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Correlation of Postural Control with Gross Motor Function in Children with Spastic Cerebral Palsy: An Analytical Cross-Sectional Study

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ABSTRACT

Background: Poor postural control limits gross motor function in children with spastic cerebral palsy (CP), the most common subtype. In Pakistan, many children reach rehabilitation services at Gross Motor Function Classification System (GMFCS) levels III–V, yet local data on gross motor change during postural-control-focused physiotherapy are scarce. This study assessed the association between postural-control-focused physiotherapy and gross motor function in children with spastic CP.

Methods: This analytical cross-sectional study reviewed clinical records from four pediatric rehabilitation centers in Karachi, Pakistan. Through purposive sampling, records of 60 children aged 4–14 years with spastic CP (GMFCS III–V) and two Gross Motor Function Measure-88 (GMFM-88) assessments six months apart were analyzed. Pre–post change was tested with a paired-samples t-test, and its association with clinically meaningful improvement (>40%) with point-biserial correlation.

Results: Of the 60 children, 32 (53.3%) were boys. The mean GMFM-88 score increased from 11.40 ± 11.27 to 44.90 ± 20.24 (mean change 33.49; 95% CI 29.40–37.59; $p < 0.001$; $d = 2.11$). GMFM-88 change correlated positively with improvement >40% ($r = 0.370$; $p = 0.004$). Overall, 41 children (68.3%) improved by more than 40%, with no significant difference between age groups (62.9% vs 76.0%; $p = 0.281$).

Conclusion: Children with spastic CP receiving postural-control-focused physiotherapy made large gross motor gains over six months, and these gains were moderately associated with clinically meaningful improvement regardless of age. Controlled studies with direct postural control measures are needed.

Keywords: *Cerebral Palsy; Child; Motor Skills; Physical Therapy Modalities; Postural Balance*

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INTRODUCTION

The most common cause of physical handicap in children is still cerebral palsy (CP), a collection of chronic problems of movement and posture that result from non-progressive abnormalities in the developing brain. While birth prevalence has decreased to about 1.6 per 1000 live births in high-income nations, the numbers from low- and middle-income countries (LMICs) are much higher[1]. In LMIC registers, close to four in five affected children have spastic CP and about three-quarters are classified at Gross Motor Function Classification System (GMFCS) levels III–V[2]. These children also carry a heavy burden of malnutrition, which affects more than half of them in some regions[3].

Pakistan has no national CP registry, so the true prevalence is unknown[4]. Hospital- and community-based studies point to birth asphyxia, maternal anaemia, consanguinity, low birth weight and delayed crying as the main risk factors, many of which are preventable[4,5]. Children therefore tend to reach services late, often with severe motor limitation, and this places a heavy and continuing demand on physiotherapy services. Families also face long travel, treatment costs and limited guidance on home exercise, which can delay or interrupt therapy[6].

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Sitting, kneeling, standing, and walking are all supported by postural control, which is the capacity to maintain the body's position in space for both stability and orientation. Spasticity, muscle weakness, and poor selective motor control disrupt postural tone and make it challenging for a child with spastic cerebral palsy to stabilize their trunk before moving their limbs[7]. Trunk control is closely tied to everyday function. Children with better trunk control show better mobility, self-care and participation[8], and early measures of postural control predict later motor impairment[9]. Gross motor development also follows predictable curves by GMFCS level, with children at levels III–V reaching their motor ceiling early[10].

International guidelines now favor goal-directed, activity-based interventions over passive approaches for improving physical function in CP[11,12]. Trunk-targeted training, task-oriented practice and core stability programmes improve trunk control, balance and gross motor function[13–16], and a recent meta-analysis of 15 randomized trials confirmed a significant, though modest, effect of trunk interventions on gross motor function[17]. In Pakistan, positioning in specific postures improved gross motor function and reduced spasticity in children with spastic CP[18]. For non-ambulant children, structured sitting postural management and intensive seated programmes with trunk support are being tested to improve sitting control and protect musculoskeletal alignment[19,20]. Faster gross motor development has also been linked to therapies based on the ontogenetic development of postural control[21].

Most of this evidence, however, comes from ambulant children at GMFCS levels I–III and from trials conducted outside South Asia. Studies of children at levels IV–V are few, small and mostly uncontrolled[22], and little is known about how gross motor function changes in severely affected children who receive postural-control-focused physiotherapy in routine Pakistani rehabilitation settings. Such data would help clinicians set realistic goals for the large group of children who are not expected to walk independently. The Gross Motor Function Measure-88 (GMFM-88), whose starting dimensions comprise lying, sitting and kneeling, is well suited for tracking progress of this kind[23]. This study therefore attempted to assess the correlation between physiotherapy aimed on postural control and gross motor function, as measured with the GMFM-88, in children with spastic CP. It was hypothesized that greater gross motor change after six months of therapy would be associated with clinically meaningful improvement.

METHODOLOGY

Study Design and Setting

A retrospective assessment of regularly recorded clinical records served as the foundation for this analytical cross-sectional study, from which two time points (baseline and six months) were taken for every child. Data were collected during the approval period of the Ethical Review Committee (ERC), May 2023 to May 2024, through single visits to four paediatric rehabilitation centres in Karachi, Pakistan: The Association for Children with Emotional and Learning Problems (ACELP), Imran Rehabilitation Center (IRC), Shaan-e-Rabi, and the Government Special Education and Rehabilitation Complex. All four centres run physiotherapy programmes that emphasise postural control, including positioning, trunk stability and weight-bearing activities, for children with CP.

Sample Size and Sampling Technique

The sample size was calculated with OpenEpi (www.openepi.com) using the formula $n = [DEFF \times Np(1 - p)] / [(d^2/Z^2_{1-\alpha/2} \times (N - 1)) + p(1 - p)]$, with a 95% confidence level and a 5% margin of error, which gave a required sample of 60 children. Participants were selected by non-probability purposive sampling.

Selection Criteria

Inclusion criteria: Children who met the following criteria were included: (i) they were between the ages of 4 and 14, regardless of gender; (ii) they were diagnosed with spastic cerebral palsy; (iii) they were categorized at GMFCS levels III–V; (iv) had restricted activities of daily living; (v) had no indication for surgery; and (vi) had at least two documented GMFM-88 assessments six months apart.

Exclusion criteria: Children were excluded if they (i) had received physiotherapy for three months or less; (ii) had gaps in treatment or were lost to follow-up; (iii) had discontinued treatment; (iv) had a seizure disorder; or (v) had severe chest deformity.

Data Collection Procedure

Written permission was obtained from the heads of the participating centres and the treating physiotherapists. The first documented GMFM-88 score of each child was recorded as the baseline (pre) score, and the GMFM-88 documented after six months of postural-control-focused physiotherapy was recorded as the follow-up (post) score. Age, sex and GMFCS level were taken from the same

records. All data were anonymised with study codes before analysis.

Outcome Measure

Gross motor function was assessed with the GMFM-88, a criterion-referenced observational measure designed to detect change over time in children with CP[23]. Its 88 items are scored on a four-point ordinal scale (0–3) across five dimensions: (A) lying and rolling; (B) sitting; (C) crawling and kneeling; (D) standing; and (E) walking, running and jumping. Dimension scores are converted to percentages and averaged to give a total score from 0 to 100, with higher scores indicating better gross motor function. Because dimensions A–C capture lying, sitting, kneeling and quadruped stability, the GMFM-88 suits children at GMFCS levels III–V, in whom standardised gross motor capacity measures track functional mobility[24]. GMFCS levels were taken from the clinical records[10].

To identify clinically meaningful change, each child was classified as showing improvement greater than 40% or improvement of 40% or less after six months, as recorded by the treating physiotherapist in each child's progress notes. This binary variable served as the clinician-rated indicator of improvement in postural control and gross motor function.

Statistical Analysis

Data were analysed with IBM SPSS Statistics (version 28). Continuous variables were presented as mean ± standard deviation (SD), and categorical data as frequencies and percentages. Normality of GMFM-88 scores was confirmed with the Kolmogorov–Smirnov test ($p = 0.200$). A paired-samples t-test compared pre- and post-treatment GMFM-88 scores, and the mean difference was reported with its 95% confidence interval (CI) and Cohen's d (mean change ÷ SD of change). The association between GMFM-88 change and the improvement category (>40% vs ≤40%) was examined with Pearson's correlation coefficient, which for a binary variable equals the point-biserial correlation. The proportion improving by more than 40% was compared between age groups (4–8 and 9–14 years) with the chi-square test. A p-value < 0.05 was considered significant.

Ethical Consideration

The study was approved by the Ethical Review Committee of Jinnah Medical and Dental College, Karachi (ERC Registration No. 00032523). Permission to use de-identified clinical records was obtained from each participating center. No identifying information was recorded, and the study followed the principles of the Declaration of Helsinki.

RESULTS

All 60 eligible children were included in the analysis. There were 32 boys (53.3%) and 28 girls (46.7%); 35 (58.3%) were aged 4–8 years and 25 (41.7%) were aged 9–14 years (Table 1).

Table 01. Participants Characteristics (n= 60)

Variable	Category	n (%)
Sex	Male	32 (53.3)
	Female	28 (46.7)
Age group	4–8 years	35 (58.3)
	9–14 years	25 (41.7)
GMFCS level	III–V	60 (100)
Improvement after 6 months	>40%	41 (68.3)
	≤40%	19 (31.7)

Values are presented as n (%). GMFCS: Gross Motor Function Classification System.

GMFM-88 scores were normally distributed (Kolmogorov–Smirnov, $p = 0.200$). The mean GMFM-88 score increased from 11.40 ± 11.27 at baseline to 44.90 ± 20.24 after six months, a mean change of 33.49 points (95% CI 29.40–37.59; $t(59) = 16.36$; $p < 0.001$; Cohen's $d = 2.11$) (Table 2; Figure 1A). Pre- and post-treatment scores were strongly correlated ($r = 0.625$; $p < 0.001$), indicating that children with higher baseline function generally remained

higher at follow-up. The larger SD at follow-up shows that children differed considerably in how much they gained.

Table 2. Within-Group Comparison of GMFM-88 scores (n = 60)

Parameter	Baseline (Mean ± SD)	After 6 Months (Mean ± SD)	Mean Change (95% CI)	t (df)	p-value	Cohen's d
GMFM-88 total score (%)	11.40 ± 11.27	44.90 ± 20.24	33.49 (29.40–37.59)	16.36 (59)	<0.001	2.11

Paired-samples t-test. Pre–post correlation r = 0.625 (p < 0.001); SD of change = 15.86. p< 0.05 was set as significance. GMFM-88: Gross Motor Function Measure-88.

GMFM-88 change showed a significant, weak-to-moderate positive correlation with improvement greater than 40% (r = 0.370; p = 0.004, two-tailed); children with larger GMFM-88 gains were more likely to reach the improvement threshold. Overall, 41 of 60 children (68.3%) improved by more than 40%. The proportion was 62.9% (22/35) among children aged 4–8 years and 76.0% (19/25) among those aged 9–14 years, a difference that was not statistically significant (χ^2 = 1.16; p = 0.281) (Table 3; Figure 1B).

Table 3. Improvement after Six Months by Age Group

Age Group	n	Improvement ≤40%, n (%)	Improvement >40%, n (%)	χ^2	p-value
4–8 years	35	13 (37.1)	22 (62.9)	1.16	0.281
9–14 years	25	6 (24.0)	19 (76.0)		
Total	60	19 (31.7)	41 (68.3)		

Pearson's chi-square test (without continuity correction). Significance set at p < 0.05.

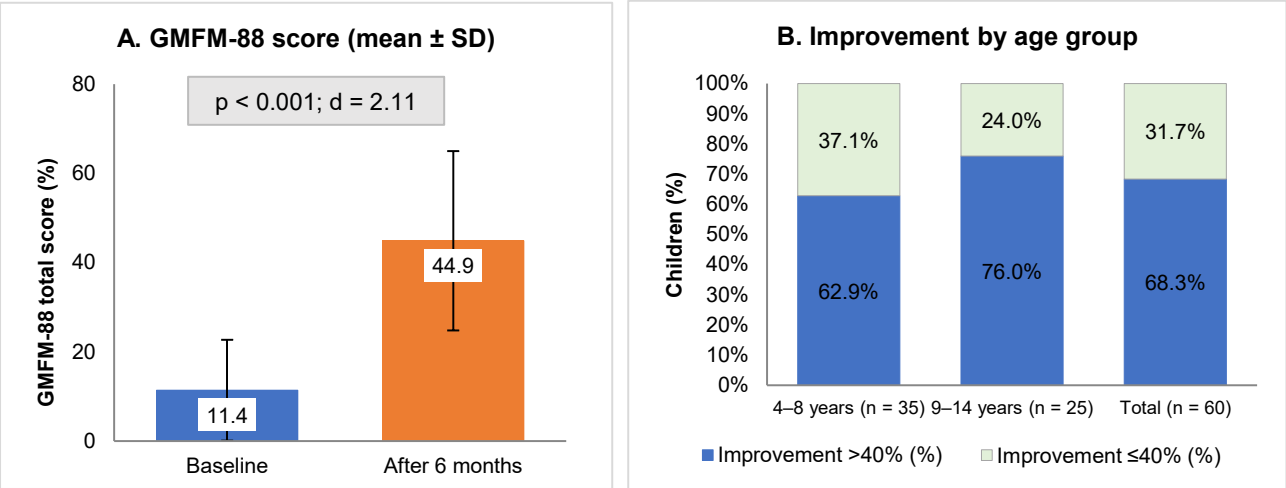


Figure 1. (A) Mean GMFM-88 total score at baseline and after six months of postural-control-focused physiotherapy (error bars show SD; n = 60). (B) Proportion of children improving by more than 40% and by 40% or less, by age group (χ^2 = 1.16; p = 0.281)

DISCUSSION

In this study, children with spastic CP at GMFCS levels III–V who received postural-control-focused physiotherapy improved markedly on the GMFM-88 over six months. The size of this change correlated positively with clinically meaningful improvement (r = 0.370), and about two-thirds of the children crossed the 40% threshold. Taken together, the findings point to a link between postural control training and gross motor gains in this severely affected group. The direction of these results matches studies that measured postural control directly. Vlčková et al. reported strong

correlations between trunk control and mobility, self-care and participation across all GMFCS levels[8], and Bosserman et al. found that early postural control measures predict later motor impairment[9], which suggests that postural control is a foundation for gross motor ability rather than a by-product of it. Ali, in contrast, found no relationship between spasticity and postural stability indices, even though spasticity was related to gross motor function[7]. Postural control may therefore shape motor outcome somewhat independently of tone. The present study inferred postural change from GMFM-88 data rather than measuring it directly, which is a weaker approach, but its findings point the same way.

Intervention research supports the same direction. Trunk-targeted programmes improved gross motor function, trunk control and balance in a review of 15 trials[13], and Lim et al. reported a pooled moderate effect on GMFM scores, with larger benefits when sessions were held more than four times a week[17].

Task-oriented and task-specific training improve GMFM scores and balance[14,25], exercise programmes that include trunk and head control training improve balance[15], core stability training has improved balance, standing and gait[16], and virtual reality-based balance training shows moderate pooled effects[26]. Closest to our sample, an eight-week core strengthening programme in children at GMFCS levels IV–V improved head and segmental trunk control with large effect sizes, although that study also had no control group[22]. Locally, positioning improved gross motor function in Pakistani children with spastic CP[18].

Even so, a mean gain of 33.5 GMFM-88 points is far larger than the changes usually reported in controlled trials, where pooled effects are small to moderate[17]. Children at GMFCS levels III–V reach about 90% of their predicted motor limit by around three years of age[10], so therapy alone is unlikely to explain the whole gain. Different assessors at the two time points, very low baseline scores and natural development may all have contributed. Because guidelines advise against passive approaches such as neurodevelopmental therapy[11,12], the content and dose of postural control programmes need to be reported clearly.

Age did not significantly influence improvement, although older children improved slightly more often. This runs against the motor development curves, in which younger children gain more[10], and probably reflects the small subgroups. During data collection, several children were seen to lose earlier gains after stopping therapy. In LMICs, distance, cost and caregiver burden predict poor use of rehabilitation[6], and limited family support weakens adherence to home programmes[27]. Structured family education and simple home-based postural routines could help children keep what they gain in the clinic.

Strengths and Limitations

This study focused on children at GMFCS levels III–V, who are under-represented in research, used a validated outcome measure and drew data from four centres. Its limitations are important. Postural control was not measured with a standardised tool; the improvement category came from clinicians' progress notes, which may have been informed by the same GMFM-88 assessments, so the correlation may partly reflect shared measurement. The record-based design without a control group cannot show that therapy caused the improvement. Purposive sampling, exclusion of children who stopped treatment and different assessors may have introduced selection and measurement bias, and GMFCS level, CP distribution, therapy dose and home programmes were not controlled.

Recommendations

Future studies should use prospective controlled designs with blinded assessors, a direct trunk control measure such as the Segmental Assessment of Trunk Control, and clear reporting of therapy content and dose. In practice, family education, home-based postural programmes and sitting postural management for children at GMFCS levels IV–V may help to sustain gains[19,20].

CONCLUSION

Children with spastic CP at GMFCS levels III–V who received postural-control-focused physiotherapy made significant gross motor gains over six months, and the size of these gains was positively correlated with clinically meaningful improvement, irrespective of age group. Structured postural control training may be considered a routine part of their rehabilitation. Prospective controlled studies with direct postural control measures, blinded assessment and longer follow-up are needed to confirm these findings.

Author Contributions

ERKG: Conception and design, supervision, and manuscript writing
SWA: Methodology, statistical analysis, and critical review
MS: Data collection and data entry

SB: Data collection and literature search
HB: Data interpretation, manuscript editing, and final approval

Conflict of interest
The authors declare no conflict of interest.

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Data availability
The de-identified dataset is available from the corresponding author on reasonable request.

Ethical approval
Approved by the Ethical Review Committee of Jinnah Medical and Dental College, Karachi (ERC Registration No. 00032523).

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