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EFFECTIVENESS OF DEVELOPED INTERACTIVE PLAY MAT IN PEDIATRIC PHYSICAL THERAPY

Original Research

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ABSTRACT

Background: Delayed milestones, particularly in gross motor development, impede a child's ability to achieve age-appropriate physical independence, including standing and walking. These delays significantly affect a child's participation in daily activities, social engagement, and long-term academic success. In pediatric populations, especially those diagnosed with conditions like cerebral palsy, early intervention remains critical for optimizing developmental trajectories and enhancing quality of life.

Objective: To assess the effectiveness of a developed interactive play mat in improving gross motor function and social interaction in children with delayed milestones or cerebral palsy.

Methods: This quasi-experimental study was conducted over six months at CRC-CMATH, Lahore. A total of 54 children aged 2 to 4 years were recruited using purposive sampling. Participants were clinically diagnosed with delayed motor milestones or cerebral palsy and met inclusion criteria including the ability to follow simple instructions. Children with severe cognitive impairment, sensory processing disorders, or conditions like spina bifida were excluded. Each child underwent a six-week intervention program consisting of three sessions per week using the interactive play mat, which incorporated haptic feedback, sound, and visual cues to facilitate movement. Outcome measures included the Gross Motor Function Classification System (GMFCS) Family Report Questionnaire and the Child Interaction Observation Questionnaire, both assessed pre- and post-intervention. Statistical analysis was performed using paired sample t-tests.

Results: The mean score on the GMFCS Family Report Questionnaire improved significantly from 4.67 ± 0.476 to 3.72 ± 0.627 ($p < 0.001$), indicating better gross motor function. Similarly, the Child Interaction Observation score improved from 1.46 ± 0.503 to 2.30 ± 0.571 ($p < 0.001$). Interaction levels increased from 0% high interaction at baseline to 35.19% post-intervention, and independent sitting rose from 33.33% to higher functional levels.

Conclusion: The interactive play mat significantly improved gross motor skills and social interaction in children with developmental delays and cerebral palsy. This intervention demonstrates strong potential as an engaging and effective tool in pediatric physical therapy.

Keywords: Cerebral Palsy, Child Development, Delayed Milestones, Motor Skills Disorders, Pediatric Rehabilitation, Physical Therapy Modalities, Play and Playthings

INTRODUCTION

Developmental milestones in children, such as independent standing and walking, form the foundation of gross motor skills and are critical for autonomy, social engagement, and academic readiness. However, a significant proportion of children experience delays in attaining these milestones, leading to a cascade of challenges that extend beyond motor development. Delayed motor milestones hinder physical independence, limit participation in daily activities, and often impair cognitive and social growth (1,2). In Pakistan, it is estimated that 15–30% of children are affected by developmental delays, with a higher prevalence seen among socioeconomically disadvantaged families. These delays are frequently exacerbated by factors such as maternal depression, poor early-life stimulation, and undernutrition—highlighting a multifactorial public health concern (3,4). Globally, 10–15% of children are reported to have developmental delays of varying severity, affecting postural control, balance, and coordination. Early detection and intervention remain the most critical strategies to mitigate the long-term impact of these delays, especially when implemented during the crucial neurodevelopmental window of 0–3 years (5-7). Despite existing early intervention frameworks, current rehabilitation practices often fall short in engaging children effectively, particularly those with limited attention spans or reduced sensory responsiveness. There is a pressing need for innovative and engaging therapeutic tools that can support conventional physiotherapy and maximize developmental outcomes.

Parents play an integral role in the early recognition of atypical development. Their insights into their child's communication, behavior, and motor performance often lead to timely consultations with healthcare providers, facilitating prompt diagnosis and intervention. Studies have consistently shown that early therapeutic engagement improves physical and cognitive outcomes and fosters better social integration and academic performance in later years (3,4,8). Yet, despite the proven benefits of early intervention, the limited availability of engaging, accessible tools remains a barrier—especially in resource-constrained settings. In recent years, the integration of technology into pediatric rehabilitation has gained traction. Haptic feedback, for instance, has emerged as a promising sensory stimulation technique that can enhance motor learning and promote engagement during therapy (9). Interactive play mats incorporating visual, auditory, and tactile stimuli are among the novel interventions designed to address this gap. These mats utilize vibration-based feedback, dynamic lighting, and sound to encourage movement, weight-bearing, balance training, and motor initiation in children with developmental delays. Research suggests that combining conventional therapy with such technological enhancements can facilitate quicker acquisition of gross motor skills, particularly among children who are otherwise disengaged from traditional rehabilitation exercises (3,5,10).

While a growing body of literature supports the use of interactive tools for children with sensory and motor impairments—including those with cerebral palsy or developmental coordination disorders—most existing technologies are designed either for niche populations or lack comprehensive evaluation in broader pediatric physiotherapy settings (3,10-12). Furthermore, current interventions often overlook the therapeutic potential of parent-child interaction during therapy sessions, which is a critical component of developmental progress. Tools that promote caregiver involvement, responsiveness, and joint participation are thus essential for achieving holistic developmental gains (8, 13). To bridge this gap, a new interactive play mat has been developed that merges evidence-based physiotherapy principles with child-centered technological innovation. Designed specifically for children aged 2 to less than 4 years with delayed gross motor milestones, the mat integrates haptic vibrations, engaging sounds, and visually stimulating feedback to motivate purposeful movement. Its development is rooted in established theories of motor learning and aims to foster therapeutic interaction, enhance neuromuscular activation, and support early postural control in a playful, non-intimidating setting (6,11,14).

This study aims to assess the effectiveness of the newly developed interactive play mat in improving gross motor function—specifically independent standing and initiation of walking—among children with developmental delays. By evaluating both motor outcomes and therapeutic interaction levels using validated tools, the research seeks to generate evidence on the utility of this technology-based intervention in pediatric physical therapy. The overarching objective is to provide a low-cost, scalable, and engaging solution that complements traditional therapy and supports children in achieving critical motor milestones.

METHODS

This quasi-experimental study was conducted to evaluate the effectiveness of a newly developed interactive play mat in promoting gross motor function among pediatric patients with delayed milestones or cerebral palsy (CP). The research adhered to ethical standards and was approved by the Ethical Review Committee of Superior University, Lahore. The study was carried out at the Children Rehabilitation Center (CRC-CMATH), Lahore, over a period of six months from April to September 2024, following synopsis approval. Participants included children aged between 2 to 4 years, of both sexes, who had been clinically diagnosed with motor delays, including delayed milestones and cerebral palsy, and were able to follow simple verbal instructions. The purposive sampling technique was employed to recruit eligible participants. Children were excluded if they presented with severe cognitive impairments, significant comorbid medical

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conditions affecting mobility such as spina bifida, or sensory processing disorders that would interfere with the effectiveness of haptic feedback—an essential component of the intervention (15, 16).

The sample size was determined using the OpenEpi tool version 3.0, yielding a required sample of 54 participants in a single-group design. Informed consent was obtained from the parents or guardians of all enrolled children. The study procedure, its potential benefits, and risks were thoroughly explained prior to enrollment. Anonymity and confidentiality of all participants were strictly maintained throughout the study, and data were securely stored with access restricted to the research team only. All enrolled participants underwent a comprehensive baseline assessment. Demographic data were recorded, and initial outcome measures were documented using standardized tools. Gross motor function was assessed using the Gross Motor Function Classification System (GMFCS) Family Report Questionnaire, which allowed caregivers to classify their child's movement capabilities, including posture, sitting, and walking abilities. Additionally, interaction levels during therapeutic sessions were assessed using the Child Interaction Observation Questionnaire, focusing on responsiveness, communication, and engagement.

The intervention consisted of therapy sessions using the interactive play mat, which integrates visual, auditory, and haptic feedback designed to stimulate gross motor activity. The play mat sessions were administered three times a week over a period of six weeks. All sessions were supervised by qualified pediatric physical therapists, and the equipment was routinely checked for safety and optimal function. Post-intervention assessments were conducted using the same outcome tools to evaluate any improvements in gross motor function and therapeutic engagement. The collected data were then analyzed to determine the effectiveness of the interactive play mat as a supplementary tool in pediatric physical therapy.

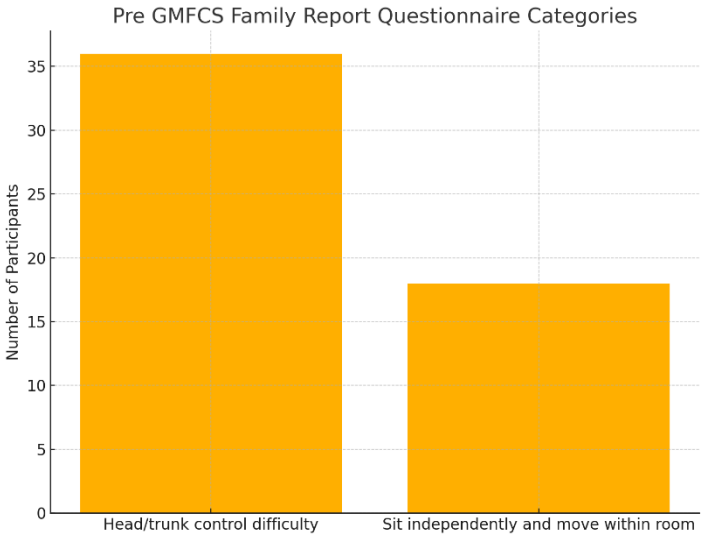
RESULTS

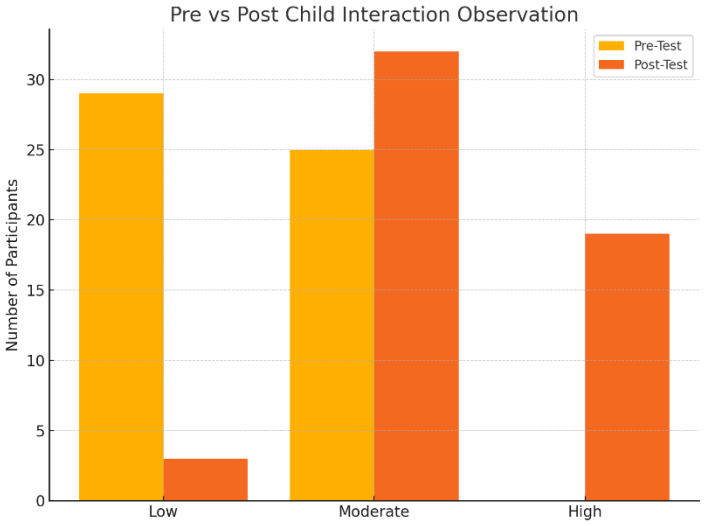
A total of 54 children aged between 2 to 4 years were included in this quasi-experimental study to assess the effectiveness of an interactive play mat in pediatric physical therapy. Among these participants, 21 children (38.89%) were aged between 2 years to 2 years and 5 months, 20 children (37.04%) were aged between 2 years and 6 months to 3 years and 4 months, and 13 children (24.07%) were aged between 3 years and 5 months to 4 years. Of the total participants, 30 (55.56%) were male and 24 (44.44%) were female. Regarding diagnosis, 46 children (85.19%) presented with delayed milestones and 8 children (14.81%) were diagnosed with cerebral palsy. The Shapiro-Wilk test confirmed the normal distribution of the data ($p > 0.05$), justifying the use of the paired sample t-test to evaluate within-group differences before and after the intervention. The analysis demonstrated a statistically significant improvement in interaction and gross motor function following the intervention. The mean score for the Child Interaction Observation Questionnaire increased from 1.46 ± 0.503 at baseline to 2.30 ± 0.571 post-intervention, with a significant correlation ($r = 0.696$) and p-value < 0.001. Similarly, the Gross Motor Function Classification System (GMFCS) Family Report Questionnaire mean score decreased from 4.67 ± 0.476 at baseline to 3.72 ± 0.627 after the intervention, indicating improvement in gross motor abilities ($p < 0.001$).

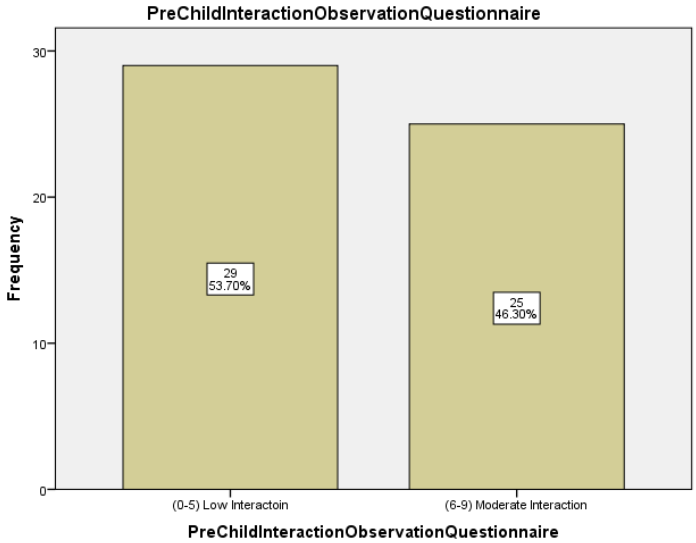
Categorical analysis of interaction levels revealed that prior to intervention, 29 children (53.70%) demonstrated low interaction, and 25 children (46.30%) demonstrated moderate interaction. Post-intervention, there was a marked shift, with only 3 children (5.56%) exhibiting low interaction, 32 (59.26%) showing moderate interaction, and 19 (35.19%) demonstrating high interaction. Assessment of pre-intervention gross motor abilities using the GMFCS Family Report Questionnaire showed that 36 children (66.67%) had difficulty controlling head and trunk posture in most positions, while 18 children (33.33%) could sit independently on the floor and move within a room.

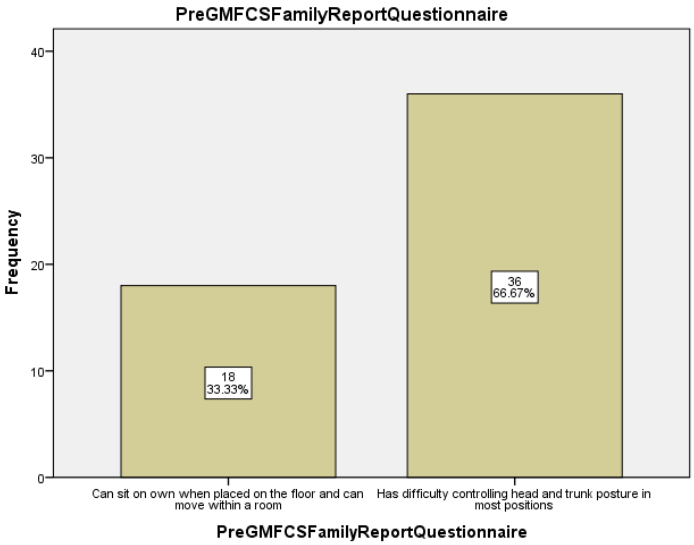
Pre-and post-treatment values, mean and St. deviation

Paired Samples Statistics						
		Mean	**N**	**Std. Deviation**	**Correlation**	**Sig. (2-tailed)**
Pair 1	Pre-Child Interaction Observation Questionnaire	1.46	54	.503	.696	.000
	Post-Child Interaction Observation Questionnaire	2.30	54	.571		
Pair 2	Pre-GMFCS Family Report Questionnaire	4.67	54	.476		
	Post-GMFCS Family Report Questionnaire	3.72	54	.627		









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DISCUSSION

The present study aimed to evaluate the effectiveness of an interactive play mat in improving gross motor skills—specifically independent standing and walking—in children with delayed milestones. The findings indicated a statistically significant improvement in both motor outcomes and child interaction levels following the six-week intervention using the developed play mat. By integrating tactile, auditory, and visual stimuli with haptic feedback, the intervention provided an engaging, multisensory environment that facilitated motor learning and promoted active participation among young children with developmental delays (17,18). The improvement in interaction levels, as measured by the Child Interaction Observation Questionnaire, supports the role of sensory-driven play in enhancing therapeutic engagement. A noticeable transition was observed, with a shift from predominantly low to moderate and high interaction levels post-intervention. Similarly, significant gains were observed in gross motor function, evidenced by a reduction in GMFCS levels after therapy. These outcomes align with earlier evidence demonstrating the benefits of interactive and technology-based interventions in pediatric motor rehabilitation. Studies involving virtual rehabilitation with haptic feedback have shown superior motor performance compared to conventional approaches, reinforcing the current study's approach in utilizing haptic sensory cues to stimulate and motivate motor responses (13, 19).

Previous research into interactive play mats has focused on various developmental domains, such as enhancing parent-child bonding or fostering exploratory behaviors in children with sensory impairments. Although these studies did not directly target gross motor improvement, they provided foundational support for the design and implementation of interactive mats in pediatric care. The current study expanded this scope by applying interactive technology specifically to gross motor skill acquisition and demonstrated that such devices can act as effective therapeutic adjuncts (20-22). While earlier studies have emphasized the importance of early detection and intervention for children at risk of developmental delays, this study contributes a practical and accessible strategy that fits within early rehabilitation protocols. The intervention not only supported skill acquisition but also appeared to indirectly benefit parental involvement, as therapy sessions created opportunities for caregivers to observe, understand, and support their child's motor development. Moreover, the interactive format of the play mat potentially addressed challenges related to limited attention spans, often seen in this population, by offering a playful yet structured therapeutic environment (23-26).

Another noteworthy aspect is the alignment between the findings and previous literature advocating for therapy intensity and consistency. The three-times-per-week intervention frequency in the current study was consistent with prior findings that more frequent therapeutic engagement correlates with better motor outcomes. Introducing an interactive tool that sustains attention and motivation may have enhanced the quality of therapeutic engagement, especially in children less responsive to conventional therapy (27). The study carries important clinical implications for pediatric physiotherapy. The interactive play mat proved to be a valuable complement to traditional therapy approaches, particularly in cases where children may require additional sensory stimulation to initiate and maintain purposeful movement. Therapists may also consider integrating similar multisensory tools into broader rehabilitation frameworks to enhance motivation and therapeutic impact (8, 28).

Despite its strengths, the study had some limitations. The quasi-experimental design without a control group limits causal inference, as improvements could be influenced by confounding factors unrelated to the intervention. The sample size was relatively small, and participants were selected via purposive sampling from a single center, potentially affecting the generalizability of the findings. Additionally, long-term outcomes were not assessed, which restricts conclusions regarding the sustainability of observed gains (29). Future research should explore randomized controlled trials with larger, more diverse samples to validate these findings. Investigations into the optimal duration, intensity, and frequency of play mat-based interventions could further refine therapeutic protocols. It would also be beneficial to analyze the specific sensory components—such as the type of haptic feedback or auditory stimuli—that contribute most significantly to motor improvement. Moreover, longitudinal studies could determine whether early interventions using interactive play mats have lasting effects on motor skill acquisition, functional independence, and participation in daily activities (12, 21).

The study provided compelling evidence that the use of a structured, interactive play mat incorporating haptic and multisensory stimuli significantly enhances gross motor function and therapeutic engagement in children with delayed developmental milestones. This approach offers a promising, child-friendly adjunct to conventional pediatric physical therapy and underscores the importance of early, engaging, and evidence-based interventions in optimizing developmental outcomes.

CONCLUSION

The findings of this study conclude that the interactive play mat proved to be an effective tool in enhancing gross motor abilities and therapeutic engagement among children with delayed milestones. By integrating multisensory elements such as haptic feedback, sound, and visual cues, the intervention created a stimulating environment that supported purposeful movement and meaningful interaction. This sensory-rich approach offers a valuable addition to conventional pediatric physical therapy, particularly for children who require more engaging and motivating strategies. The study underscores the potential of interactive technologies to support early motor

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development and highlights the importance of integrating innovative, child-centered tools into rehabilitation practices to help children reach their full developmental potential.

AUTHOR CONTRIBUTION

Author	Contribution
Gulnaz Yamin	Conceptualization, Methodology, Formal Analysis, Writing - Original Draft, Validation, Supervision
Suriyakala Perumal Chandran	Methodology, Investigation, Data Curation, Writing - Review & Editing
Kainat Fatima	Investigation, Data Curation, Formal Analysis, Software
Zohaib Shahid	Software, Validation, Writing - Original Draft

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