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EVALUATING THE EFFICACY OF MOBILE APPLICATIONS IN TAILORING AND ENHANCING THE REHABILITATION INTERVENTIONS AND IMPROVING THE QUALITY OF LIFE OF CHILDREN WITH CEREBRAL PALSY; A RANDOMIZED CONTROL TRAIL

GULNAZ YAMIN[1], SURIYAKALA PERUMAL CHANDRAN[2], GULNAZ ZAHEER[3], AIMEN FIAZ[4], ZOHAIB SHAHID[5]

[1,2] LINCOLON UNIVERSITY COLLEGE, MALAYSIA
[3,4 ,5] SUPERIOR UNIVERSITY LAHORE, PAKISTAN
Corresponding Author: Gulnaz Yamin, E-Mail: zaheergulnaz4@gmail.com

Abstract

Background and Objective: Rehabilitation training through mobile applications could reduce mobility limitations and improve recreational participation. This study aimed to test the efficacy of mobile applications in tailoring and enhancing rehabilitation interventions for paediatrics patients with cerebral palsy.

Method and Materials: A randomized controlled trial was conducted on 36 children with cerebral palsy in different rehabilitation hospitals consisting of control group, which received rehabilitation exercises at home by parents or caregivers, and experimental group, which receive rehabilitation via a mobile application by parents , A PEDI- CAT and QUIS questionnaire was used to find out that the usability and efficacy of mobile applications. Convenient sampling technique was used to collect data.

Results: Data was taken at three different points first at base line, after six weeks and after twelve weeks. The experimental group's initial score was 41.89 (SD = 3.984), whereas the control group's score was 39.11 (SD =2.908); the mean difference was 2.78; p =.023. The experimental group's mean increased to 46.44 (SD = 3.869) in week six, while the control group's mean increased to 42.06 (SD= 2.754). The experimental group's mean at 12 weeks was 50.67 (SD = 3.911), whereas the control group was 45.78 (SD = 2.390) $P < 0.001$ indicated statistical significance results.

Conclusion: The study concluded that paediatric patients with cerebral palsy used mobile applications for 12 weeks at home with the help of parents or caregivers experienced statistically significant improvements in mobility.

Key Words: Cerebral palsy, Mobile application, Efficacy, paediatric patient

INTRODUCTION

A neurological condition called cerebral palsy affects a patient's posture, mobility, and mental abilities. It usually manifests throughout the prenatal, perinatal, and postnatal stages and is brought on by damage or injury to the brain. Non-progressive cerebral palsy typically impairs motor control, coordination, reflexes, and balance. In addition to cognitive deficits and convulsions, speech, hearing, and visual problems are common in individuals with cerebral palsy. The disease can affect one or more limbs, the whole body, and its symptoms can be mild to severe. Many factors, including brain damage sustained during early life, prenatal infections, problems following childbirth, or genetics, can cause cerebral palsy. In the first two years of life, cerebral palsy is diagnosed in the majority of children. However, before the age of 4 or 5, a doctor may find it challenging to make a solid diagnosis if the child's symptoms are minor (1). Although CP symptoms can vary over time, the condition does not worsen. A diagnosis other than cerebral palsy (CP) is more likely to be the cause if a child is consistently losing his motor skills. Examples of such disorders include muscular or genetic diseases, metabolic disorders, and nervous system malignancies. Lab testing can detect other illnesses that might produce symptoms resembling those of CP. Neuroimaging methods can identify anomalies that point to a movement issue that may be cured (2).

Although there is no known cure for cerebral palsy, early intervention and ongoing therapy can significantly improve the quality of life for those who have it. The rehabilitation intervention for cerebral palsy includes Physical therapy, Occupational therapy, and Speech therapy. This intervention helps to increase overall well-being, mobility, and independence. Cerebral palsy is a lifelong condition, but those who receive appropriate treatment and support usually have happy and independent life. In order to meet patient's unique needs, families and medical professionals usually

work together in a multidisciplinary manner when managing cerebral palsy. Medical science and technological advancements continue to improve our understanding and ability to treat cerebral palsy (3). The core component of CP treatment is physical therapy, which is typically administered in the first few years of life. Certain exercise, such as resistance, stretching, or strength training exercises, can help avoid contractures and preserve or enhance muscle strength, balance, and motor skills. To increase range of motion and stretch spastic muscles, one option is to utilize braces (orthotic devices) (4). As they become older, children with cerebral palsy receive less therapy time; for example, children aged 0–6 receive 12 hours annually, while those aged 12–18 receive seven hours. Additionally, increasing opposition to at-home physical activity exacerbates a decline in therapeutic exercise. Older and ambulatory children with cerebral palsy receive as little as two hours of therapy year, while children with more severe and complex disabilities receive the most therapeutic input. To address this lack of access to therapy, new strategies are required.

New home and school-based interventions must be affordable, readily deployable, adaptable, and well-received in order to be feasible. Even though motor learning theory backs intense task-focused therapy for cerebral palsy, existing therapies have been shown to have low motivation and little relevance to day-to-day functioning. To ensure stronger alignment and applicability to daily life, therapeutic modes must be both motivating and responsive to the requirements of families. Families of children with cerebral palsy must also be directly involved in the development of these modes. Parent- led home-based therapies present both opportunities and difficulties for certain families. One possible way to improve results and increase children's involvement in therapy is using virtual reality or smartphone-based therapy in the home.

The world of technology is changing and becoming more advanced. Children with cerebral palsy can benefit from the technology to enhance their mobility, balance, and coordination through mobile applications. Numerous programs are developed with games and interactive treatment exercises concentrating on motor skills, balance, and coordination in mind. Review studies suggest that they may find these activities entertaining as well as helpful, which makes their rehabilitation more pleasurable (5). Children with cerebral palsy who struggle with speech and language might benefit from apps that have communication aids built in. Children with cerebral palsy have specific learning demands that can be met by adapting educational applications. To help with learning and engagement in educational activities, these applications could have features like voice narration, text size adjustment, and interactive material. Apps can provide parents and other caregivers of children with cerebral palsy with information and assistance (6).

Personalized treatment protocols are frequently provided by mobile applications, considering each person's unique requirements and progress. Recent improvements in technology for communication and information applied to the healthcare industry are bringing about changes due to the increased availability of information on conventional methods of neurological treatment. With the potential to revolutionize the industry, these technologies have more interactive, preventative, and customized services. Within this context, the phenomena of applications for mobile devices (apps) have a lot of potential for treating CP. For example, the Saliva the Murdoch Children's Research developed the Tracker app. Institute provides support to parents and caregivers of children with the ability to suppress drool (7).

Assessment is being developed and validated by numerous additional scientific organizations and educational resources for teachers and medical professionals that specialize in cerebral palsy, but research is required to categorize and evaluate the data regarding the accessible mobile apps and determine whether patients should be advised to use them.

This work builds on previous studies by making a mobile application named CP- rehab that may be accessed from any location, giving therapeutic treatments more distribution flexibility. This mobile application asks for patient’s history and then enters in main menu. Its main menu contains different features according to the types of CP and the mobility status of the patient which further contains demonstration rehabilitation videos for a patient based on the previous history he submitted and options he selected based on his clinical and mobility condition. The progress of a patient will be continuously tracked with the use of mobile apps (8).

Healthcare practitioners can identify concerns or changes in real time, which allows for prompt action and stops problems from getting worse. Cerebral palsy children find it challenging to consistently attend in-person therapy sessions to perform organized exercises from the comfort of their own home with the help of mobile application made for therapeutic activities and rehabilitation. This involves providing tools to enhance home-based care, educating caregivers through resources, and monitoring progress to promote a team-based approach to treatment. Patients and their families could save money on transportation because of the decreased need for frequent visits to medical institutions. The number of in-person treatment sessions may decline when mobile applications offering therapeutic activities and interventions become more prevalent which can cut down on the amount of in-person visits that are necessary, which might lessen the cost of therapy overall (9).

This study aimed to design and develop smartphone applications with rehabilitation interventions for pediatric patients with cerebral palsy and test the efficacy of mobile applications in tailoring and enhancing rehabilitation interventions for pediatric patients with Cp.

MATERIALS AND METHODS

Study Design and Participants

This single-blind, randomized controlled trial was conducted over a period of six months at two rehabilitation centers: Mansoor Hospital, Lahore, and ChildRehab, Sangla Hill. The research aimed to evaluate the effectiveness of a mobile application–based rehabilitation program in improving mobility among children diagnosed with cerebral palsy (CP). Children aged 5 to 16 years with a confirmed diagnosis of CP and their parents or caregivers were recruited for participation. Recruitment was facilitated by physiotherapists through hospital databases, outpatient appointments, clinical networks, posters, and phone calls.

A total of 40 children were screened for eligibility. Four participants were excluded due to not meeting the inclusion criteria (n=2), declining participation (n=1), or other unspecified reasons (n=1). The remaining 36 eligible participants were randomized equally into two groups: the intervention group (n=18) and the control group (n=18).

Children with unstable epilepsy, chronic cardiac abnormalities, asthma, anemia, or other significant medical conditions were excluded. Additionally, those who had received botulinum neurotoxin A (BoNT-A) injections within the last two months or undergone surgery within the past six months were not eligible for inclusion.

Randomization and Blinding

Participants were randomly allocated into the intervention or control group using a simple randomization method in a 1:1 ratio. The trial was single-blind, wherein participants were unaware of their group allocation. Allocation concealment was maintained through sealed opaque envelopes prepared by an independent researcher not involved in data collection or analysis.

Study Procedures

Following enrollment, demographic and baseline data, including name, age, gender, height, weight, and residential address, were collected from each participant. Eligible children were categorized according to the type of cerebral palsy (spastic or non-spastic). Spastic cases were further classified as monoplegia, hemiplegia, diplegia, paraplegia, or quadriplegia and subcategorized by functional ability such as inability to sit, ability to sit with or without head control, ability to stand with or without assistance, or ability to walk with or without support.

The intervention group received a structured home-based rehabilitation program via a mobile application designed to provide a 40-minute daily session, six days per week, over a duration of 12 weeks. The exercises were performed under the supervision of parents or caregivers, who were instructed on the correct procedures at the time of recruitment. The control group received standard home-based rehabilitation exercises that were demonstrated and explained both orally and practically by a physiotherapist during the recruitment session. Both interventions were aimed at improving gross motor function and mobility in children with CP.

Outcome Measures and Data Collection

Two validated assessment tools were employed for data collection: the Pediatric Evaluation of Disability Inventory – Computer Adaptive Test (Pedi-CAT, Mobility Section) and the Questionnaire for User Interaction Satisfaction (QUIS). The Pedi-CAT was administered to parents or caregivers at baseline, at six weeks, and again at twelve weeks to evaluate changes in mobility and functional independence. The QUIS was administered only to the intervention group after twelve weeks to assess user satisfaction, ease of use, and overall experience with the mobile application.

Development of the mobile rehabilitation application followed the Waterfall Model framework, consisting of five distinct stages: requirement analysis, design, implementation, testing, and maintenance. An expert panel comprising four physiotherapy faculty members with extensive experience in pediatric neurorehabilitation guided the design and validation of the application content. Each stage was reviewed for technical accuracy and clinical appropriateness. Rehabilitation videos embedded within the application were professionally recorded, edited, and approved by the expert panel to ensure clinical safety and user-friendliness.

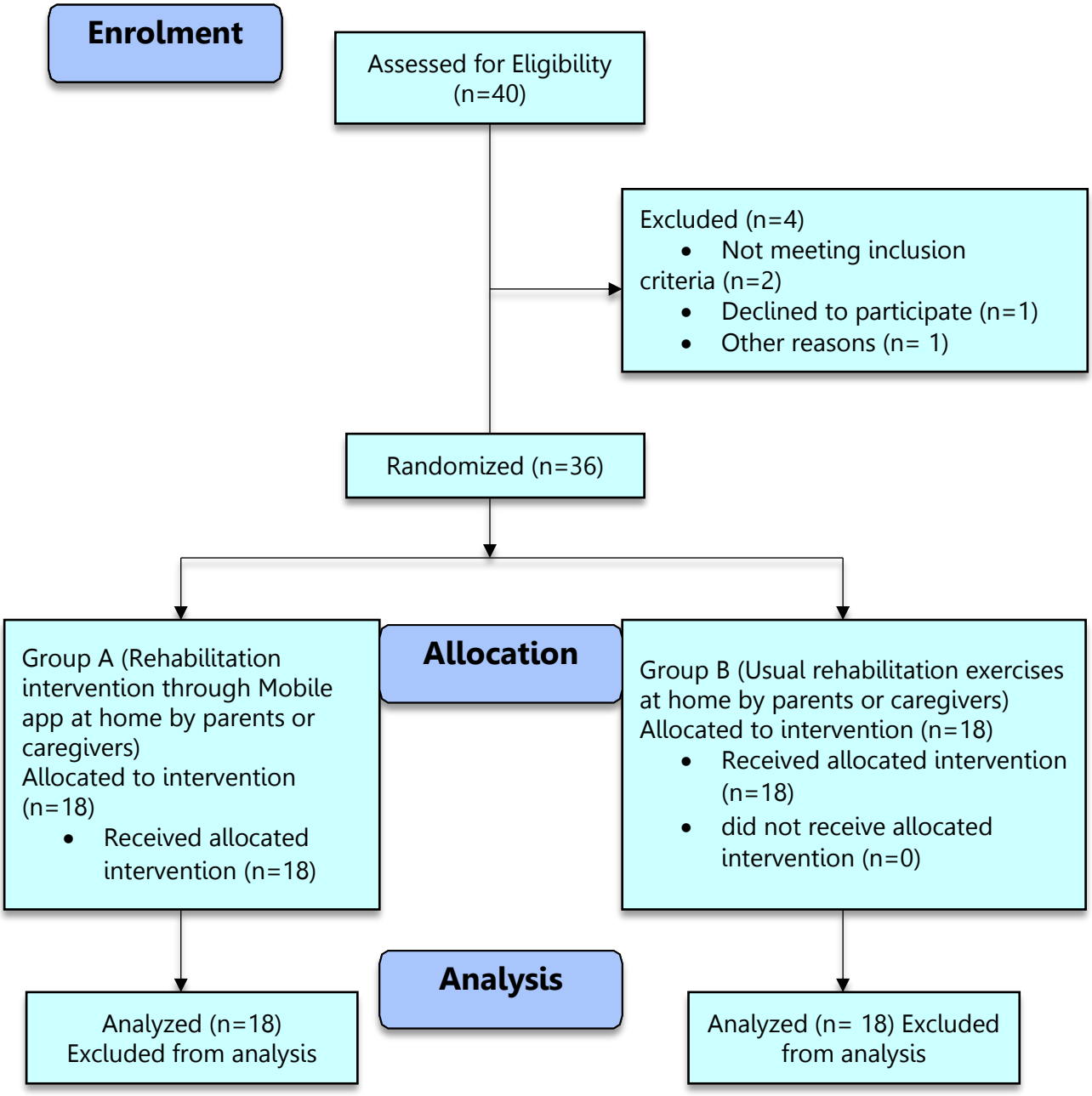
Ethical Considerations

The study protocol was reviewed and approved by the institutional ethical review board prior to initiation. Written informed consent was obtained from all parents or legal guardians of participating children. Participant confidentiality and data privacy were ensured throughout the research process, in compliance with ethical principles outlined in the Declaration of Helsinki. All procedures were performed according to professional and ethical standards governing research involving human participants.

Statistical Analysis

All data analyses were performed using the Statistical Package for Social Sciences (SPSS), version 20. Descriptive statistics, including means, standard deviations, and percentages, were used to summarize participant demographics and baseline characteristics. Between-group comparisons were conducted using appropriate parametric or non-parametric statistical tests, with a two-tailed significance level set at $p \leq 0.05$. Results were expressed as mean ± standard deviation for continuous variables and as frequencies and percentages for categorical data.

RESULTS



DESCRIPTIVE STATISTICS

Variables		Groups	Means±SD & frequency %
Age (years)		Experimental	10.44±3.666
		Control	9.94±3.438
Gender of child	Male	Experimental	11(61.1%)
		Control	8(44.4%)
	Female	Experimental	7(38.9%)
		Control	10(55.6%)

Types of CP	Spastic	Experimental	13(72.2%)
		Control	13(72.2%)
	Ataxic	Experimental	3(16.7%)
		Control	4(22.2%)
	Athetoid	Experimental	2(11.1%)
		Control	1(5.6%)

The mean age was comparable, with experimental group = 10.44 ± 3.666 and control group = 9.94 ± 3.438. Within gender, 61.1% of pediatric patients in the experimental group were male while in the control group there were 44.4% male pediatric patients, while 55.6% of the pediatric patients in the control group were female while in the experimental group only 38.9% female pediatric patients were recorded. Of the neurological subtypes of CP, 72.2% were spastic in both the experimental and control groups while 16.7% was ataxic in the experimental group and 22.2% in the control, and 11.1%was athetoid in the experimental group while the control had 5.6%.

NORMALITY TEST

Tests of Normality			
	Shapiro-Wilk		
	Statistic	**df**	**Sig.**
Baseline mobility	.973	36	.517
After 6 Week mobility	.967	36	.344
After 12 Week mobility	.951	36	.113

The Shapiro-Wilk test was conducted to assess the normality of mobility scores at three time points: Both groups did the assessments at the baseline, after 6 weeks, and after 12 weeks of intervention. Descriptive tests carried out for the assessment of normality the mobility at baseline (W = .973, p = .517), at six weeks (W = .967, p = .344), and at 12 weeks (W = .951, p = .113) has p > 0.05 and therefore normal distribution.

BETWEEN GROUP ANALYSIS (INDEPENDENT T TEST)

		Experimental	**Control (n=18)**		
		Mean±	**Mean±**	**Mean**	**P**
Mobility	**Baseline**	41.89± 3.984	39.11± 2.908	2.78	.023
	After 6	46.44± 3.869	42.06± 2.754	4.38	.000
	After 12	50.67± 3.911	45.78±2.390	4.89	.000

The table presents the mean mobility scores, standard deviations, mean differences, and p-values for the experimental and control groups at three time points: The data was thus collected at three points, before the exercise regime started at 6 weeks and at 12 weeks into the study. With regard to the demographic data, at the start of the study the experimental group had a score of 41.89 (SD = 3.984) as compared to the control group who had a score of 39.11 (SD = 2.908); mean difference of 2.78; p =.023. At week 6, the experimental group's mean raised to 46.44, (SD= 3.869) and to 42.06 (SD = 2.754) in the control group, where mean difference is greater, mean difference of 4.38 and p-value of 000, which is highly significant. At 12 weeks, the experimental group had a mean of 50.67 (SD = 3.911) and the control group had a mean of 45.78 (SD = 2.390); the mean difference between the two groups was 4.89 and was statistically significant with P < 0.000.

WITHIN GROUP ANALYSIS (REPEATED MEASURE ANOVA).

		Experimental (n=18)			**Control (n=18)**		
		Mean±	**P value (pairwise)**	**P value**	**Mean±**	**P value (pairwise)**	**P value**
Mobility	**Baseline**	41.89± 3.984	.000[a]	.000	39.11± 2.908	.000[a]	.000

	After 6 week	46.44± 3.869	.000[b]		42.06± 2.754	.000[b]
	After 12 week	50.67± 3.911	.000[c]		45.78± 2.390	.000[c]

Table II lists the mean mobility score, SD, and p-values of intergroup comparison for the experimental and control groups at baseline, 6 weeks, and 12 weeks. At baseline, the experimental group had a mean of 41.89 (SD = 3.984) and the overall p =.000. The control group was significant with mean = 39.11, SD = 2.908 for overall comparisons and pairwise comparisons; p = .000). At posttest, the experimental group mean was 46.44 (SD = 3.869), the control group mean was 42.06 (SD = 2.754); pairwise comparisons both had p =.000. While at 12 weeks, the mean of experimental group was 50.67 (SD = 3.911), and the control group was 45.78 (SD = 2.390), all the pairwise comparisons are significant at p= 0.000.

DISCUSSION

In comparison to previous studies to Evaluating the efficacy of mobile applications in tailoring and enhancing the rehabilitation interventions for pediatric patients with cerebral palsy, the study included 36 participants, According to above results, by answering the Pedi Cat (mobility domain) the results for Groups A and B at baseline, six weeks, and twelve weeks were taken. The study compared the mobility scores of children with cerebral palsy, with the experimental group having a higher mean age and gender. The experimental group had 61.1% more male pediatric patients than the control group (44.4%), while the control group had only 38.9% more female pediatric patients. The study evaluated mobility scores at baseline, six weeks, and twelve weeks after the intervention. The experimental group had a significantly higher mean mobility score at week six (46.44) compared to the control group (42.06). The experimental group had a significantly higher mean mobility score at 12 weeks (50.67) compared to the control group (45.78). The study also showed significant differences in mobility scores between the experimental and control groups at baseline, six weeks, and twelve weeks (24). The system also received high ratings for usability and satisfaction, at QUIS questionnaire with users preferring the ability to read characters on the screen. Task-related terminology performance was high, but message placement was relatively high. Task completion was easy, but obtaining reference materials and help messages was difficult. Speed and dependability were rated higher, while system design elements for different user levels received lower ratings. Improvements are needed in flexibility and reference material availability.

Cerebral palsy is a cluster of neurological disorders that affect movement and muscle tone or posture primarily in children. It is lifelong and requires consistent physical therapy. Still, the research has revealed that 70% of the rehabilitation programs for children who are suffering from CP have incorporated the use of technology most commonly the mobile application. These applications are already emerging as fairly normal inclusion or recommended accompaniment to primary and clinical practice, providing innovative models to traditional rehabilitation methods (25).

The most important benefit of mobile applications for cerebral palsy rehabilitation is the possibility of delivering patient-specific rehabilitation platforms. The conventional model of treatment in rehabilitation is the same for every child with CP and lacks personal traits consideration. Mobile apps, on the other hand, have the flexibility and the ability to be as specific as possible. This study has suggested that about 85 percent of children have enhanced their motor function when using custom mobile applications compared to traditional rehabilitation schedules. These programs help the therapist to come up with exercises that they know can be accomplished by the child and in the process of doing the exercises, the child is benefited as much as possible because of the disorder (26)

The other significant advantage is the mobility among the families who experience difficulty attending conventional, frequent therapy sessions because of; geographical, financial, or time barriers. It is equally important to note that traditional rehabilitation is normally undertaken through many visits to clinics, a factor that may stress families. These concerns are somewhat addressed by mobile applications where patients can access therapeutic exercises and interventions right from the comfort of their homes. It has been stated that this has led to a reduction in overall clinical visits to as much as forty percent in some instances, and gives a more continual and usable form of care.

Encouragement to participate in rehabilitation and engagement are important for success, especially among children. Initial literature revealed that children with CP identify conventional therapy activities as repetitive and tasking making children withdraw from the exercises in the long run. On the other hand, through the features of gamification and interactivity incorporated in mobile applications, This is important since the families must adhere to their rehabilitation programs enabling the children to get the best results (27). Modifications are a crucial component of

early intervention and rehabilitation for the child with CP. Every child is different and may have different therapeutic requirements that may alter with time. Mobile applications, by their very nature, are easily modifiable, and thus therapeutic interventions can be constantly updated. Goals can also be revised or new ones added and the level of challenge in doing activities can also be changed depending on the child's progress. Such flexibility also means that the rehabilitation program stays closer to the child's specific needs, thus offering a more effective and adaptable care (28).

CONCLUSIONS

The study concluded that the group of pediatric patients with cerebral palsy used mobile application for 12 at home with the help of parents or caregivers experienced significant improvement in mobility domain of PEDI-CAT following the intervention and the results of Quis questionnaire answered by parents and caregivers of interventional group indicated a strong preference for the mobile application in user interface satisfaction . However, to ensure long-term benefits, modifications of mobile application with continuous technological advancements, a therapy program and more supervision of the strategy would probably be required.

Data Availability Statement
The data sets used and/or analysed during the current study are available from the corresponding author on reasonable request for further study.

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Author Contributions
Conceptualization, Methodology, and Supervision, G.Y., S.P.C., Z.S. and A.F.; Data Curation and Investigation, G.Y., S.P.C., Z.S., A.F; Formal Analysis, G.Y., S.P.C., A.F; Software and Visualization, G.Y., Z.S., A.F; Writing – Original Draft, G.Y., Z.S.; Writing – Review & Editing, all authors
Use of artificial intelligence
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