The Research of Medical Science Review
ISSN: 3007-1208 & 3007-1216 Volume 4, Issue 2, 2026

ADOPTION AND PERCEPTIONS OF GAMIFICATION-BASED PHYSIOTHERAPY IN PEDIATRIC NEURODEVELOPMENTAL DISORDERS: A CROSS-SECTIONAL STUDY

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DOI: https://doi.org/10.5281/zenodo.18859359

Keywords
Gamification, pediatric neurorehabilitation, physiotherapy, adoption, digital rehabilitation, neurodevelopmental disorders

Article History
Received: 29 December 2025
Accepted: 13 February 2026
Published: 28 February 2026

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Abstract

Introduction:
Rehabilitation using gamification has become one of the promising strategies of enhancing the level of engagement, motivation, and adherence in children with neurodevelopmental disorders (NDDs). Although increased evidence is provided around the world, regarding its effectiveness, its use in clinical practice is still dependent on readiness and contextual factors, especially in low- and middle-income countries, such as Pakistan

Objective:
This study aimed to examine the adoption and perceptions of gamification-based physiotherapy among practitioners managing pediatric neurodevelopmental disorders in Karachi and to identify key predictors influencing adoption.

Methods:
A quantitative study, cross-sectional in nature, was conducted on licensed physiotherapists who were actively working in hospitals, rehabilitation centers, private clinics and academic institutions, across Karachi. A total of 278 participants took part in the study through convenience sampling of the Gamification Adoption Readiness Scale that was based on the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT). Analysis of the data was done using SPSS version 25. Participant characteristics were summarized using descriptive statistics, Pearson correlation and multiple linear regression tests were done to determine relationships and predictors of adoption. The statistical significance was determined as p 0.05.

Results:
Only 12.6% of participants reported formal training in digital or gamified rehabilitation. Correlation analysis demonstrated significant positive associations between barriers and adoption ($r = .318$, $p < .001$) and between barriers and facilitation factors ($r = .677$, $p < .001$). Perception was not significantly associated with adoption ($r = —.002$, $p = .968$). Multiple linear regression revealed a significant overall model ($F(3,274) = 13.626$, $p < .001$), explaining 13% of variance in adoption ($R^2 = .130$). Barrier score was the

strongest predictor (β = .479, p < .001), while facilitation score showed a significant negative association (β = −.213, p = .006); perception was not a significant predictor.

Conclusion:

The adoption of gamification-based physiotherapy is not only dependent on perception but also mainly on contextual and organizational factors. Enhancing institutional support, professional growth, and resources provisioning cannot be underestimated in making gamified rehabilitation a part of the pediatric physiotherapeutic practice.

INTRODUCTION

Neurodevelopmental disorders (NDDs) have a wide spectrum of conditions developed through the developmental period resulting in personal, social, academic, or occupational problems. Such disorders encompass typical diseases, which are autism spectrum disorder (ASD), attention-deficit/hyperactivity disorder (ADHD), developmental coordination disorder (DCD), and intellectual disabilities (ID), including Down syndrome. Altogether, NDDs have a significant worldwide impact, with such conditions as ASD and ADHD posing 5-15% of the global children population, and any association with another condition increases its prevalence (Bölte et al., 2021).In the case of neurodevelopmental disorders, the repetitive and task-based exercises of traditional physiotherapy can be considered as monotonous and result in low motivation and interest in pursuing the therapy program, particularly in young children who require a steady level of adherence to the treatment plan and extended intervention in order to see significant functional improvement. (Iosa *et al.*, 2022; Pimentel-Ponce *et al.*, 2024; Tobaiqi, 2023).

Effective neurorehabilitation is in accordance with sensorimotor. and cognitive learning model, the key principles of which are interaction and practical and hands-on practice. All

Those things need deep devotion, which are not always easy to follow in children. Regarding this, the emergent gaming is used to permit the use of technology, which is to be humorous and entertains children to repeat an intensive and extended repetition of the body movements asked to achieve high scores in the game. The absence of interest does not occur in the case of reinforcement and feedback received, which in turn are relevant tips in motor learning of enhancing neuroplasticity (Jurdi et al., 2017, Pin TW, 2019, Morone et al., 2019)

Gamification in rehabilitation, particularly for the pediatric population, integrates game design elements like points, badges, leaderboards, and interactive challenges into therapeutic exercises to boost engagement, motivation, and adherence.(Wang et al., 2025)Well-known obstacles in children, including boredom and low compliance during repetitive physical, motor, or neurorehabilitation, are dealt with by using reward systems and fun mechanics to facilitate neuroplasticity and practice sustainability. The latest research of 2021-2026, systematic reviews, and meta-analyses proved that it is effective to enhance moderate-vigorous physical activity (MVPA), emotional and social skills, and motor functions among children with disabilities or conditions. (Mahmoudi etal., 2024, Iosa *et al.*, 2022, Johnson et al ., 2022)

Despite the bulk of clinical evidence regarding the use of serious exergames in children is rather insufficient, currently there is a continuous and progressive spread of gaming technology in neurorehabilitation.

In Pakistan, where access to traditional therapy is restricted due to a lack of resources and a high prevalence of diseases like autism spectrum disorder (ASD), gamification is becoming more useful for pediatric rehabilitation.

In comparison to normal therapy, a 12-week randomized controlled study of a culturally tailored gamified virtual reality platform among Pakistani teenagers with ASD (12-18 years) revealed notable increases in social responsiveness,

emotion recognition (45.72%), and adaptive behaviors. (Khan, M.K., 2025) such interventions suit Pakistan's context by enabling low-cost, home-based tele-rehabilitation amid limited specialists, especially in urban areas like Karachi. While direct pediatric physiotherapy studies are emerging, VR-gamification extensions from adult stroke rehab highlight scalability for child motor issues. (Khushnood et al.,2020). No ongoing gamification projects in Pakistan's rehabilitation sector are widely documented in recent public sources (Emaliyawati et al., 2025)

Pakistan's rehab landscape features pilot VR-gamified trials for neurorehabilitation, like the 2025 culturally adapted platform for adolescents, but these are completed studies rather than active projects. (Malik et al., 2024)

Pediatric physiotherapy in Karachi, the largest metropolitan city in Pakistan and one of the largest centers of healthcare and rehabilitation services, is mostly provided using traditional means that are based on repetitive and therapist-oriented exercises. Despite the slow introduction of digital health technologies in clinical environments, there is scant knowledge regarding the perception of physiotherapy practitioners towards gamification-based intervention in the management of pediatric neurodevelopmental disorders. Lack of training, institutional resources, insufficient awareness, and uncertainty about clinical effectiveness are likely to affect the readiness of practitioners to implement gamified therapy into clinical practice, but there is a lack of empirical data that has investigated these factors in the local setting.

Therefore, this study is being conducted in Karachi to investigate the adoption and perceptions of gamification-based physiotherapy among pediatric rehabilitation practitioners. Identifying current levels of awareness, attitudes, and barriers will provide evidence necessary for developing targeted training programs, improving implementation strategies, and supporting the integration of innovative, child-centered rehabilitation approaches within local physiotherapy practice.

MATERIALS AND METHODS:

The study design used was a quantitative cross-sectional study to determine the adoption and perceptions of physiotherapy interventions based on gamification on pediatric neurodevelopmental disorders by practicing physiotherapists. The study was conducted in Karachi, Pakistan, involving physiotherapists working in hospitals, rehabilitation centers, private clinics, and academic institutions providing pediatric physiotherapy services. The target population included licensed physiotherapy practitioners involved in the management of children with neurodevelopmental disorders such as cerebral palsy, autism spectrum disorder, and developmental coordination disorders. The sample size was calculated using the formula for cross-sectional studies as described by Charan and Biswas (2013), assuming a 95% confidence level, 5% margin of error, and an expected prevalence of 50% due to the absence of prior local data. The calculated minimum sample size was adjusted using finite population correction based on the estimated number of practicing physiotherapists in Karachi. The final required sample size was 278 participants, which was achieved during data collection. A convenience sampling method, which was not a probability sampling, was employed. Professional networks, hospitals, rehabilitation centers and online professional groups were used to contact eligible physiotherapists. The study included participants meeting the inclusion criteria and giving informed consent. Inclusion criteria include Licensed physiotherapists practicing in Karachi, currently involved in clinical physiotherapy practice, experience in treating pediatric or neurodevelopmental cases, Willingness to participate in the study. Data were collected using a structured self-administered questionnaire titled Gamification Adoption Readiness Scale for Pediatric Physiotherapy (Adapted TAM-UTAUT Model). The questionnaire was developed based on validated constructions from the Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT). After receiving ethical permission from the appropriate institutional review board, data were

gathered. Before beginning the study, participants were given information about it and asked for their informed consent. The questionnaire was distributed both in paper-based and online formats to maximize response rates. Responses were anonymized to preserve confidentiality, and participation was entirely voluntary.

Data were entered and analyzed using Statistical Package for Social Sciences (SPSS) version 25. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize demographic characteristics and questionnaire responses. Inferential statistics were applied to examine relationships between variables, including chi-square tests, independent t-tests, and regression analysis where appropriate. Statistical significance was set at $p < 0.05$.

With ethical approval in place, data collection was carried out. The goal of the study, the confidentiality of their data, and the fact that leaving the study would not be penalized were all explained to the participants. The material was protected for use in research, and no data was identified.

RESULT.

The number of physiotherapists in the study was 278. Out of them, 58.6% were female (n = 163) and 41.4% were male (n = 115). In terms of professional experience, most of the participants were experienced in clinical practice with a range of 6-10 years' experience (50.4), and 2-5 years (32.0) and further the less experienced group had (17.6) less than 2 years' experience. The proportion of participants who have been exposed to digital rehabilitation exposure is 12.6% (n = 35) indicating formal training in digital or gamified physiotherapy at some point and the rest (n = 243) indicated having no training. Also, 58.3 (n=162) said that they had heard about gamification in physiotherapy and the rest (41.7 n=116) said they had no prior knowledge. The normality tests, the Kolmogorov-Smirnov and the Shapiro-Wilk tests showed that the study variables were not normally distributed ($p < 0.05$). But since it was the large sample size, the parametric tests were deemed to be the right tests to use under the Central Limit Theorem. Pearson correlation analysis was used to test the correlation between the perception, adaptation, barriers, and facilitation scores regarding gamification-based physiotherapy. The findings indicated that perception and barrier scores were significantly correlated with adaptation and barrier scores (r =.196, p= 0.001), and vice versa (r =. 318, p=0.001). There was a high positive relationship between barrier scores and facilitation scores (r =.677, p <.001). did not find any significant correlations between perception and adaptation scores (r = -.002, p =.968), perception and facilitation scores (r =.043, p =.472) or between adaptation and facilitation scores (r =.108, p =.072) as shown in table 1.

Table 1: Correlation analysis

Variable	Perception Score	Adaptation Score	Barrier Score	Facilitation Score
1. Perception Score	1	-.002	.196**	.043
2. Adaptation Score	-.002	1	.318**	.108
3. Barrier Score	.196**	.318**	1	.677**
4. Facilitation Score	.043	.108	.677**	1

Further, the analysis of multiple linear regression was conducted to find out predictors of adaptation score. This overall regression equation was significant, F(3, 274) = 13.626, p <.001, and explained 13% of the adaptation variance (R 2 =.130, adjusted R 2=.120). Barrier score and facilitation score were observed to be a significant positive and significant negative predictor of adaptation respectively (B =.787, 2 =.479, p <.001 and B = -.161, 2 = -.213, p =.006). The predictor of the perception score was not significant (B = -.064, 8 = -.087, p =.134) as indicated in table 2. These findings imply that contextual and organizational contexts have a greater effect compared with

perception-only on adjustment to gamification-based physiotherapy.

Table 2: ANOVA

Source	Sum of Squares	df	Mean Square	F	p
Regression	169.994	3	56.665	13.626	.000**
Residual	1139.434	274	4.159		
Total	1309.428	277			

DISCUSSION:

The present paper examined the practices and attitudes of gamification-based physiotherapy by practitioners dealing with pediatric neurodevelopmental disorders in Karachi. The results show that despite the positive perceptions and awareness of clinicians to gamified rehabilitation, the contextual and organizational factors seem to affect the adaptation in a stronger way, rather than only the perception. This shows an incongruence between theoretical acceptance and practical application of gamification in clinical practice.

The correlation analysis showed that there are strong connections between the barrier scores with the perception and adaptation scores indicating that practitioners more aware of gamification also realize more issues of implementation. The same trends have been cited in recent literature on rehabilitation where growing awareness of digital interventions is likely to result in growing awareness of a variety of technological, institutional, and resource-related barriers instead of an immediate adoption (Bölte et al, 2021, Iosa et al 2022). The systematic reviews have also demonstrated that gamification enhances motivation, engagement, and adherence in pediatric patients, but the implementation of the intervention can be successful only with conditioned readiness of clinicians and environmental conditions (Iosa et al 2022, Pimentel-Ponce et al 2024)

The positive correlation between the barrier and facilitation scores is very strong and this implies that facilitators and barriers are interrelated constructs as perceived by clinical workers. The result is consistent with other recent studies of digital rehabilitation, which underline that the introduction of technology is presented in the context of complex healthcare systems, in which organizational preparedness, training accessibility, and infrastructure all act as facilitators and barriers at the same time (Wang et al., 2025. Mahmoudi et al., 2024). The research investigating the implementation of mobile and gamified rehabilitation interventions has also emphasized the fact that institutional support and access to resources have a strong impact on the incorporation into the normal practice of clinical care (Johnson et al ., 2022)

The analysis of regression proved that barriers were a significant predictor of adaptation, whereas perception alone was not a significant predictor of adaptation when other factors were controlled. These results may be regarded as evidence of spreading the Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT), according to which the external conditions and the perceived control over behavior are vital factors in the adoption behavior determinants. Pediatric rehabilitation clinicians may be aware of the theoretical advantages of using gamification, yet they are reluctant to incorporate this method because they do not know how to train, the costs or the effectiveness of this approach (Iosa et al 2022, Tobaiqi 2023). Recent scopes in child neurorehabilitation equally note that the success of implementation is more reliant on contextual preparedness and feasibility than favorable attitudes in isolation (Jurdi et al, 2018, Pimentel-Ponce et al., 2024)

The negative correlation of facilitation and adaptation may be a reality on the ground in low and middle-income nations. Such practitioners who recognize factors of facilitation may also be

more conscious of discrepancies between optimal resources and clinical reality. Pediatric physiotherapy in Pakistan is mostly therapist-based, and there is a lack of training on digital rehabilitation. New evidence in the region indicates that gamified and virtual rehabilitation interventions are on the rise, but their adoption is still inactive because of resource constraints and the absence of unified models of their implementation (Khan. 2025, Malik et al., 2024)
Overall, the results are in line with the world concerning the use of gamification as a valid method of improving motivation, physical activity and functional outcomes in children with neurodevelopment disorders (Wang et al., 2025, Mahmoudi et al., 2024). Nevertheless, it is in line with the findings of other international studies that the implementation will not be successful without sufficient training of clinicians, institutional encouragement, and culturally adapted models of interventions (Emaliyawati et 2025, Johnson et al ., 2022)
In the Pakistani setting, the current study offers significant background evidence that demonstrates the necessity of professional development courses and organizational policies to reduce the gap between awareness and practice.

PRACTICAL IMPLICATIONS

The results indicate that there are several practical implications of the study to the practice of pediatric rehabilitation:
Creation of systematic education programs based on physiotherapy based on gamification.
Incorporation of digital rehabilitation educational content into physiotherapy training and CPD.
Organizational investment in available and affordable gamified rehabilitative technologies.
Marketing of locally designed gamified tools to resource-constrained environments.

STRENGTHS AND LIMITATIONS

One of the principal advantages of this study is that a rather big sample of physiotherapists practicing in various clinical settings was utilized, which gives the reflection of the general perception of the practitioners in Karachi. Nevertheless, cross-sectional design restricts the ability to make causal inferences and convenience sampling can limit the ability to generalize outside of the study context. Future longitudinal investigations are suggested to study the practice of actual clinical adoption and patient outcomes of gamification-based physiotherapy.

FUTURE DIRECTIONS

To understand the longitudinal aspects of adoption behavior, patient-level outcomes of gamified interventions, and the impact of organizational policies and training programs on the implementation readiness needs to be examined in future research. Evidence-based clinical integration, especially the comparison of traditional and gamified physiotherapy in the context of low-resource environments of pediatric neurodevelopmental disorders would rely further on comparative studies.

CONCLUSION

The given study gives valuable information about the adoption and perception of gamification-based physiotherapy among practitioners dealing with pediatric neurodevelopmental disorders in Karachi. The results suggest that even though there is an average awareness of physiotherapists and overall positive perceptions towards gamification, the contextual and organizational factors have a stronger impact on actual adaptation than perception. The barriers associated with the implementation proved to be relevant predictors of adaptation, and the practical difficulty which clinicians are exposed to when implementing the innovative rehabilitation strategies into everyday practice.
The findings highlight that ensuring adoption in the absence of proper training, institutional support and easy access to technological resources is not possible without positive attitudes towards gamification. With increasing evidence in the world, which has proven that gamification is an effective approach to improving motivation, engagement, and functional outcomes of pediatric rehabilitation, there is a distinct necessity to reinforce the development of professional opportunities and facilitate systematic adoption of

digital rehabilitation strategies in the clinical and academic environment in Pakistan.

In general, the current research adds background information about a low-resource setting and indicates that it is vital to tackle systematic and feasible obstacles to enable the extension of gamification-based physiotherapy to a large audience. The future research is based on longitudinal implementation investigation, patient outcome analysis, and creation of culturally modified gamified interventions to make them be an integral part of pediatric rehabilitation practice.

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