Virtual Reality in Rehabilitation for Children with Cerebral Palsy: A Narrative Review

Realidade virtual na reabilitação em crianças com paralisia cerebral: uma revisão narrativa

Talita Aparecida Alves Leite[1] , Natália Fernandes da Luz Silvério[1] , Kelly Cristina Melnic Dantas[1] , Marco Aurélio Bonvino[2], Thais Botossi Scalha Tiezzi[2] , Lucas Villalta Santos[3]

[1] University of Sorocaba, Undergraduate Student, Physiotherapy Program, Sorocaba, SP, Brazil;
[2]University of Sorocaba, Faculty of Physiotherapy, Sorocaba, SP, Brazil
[3]Instituto Villalta Santos and TMPI-PIMT Professor

ABSTRACT

Cerebral palsy (CP) is the most common motor disorder in childhood, causing persistent motor dysfunction. Rehabilitation seeks to promote functional performance. Virtual Reality (VR) is an innovative technology for repetitive, task-specific motor practice for children with CP. This study aimed to analyze the scientific literature on the use of Virtual Reality in the rehabilitation of motor function, specifically in the domains of balance, gait, and gross motor function, in children with cerebral palsy. The narrative review was structured with a search (August 2025) in the PubMed, PEDro, Cochrane, and LILACS databases. Four clinical trials (2023 - 2025) evaluating VR in 202 children with CP were included. The results demonstrated that VR training provided effectiveness in improving balance, gait parameters, and motor function, surpassing conventional physiotherapy in some outcomes. The findings indicate that VR is an effective and promising intervention for improving balance, gait, and gross motor function in children with CP. However, the current evidence is not robust enough to support its superiority or replacement of established specialized therapies across all domains, and therefore VR should be considered a valuable complementary tool within a structured therapeutic process.

Keywords: Cerebral Palsy; Virtual Reality; Rehabilitation.

RESUMO

A Paralisia Cerebral (PC) é o distúrbio motor infantil mais comum, caracterizado por limitações motoras persistentes. A reabilitação busca promover o desempenho funcional. A Realidade Virtual (RV) é uma tecnologia que facilita a prática motora orientada a tarefas de forma interativa e motivadora na PC. O objetivo deste estudo foi analisar os efeitos da RV na reabilitação da funcionalidade motora, especialmente nos domínios de equilíbrio, marcha e função motora grossa, em crianças com PC. A metodologia foi uma revisão narrativa estruturada com busca (agosto de 2025) nas bases de dados PubMed, PEDro, Cochrane e LILACS. Foram incluídos quatro ensaios clínicos (2023-2025) avaliando RV em 202 crianças com PC. Como resultados, o treinamento com realidade virtual demonstrou melhoras no equilíbrio, nos parâmetros da marcha e na função motora, embora não tenha sido superior a todas as outras intervenções avaliadas. Em alguns desfechos, apresentou desempenho semelhante ou ligeiramente superior à fisioterapia convencional. Conclui-se que a realidade virtual pode ser utilizada como recurso complementar na reabilitação de crianças com paralisia cerebral, contribuindo para equilíbrio, marcha e função motora grossa, no entanto, os achados ainda não apresentam robustez suficiente para sustentar sua superioridade ou substituição das abordagens fisioterapêuticas especializadas já consolidadas, devendo ser aplicada de forma integrada ao processo terapêutico.

Palavras-chave: Paralisia Cerebral; Realidade Virtual; Reabilitação.

ARTICLE INFO

DOI: https://doi.org/10.46979/rbn.v61i4.70004

Corresponding author: Natália Fernandes da Luz Silvério.
E-mail: nataliaflsilverio@gmail.com

Conflict of Interest Statement: The authors declare that there is no conflict of interest.

Funding Statement: This study received no funding.

Author Contributions (CRediT)

Conceptualization: Natália Fernandes da Luz Silvério, Kelly Cristina Melnic Dantas, and Talita Aparecida Alves Leite;
Data curation: Talita Aparecida Alves Leite;
Investigation: Natália Fernandes da Luz Silvério, Kelly Cristina Melnic Dantas and Talita Aparecida Alves Leite;
Methodology: Natália Fernandes da Luz Silvério;
Project administration: Natália Fernandes da Luz Silvério, Kelly Cristina Melnic Dantas, and Talita Aparecida Alves Leite;
Supervision: Lucas Villalta Santos, Marco Aurélio Bonvino, and Thais Botossi Scalha Tiezzi;
Validation: Lucas Villalta Santos, Marco Aurélio Bonvino, and Thais Botossi Scalha Tiezzi;
Visualization: Natália Fernandes da Luz Silvério e Talita Aparecida Alves Leite;
Writing - original draft: Natália Fernandes da Luz Silvério, Kelly Cristina Melnic Dantas, and Talita Aparecida Alves Leite;
Writing - review & editing: Talita Aparecida Alves Leite.

INTRODUCTION

Cerebral palsy (CP) is a non-progressive neurodevelopmental disorder arising from prenatal and perinatal brain insults, manifesting as persistent motor and postural dysfunction with associated activity limitations[1]. It is the most frequent motor condition of childhood, with an estimated prevalence between 1.6 and 3.4 cases per 1,000 live births. These figures appear to vary according to income levels, as suggested by the systematic analysis of McIntyre et al. (2022), which utilized World Bank classifications to group global data.[2]. Furthermore, certain populations may be at a particularly high risk, such as newborns with a birth weight <1,500 g, especially extremely preterm infants[1].

Motor impairments associated with CP are frequently accompanied by sensory, cognitive, communication, and behavioral disorders, as well as epilepsy and secondary musculoskeletal problems[3]. Clinical diagnosis generally occurs before two years of age, based on neurological signs such as spasticity, dyskinesia, ataxia, hyperreflexia, and, more rarely, hypotonia[4]. Rehabilitation is essential and involves a multidisciplinary approach, aiming to assist mobility, correct posture, address inadequate movement patterns, develop and learn new skills, facilitate the use of the hands and arms in daily activities, train gait, and promote clearer speech[5–7].

According to the International Classification of Functioning, Disability and Health (ICF), proposed by the World Health Organization (WHO), functionality is understood as the result of the interaction between health conditions and contextual factors, encompassing body functions and structures, activities, and social participation [8]. This model broadens the understanding of disability, valuing not only bodily limitations but also their impact on daily activities and social participation[8]. Thus, the focus of rehabilitation should go beyond isolated motor recovery, seeking to promote autonomy, engagement, and functional performance in real-life contexts[9].

In recent years, the development of new technologies has enabled the implementation of Virtual Reality (VR) in rehabilitation, providing more personalized and engaging experiences that may improve adherence and outcomes[10,11]. This innovative approach has shown positive effects on task-oriented motor learning, reinforcing the acquisition and improvement of functional skills across different populations, including children with CP[12].

Virtual Reality is a technological tool that allows the creation of immersive and interactive environments, fostering repetitive and motivating practice of specific motor tasks[13]. Its use in rehabilitation aims to enhance motor function, coordination, and functional independence, as well as stimulate performance in activities and participation[13], consistent with the domains described by the ICF[8,9]. Accordingly, this study aims to analyze the scientific literature on the use of VR in the rehabilitation of functionality in children with cerebral palsy.

Despite the growing number of studies addressing virtual reality (VR) in pediatric neurorehabilitation, the available evidence remains fragmented and heterogeneous regarding intervention protocols, duration, and evaluated outcomes. Previous systematic reviews and meta-analyses have highlighted methodological inconsistencies, small sample sizes, and variations in functional assessment tools, limiting the comparability and generalizability of findings[12–14]. Therefore, a narrative synthesis that consolidates recent clinical evidence, particularly studies published in the last three years, is justified to clarify the current state of knowledge, identify methodological gaps, and guide future research and clinical applications of VR in children with cerebral palsy.

METHODOLOGY

This structured narrative review was conducted using elements of the PICO strategy (Population, Intervention, Comparator, and Outcome) to guide the research question: How does Virtual Reality impact the functional capacity of children with cerebral palsy, and how does its effectiveness compare with other therapeutic approaches?

The PICO components were defined as follows: Population (P): Children diagnosed with cerebral palsy, aged 4 to 14 years, of any clinical subtype and functional level (Gross Motor Function Classification System [GMFCS] I–II). Intervention (I): Virtual Reality-based motor rehabilitation programs, using immersive or non-immersive systems (e.g., Wii, Kinect, or similar platforms). Comparator (C): Conventional physiotherapy, specific balance training, or other neurorehabilitation modalities such as transcranial direct current stimulation (tDCS). Outcomes (O): Improvements in balance, gross motor function, gait parameters, and functional independence according to standardized assessments (e.g., Gross Motor Function Measure - GMFM, Pediatric Balance Scale - PBS, Pediatric Evaluation of Disability Inventory - PEDI). The PICO strategy analysis, study screening, and data extraction were performed independently by three researchers, all of whom are Physical Therapy undergraduates, under the supervision of a faculty advisor with expertise in academic research production. Any disagreements during the selection process were resolved through consensus among the reviewers.

We followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) recommendations to ensure methodological quality.

The literature search was performed in internationally recognized medical databases: PubMed (U.S. National Library of Medicine), PEDro (Physiotherapy Evidence Database), Cochrane Library, and LILACS (Latin

American and Caribbean Health Sciences Literature). To guide the search, specific combinations of Health Sciences Descriptors (DeCS) and their corresponding Medical Subject Headings (MeSH) were used, combined with the Boolean operator AND, across the three languages included in the search.

The primary terms utilized were: "Cerebral Palsy" AND "Virtual Reality" (English/MeSH); "Paralisia Cerebral" AND "Realidade Virtual" (Portuguese/DeCS); and "Parálisis Cerebral" AND "Realidad Virtual" (Spanish/DeCS), as detailed in Figure 1. The search was carried out between August 13, 2025, and August 29, 2025, including articles in English, Portuguese, and Spanish.

In PubMed, the search yielded 11 articles, of which 6 were selected for abstract screening. In PEDro, 5 articles were found; 2 were considered relevant after title and abstract analysis, and the remainder were duplicates from PubMed. In LILACS and the Cochrane Library, 33 and 175 articles were initially identified, respectively, and all studies not pertinent to the topic were excluded after title and abstract screening.

We included clinical trials published between 2023 and 2025 that evaluated Virtual Reality, alone or in combination with other therapies, in children aged 4 to 14 years with a diagnosis of cerebral palsy. Studies involving adults or those that did not apply VR were excluded.

After initial screening and exclusion of duplicates and non-pertinent articles, 8 studies were considered potentially relevant. Of these, only 4 were available in full text and were included in the narrative synthesis. The authors of the remaining articles were contacted by email, but no responses were received.

From the included articles, information was extracted on authorship, year of publication, sample characteristics, type and duration of interventions, evaluated outcomes, and main conclusions. The analysis was conducted in a descriptive and interpretative manner, enabling the identification of trends, comparison of results among studies, and discussion of the impact of Virtual Reality on the functionality of children with cerebral palsy.

The studies included in this review involved a total of 202 participants, all children and adolescents diagnosed with cerebral palsy. The participants were aged between 4 and 14 years and represented different clinical subtypes of CP (spastic, ataxic, and mixed forms). Most studies included children classified at levels I and II on the Gross Motor Function Classification System (GMFCS), indicating mild to moderate motor impairment and preserved functional mobility. Eligibility criteria generally excluded participants with severe cognitive deficits, uncontrolled epilepsy, or orthopedic deformities that could interfere with motor training. This characterization ensured sample homogeneity and comparability among the selected studies.

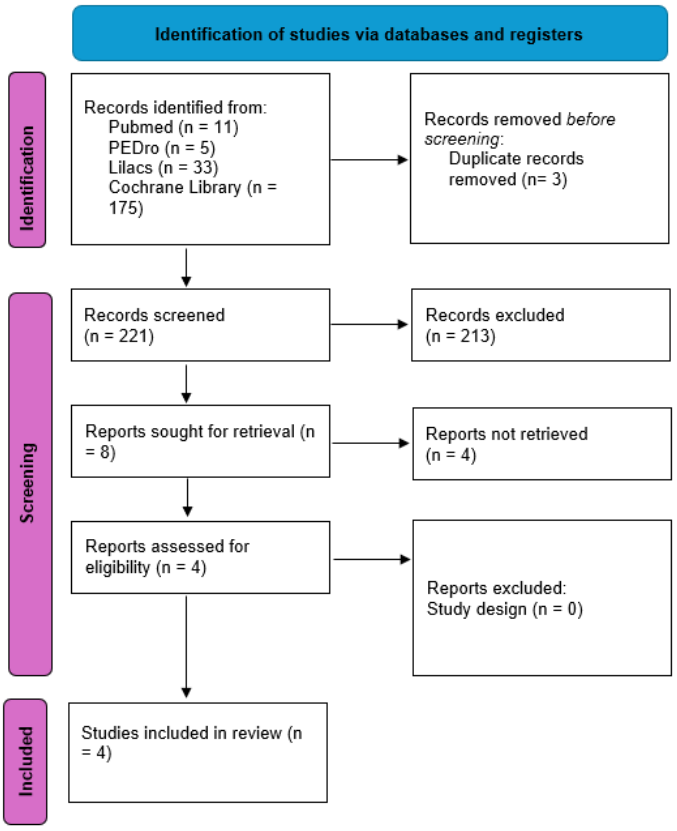

Figure 1. Detailed flowchart of the study identification, screening, eligibility, and inclusion process, according to the PRISMA model. Where 'n' is representative of the number of studies.

RESULTS

Table 1 presents the characteristics of the four studies included in this review, totaling 202 children with cerebral palsy of different types (bilateral spastic, spastic, ataxic, and mixed forms), aged 4 to 14 years. The mean or range of participants' ages is presented in Table 1, according to each study. The interventions investigated VR training using platforms such as Nintendo Wii or Xbox Kinect, with sessions of 30 to 60 minutes, delivered two to five times per week, and a total duration ranging from two weeks to three months. Comparator groups included conventional physiotherapy, transcranial direct current stimulation, and specific balance training. Outcomes assessed covered domains such as balance, gross motor function, gait parameters, center-of-mass displacement, and upper limb skills. The studies are organized chronologically from oldest to most recent.

Table 1: Identification table of the characteristics of the included studies, where: "n" = number of participants; CP = Cerebral Palsy; VR = Virtual Reality; tDCS = Transcranial Direct Current Stimulation; Walkway™ Pressure Measurement System (pressure-mat–based gait analysis system); PBS = Pediatric Balance Scale; GMFM-88 = Gross Motor Function Measure, 88 items; GMFM D and E = GMFM dimensions D (Standing) and E (Walking, Running, and Jumping); STS = Sit-to-Stand Test; FRT = Functional Reach Test; QUEST = Quality of Upper Extremity Skills Test; PEDI = Pediatric Evaluation of Disability Inventory; Biodex = Biodex Balance System; BST = balance-specific training; UCOM = Upper Center of Mass; LCOM = Lower Center of Mass. Time notation includes min (minutes) and x/week (times per week).

ID	Year and Author	Sample Characteristics	Intervention and Protocol	Outcome Measures	Main Findings
1	2023 - Radwan et al.	**Experimental group (n=20):** children with spastic bilateral CP, aged 7-12 years. **Control group (n=20):** children with spastic bilateral CP, aged 7-12 years.	**Experimental:** Virtual Reality using Nintendo Wii and Wii Balance Board combined with gait training, 30 min/session, 5x/week, 2 weeks. **Control:** tDCS combined with gait training, 20 min/session, 5x/week, 2 weeks.	Walkway™ Pressure Measurement System.	Both groups improved in spatiotemporal parameters. The tDCS group showed additional gains in kinetic parameters and maintained higher values after 10 weeks (longer-lasting effect).
2	2023 - Fidan & Genç	**Experimental group (n=27):** children with spastic CP, mean age 9.2 years. **Control group (n=25):** children with spastic CP, mean age 9.4 years.	**Experimental:** Xbox Kinect training (45 min/session, 2x/week, 8 weeks). **Control:** Conventional physiotherapy (45 min/session, 2x/week, 8 weeks).	PBS, GMFM-88, FRT, STS, QUEST, PEDI.	Both groups improved balance and motor function; conventional physiotherapy produced greater gains in upper limb function, while VR was more beneficial for balance and overall motor function.
3	2024 - Mouhamed et al.	**Experimental group (n=32):** children with ataxic CP, aged 9-14 years. **Control group (n=32):** children with CP, aged 9-14 years.	**Experimental:** Virtual Reality with Nintendo Wii (30 min) combined with physiotherapy (30 min), 3x/week, 3 months. **Control:** Conventional physiotherapy (60 min/session, 3x/week, 3 months).	PBS, Biodex (general, anteroposterior, and mediolateral stability indices).	Both groups improved balance; the VR group showed more expressive progress, demonstrating greater therapeutic efficacy.
4	2024 - Ziab et al.	**Experimental group (n=15):** children with mixed-type CP, aged 4-12 years. **Control group 1 (n=15):** children with CP, aged 4-12 years. **Control group 2 (n=16):** children with CP, aged 4-12 years.	**Experimental:** VR with Xbox 360 Kinect (60 min/session, 3x/week, 6 weeks). **Control 1:** BST, same schedule. **Control 2:** Conventional Physiotherapy, same schedule.	PBS, GMFM D & E, STS, Digital Photography (UCOM/LCOM).	VR and BST were superior to conventional physiotherapy in PBS, STS, and LCOM. VR and BST showed similar performance, with VR being superior to BST only in right UCOM. No significant differences were found between groups for GMFM D and E.

Radwan et al[14] conducted a study with 40 children with bilateral spastic cerebral palsy with GMFCS (Gross Motor Function Classification System) levels I–II and scores of 1 and +1 on the Modified Ashworth Scale (MAS) to compare the effectiveness of Virtual Reality (VR) and transcranial direct current stimulation (tDCS), both combined with one additional hour of gait training. Both interventions were effective, producing significant improvements in spatiotemporal gait parameters after the training period ($p \leq 0.05$), including speed, cadence, stance phase, and step and stride length. Only the tDCS group obtained additional kinetic gains in peak force and pressure ($p \leq 0.05$). Notably, measurements taken 10 weeks post-intervention showed the tDCS group maintained superior results compared with VR, with higher gait speed, cadence, and step and stride lengths ($p \leq 0.05$), indicating broader and more sustained therapeutic benefits for gait function.

Fidan and Genç[15] evaluated 52 children with spastic CP (GMFCS I–II; MAS ≤ 3), with a mean age of 9.2 years in the VR training group and 9.4 years in the control group. Participants were randomized to receive either 45 minutes of VR using Xbox One Kinect twice a week for eight weeks, or conventional physiotherapy consisting of sit-to-stand on different balance platforms; ball throwing and catching on a trampoline; weight transfers in different directions; stretching; strengthening; simulation of activities of daily living such as dressing; and exercises targeting upper-limb peripheral function. Assessments included the Pediatric Balance Scale (PBS), the Gross Motor Function Measure-88 (GMFM-88), the Sit-to-Stand Test (STS), the Functional Reach Test (FRT), the Quality of Upper Extremity Skills Test (QUEST), and the Pediatric Evaluation of Disability Inventory (PEDI). Both groups showed significant improvements in balance, motor function, and upper limb skills ($p \leq 0.05$). However, between-group comparisons showed that improvements in upper limb functions were greater in the control group than in the VR training group ($p \leq 0.05$).

The study by Mouhamed et al[16] evaluated 64 children with ataxic CP, aged 9 to 14 years, classified at GMFCS levels I and II and with an intelligence quotient (IQ) score above 70. The intervention lasted three months, with sessions held three times per week. The control group received 60 minutes of conventional physiotherapy (balance training using dumbbells, sensory stimulation of the foot, and center-of-force stability), while the VR group performed 30 minutes of the same program plus 30 minutes of balance training with the Wii Balance Board (Nintendo Wii balance and pressure platform). Results showed significant improvements in stability indices (overall, anteroposterior, and mediolateral) and in the Pediatric Balance Scale (PBS) score in both groups, with a notable advantage favoring the VR group ($p \leq 0.05$). It was concluded that adding VR training with a Wii balance board to a structured physiotherapy program has a significant impact on improving balance deficits in children with ataxic CP.

Ziab et al[17] evaluated the effectiveness of VR training, specific balance training (SBT), and conventional physiotherapy in the rehabilitation of 46 children with mixed CP, aged 4 to 12 years (GMFCS I-II; MAS < 2), over six weeks. The conventional group received stretching, strengthening, functional balance, aerobic exercises, and neurodevelopmental techniques. Although all groups showed significant improvement over time ($p \leq 0.05$), both VR and SBT were superior to conventional physiotherapy for improving balance (PBS) and motor function (STS), but neither was superior to the other in clinical scales. VR, in particular, showed a statistically significant advantage for right Upper Center of Mass (UCOM) ($p \leq 0.05$). However, for overall gross motor function (GMFM dimensions D and E), there was no significant difference among the three groups ($p > 0.05$), indicating that VR is an effective clinical complement but not superior to structured balance training.

All studies reported statistically significant improvements ($p \leq 0.05$) in at least one functional domain, indicating the effectiveness of Virtual Reality interventions when compared to conventional physiotherapy or other training modalities.

DISCUSSION

The findings of this review indicate that VR is a promising intervention for improving aspects of functionality in children with CP[15–18]. The four investigations included reported gains in balance, spatiotemporal gait parameters, and, in some cases, upper limb skills, especially when VR was incorporated into structured physiotherapy programs. These results are consistent with recent reviews reporting positive effects of VR on balance, gait, and motor function in pediatric CP populations, while noting methodological heterogeneity across studies[13,14,19,20].

When comparing VR with other therapeutic modalities, such as tDCS combined with gait training, distinct clinical outcomes emerge. The study by Radwan et al. (2023), which compared VR with transcranial direct current stimulation (tDCS) combined with gait training, showed that although both interventions improved spatiotemporal parameters ($p \leq 0.05$), tDCS produced broader kinetic effects and more sustained gait gains over time ($p \leq 0.05$). These findings suggest that tDCS may provide additional benefits over VR alone in specific gait domains. Based on the reviewed studies, it is observed that the combination of VR and tDCS can potentiate therapeutic results in children with CP, particularly in aspects related to gait and motor control, reinforcing that although VR is effective, its association with tDCS may maximize functional gains[15,21].

Other included studies and the recent literature show that videogame-based platforms (e.g., Wii or Kinect) improve balance and stability indices, often with results comparable to specific balance training and superior to conventional physiotherapy in some kinetic outcomes[12,17,22]. These findings reinforce that VR, especially in its non-immersive form, is effective for improving postural control and balance[23,24].

It is essential to note the methodological heterogeneity among the studies included in this review. Such variability complicates direct comparisons and limits the generalizability of findings, as differences in study design, intervention dosage, and duration can influence treatment outcomes. For instance, Radwan et al. (2023)[15] implemented a two-week intervention protocol, markedly shorter than the three-month program applied by Mouhamed et al. (2024)[17]. Another point of divergence lies in the sample profiles: Radwan et al. (2023)[15] and Fidan & Genç (2023)[16] investigated children with spastic cerebral palsy, whereas Mouhamed et al. (2024)[17] focused on the ataxic subtype, and Ziab et al. (2024)[18] included participants with mixed types. This clinical variation directly influences motor responses and the applicability of the results. Despite these differences, all studies showed similar functional levels, with participants classified between GMFCS levels I and II. However, the variability in dosage, cerebral palsy subtype, age, and outcome measures highlights the need to standardize protocols in future research.

Despite this heterogeneity, the flexibility of VR protocols makes it a valuable tool to extend task-oriented practice time, a critical factor in motor learning, and to increase adherence and training frequency outside the clinic. Moreover, the possibility of incorporating motivational challenges and real-time visual feedback enhances the repetition of functional movements and engagement, factors that are fundamental in pediatric motor rehabilitation.

In addition to balance and gait parameters, functional improvements derived from Virtual Reality interventions extend to upper limb and hand function domains, which are essential components of daily activities and participation according to the International Classification of Functioning, Disability and Health (ICF). Rathinam et al. (2019)[23] demonstrated that VR-based hand training protocols effectively enhance grasp, coordination, and fine motor control, leading to significant functional gains in activities of daily living. Similarly, Tobaiqi et al. (2023)[25] highlighted that exergaming interventions, combining VR with interactive physical games, produced improvements not only in gross motor performance but also in cognitive engagement and social participation, reinforcing the multidimensional benefits of technology-assisted rehabilitation.

These findings align with the ICF model, which emphasizes functionality as the interaction between body functions, activities, and participation within environmental and personal contexts. By stimulating multiple domains, motor, cognitive, and psychosocial, Virtual Reality-assisted therapies address broader aspects of functionality than conventional physiotherapy alone. Therefore, integrating VR with complementary approaches, such as task-oriented exergames or tDCS, may maximize the generalization of functional skills beyond isolated motor gains, favoring autonomy and participation in real-world contexts.

Beyond its physiotherapeutic applications, Virtual Reality has also been increasingly used within the field of Occupational Therapy, aiming to enhance functional independence and participation in daily activities. Occupational therapists utilize VR and exergames to simulate real-life tasks, such as dressing, feeding, and object manipulation, providing a safe, engaging, and feedback-rich environment that promotes motor learning and cognitive engagement[26,27]. These interdisciplinary approaches align with the principles of the International Classification of Functioning, Disability and Health (ICF), emphasizing the integration of body functions, activities, and participation. By combining physiotherapy and occupational therapy perspectives, VR-based interventions can support both gross and fine motor domains, thereby fostering greater autonomy and social participation. Recent studies have demonstrated that such combined approaches lead to improvements not only in postural control and upper-limb coordination but also in task performance and quality of life, confirming the relevance of multidisciplinary strategies in pediatric neurorehabilitation[23,25,26].

CONCLUSION

Virtual Reality is effective in improving balance, gait, and motor function in children with cerebral palsy, particularly when integrated into structured rehabilitation programs. However, other interventions, such as transcranial direct current stimulation and specific balance training, may achieve similar or superior results in certain outcomes, reinforcing that VR should be regarded as a complementary, rather than exclusive, componeṇt of the

therapeutic process.

REFERENCES

1. Sadowska M, Sarecka-Hujar B, Kopyta I. Cerebral Palsy: Current Opinions on Definition, Epidemiology, Risk Factors, Classification and Treatment Options . Neuropsychiatr Dis Treat. 2020 Jun;Volume 16:1505–18.
2. McIntyre S, Goldsmith S, Webb A, Ehlinger V, Hollung SJ, McConnell K, et al. Global prevalence of cerebral palsy: A systematic analysis. Dev Med Child Neurol. 2022 Dec 11;64(12):1494–506.
3. Dar H, Stewart K, McIntyre S, Paget S. Multiple motor disorders in cerebral palsy. Dev Med Child Neurol. 2024 Mar 14;66(3):317–25.
4. Brandenburg JE, Fogarty MJ, Sieck GC. A Critical Evaluation of Current Concepts in Cerebral Palsy. Physiology. 2019 May 1;34(3):216–29.
5. Katsma M, Liu H, Pan X, Ryan KJ, Roye DP, Chambers HG. Management and treatment of musculoskeletal problems in adults with cerebral palsy: Experience gained from two lifespan clinics. J Pediatr Rehabil Med. 2024 Mar 26;17(1):19–33.
6. Demont A, Gedda M, Lager C, de Lattre C, Gary Y, Keroulle E, et al. Evidence-Based, Implementable Motor Rehabilitation Guidelines for Individuals With Cerebral Palsy. Neurology. 2022 Aug 16;99(7):283–97.
7. Metin Ökmen B. Effect of virtual reality therapy on functional development in children with cerebral palsy: A single-blind, prospective, randomized-controlled study. Turk J Phys Med Rehabil. 2019 Dec 5;65(4):371–8.
8. Organização Mundial da Saúde. Classificação Internacional da Funcionalidade. 2003rd ed. Vol. 1. São Paulo: Edusp; 2003.
9. Aaron Emmanuel Costa de Oliveira; Bruno José Leal; Andrei Pereira Pernambuco. APPLICATION OF THE ICF IN PHYSIOTHERAPY: A REVIEW OF BRAZILIAN STUDIES (2018-2022) . Revista Conexão Ciência. 2025;Vol. 20, Nº 2.
10. Kouijzer MMTE, Kip H, Bouman YHA, Kelders SM. Implementation of virtual reality in healthcare: a scoping review on the implementation process of virtual reality in various healthcare settings. Implement Sci Commun. 2023 Jun 16;4(1):67.
11. Camara Machado FR, Novak G dos S, Kakuta Kato S, Alves de Oliveira A. Evaluation of the Usability of a Serious Game in Virtual Reality with a Focus on the Perception and Experience of Health Professionals for Motor Rehabilitation in Children with Cerebral Palsy. Games Health J. 2024 Jun 1;13(3):201–6.
12. Velasco Aguado J, Espada MC, Muñoz-Jiménez J, Ferreira CC, Gámez-Calvo L. Physical Exercise Interventions Using Virtual Reality in Children and Adolescents with Cerebral Palsy: Systematic Review. Healthcare. 2025 Jan 19;13(2):189.
13. Komariah M, Amirah S, Abdurrahman MF, Handimulya MFS, Platini H, Maulana S, et al. Effectivity of Virtual Reality to Improve Balance, Motor Function, Activities of Daily Living, and Upper Limb Function in Children with Cerebral Palsy: A Systematic Review and Meta-Analysis. Ther Clin Risk Manag. 2024 Feb;Volume 20:95–109.
14. Liu C, Wang X, Chen R, Zhang J. The Effects of Virtual Reality Training on Balance, Gross Motor Function, and Daily Living Ability in Children With Cerebral Palsy: Systematic Review and Meta-analysis. JMIR Serious Games. 2022 Nov 9;10(4):e38972.
15. Radwan A, Eltalawy HA, Abdelziem FH, Macaluso R, O'Brien MK, Jayaraman A. Effect of Transcranial Direct Current Stimulation versus Virtual Reality on Gait for Children with Bilateral Spastic Cerebral Palsy: A Randomized Clinical Trial. Children. 2023 Jan 27;10(2):222.
16. FİDAN Ö, GENÇ A. EFFECT OF VIRTUAL REALITY TRAINING ON BALANCE AND FUNCTIONALITY IN CHILDREN WITH CEREBRAL PALSY: A RANDOMIZED CONTROLLED TRIAL. Türk Fizyoterapi ve Rehabilitasyon Dergisi. 2023 Apr 20;34(1):64–72.
17. Ziab H, Saleh S, Talebian S, Olyaei G, Mazbouh R, Sarraj AR, Hadian MR. Effectiveness of virtual reality training compared to balance-specific training and conventional training on balance and gross motor functions of children with cerebral palsy: A double blinded randomized controlled trial. J Pediatr Rehabil Med. 2024 Sep;17(3):353-368. doi: 10.3233/PRM-220120. PMID: 39150837.
18. MOUHAMED HA, ABO-ZAID NA, KHALIFA HA, ALI ME, ELSERTY NS, BEHIRY MA, et al. Efficacy of virtual reality on balance impairment in ataxic cerebral palsy children: randomized controlled trial. Eur J Phys Rehabil Med. 2024 Dec;60(6).
19. Chen Y, Fanchiang HD, Howard A. Effectiveness of Virtual Reality in Children With Cerebral Palsy: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Phys Ther. 2018 Jan 1;98(1):63–77.
20. Warnier N, Lambregts S, Port I Van De. Effect of Virtual Reality Therapy on Balance and Walking in Children with Cerebral Palsy: A Systematic Review. Dev Neurorehabil. 2020 Nov 16;23(8):502–18.
21. Silva TD da, Fontes AMGG, Oliveira-Furlan BS de, Roque TT, Lima AII, Souza BMM de, et al. Effect of Combined Therapy of Virtual Reality and Transcranial Direct Current Stimulation in Children and Adolescents With Cerebral Palsy: A Study Protocol for a Triple-Blinded Randomized Controlled Crossover Trial. Front Neurol. 2020 Sep 2;11.
22. Li F, Pan W, Huang J, Zhu L, Li X. Effects of Virtual Reality Intervention on Motor Function and Activities of Daily Living of Children and Adolescents with Cerebral Palsy: A Systematic Review and Meta-analysis of Randomized Controlled Trials. Arch Phys Med Rehabil. 2025 Jun;
23. Rathinam C, Mohan V, Peirson J, Skinner J, Nethaji KS, Kuhn I. Effectiveness of virtual reality in the treatment of hand function in children with cerebral palsy: A systematic review. Journal of Hand Therapy. 2019 Oct;32(4):426-434.e1.
24. Ren Z, Wu J. The Effect of Virtual Reality Games on the Gross Motor Skills of Children with Cerebral Palsy: A Meta-Analysis of Randomized Controlled Trials. Int J Environ Res Public Health. 2019 Oct 14;16(20):3885.
25. Tobaiqi MA, Albadawi EA, Fadlalmola HA, Albadrani MS. Application of Virtual Reality-Assisted Exergaming on the Rehabilitation of Children with Cerebral Palsy: A Systematic Review and Meta-Analysis. J Clin Med. 2023 Nov 14;12(22):7091.
26. Landim SF, López R, Caris A, Castro C, Castillo RD, Avello D, et al. Effectiveness of Virtual Reality in Occupational Therapy for Post-Stroke Adults: A Systematic Review. J Clin Med. 2024 Aug 7;13(16):4615.
27. Cano Porras D, Sharon H, Inzelberg R, Ziv-Ner Y, Zeilig G, Plotnik M. Advanced virtual reality-based rehabilitation of balance and gait in clinical practice. Ther Adv Chronic Dis. 2019 Jan 23;10.