Scoping review

FUNCTION THROUGH FUN

Games in Upper Motor Rehab for Children with Hemiplegic Cerebral Palsy, Navigating the Challenges and Benefits: a Scoping Review

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ABSTRACT

Background and Objective: Children with hemiplegic cerebral palsy (CP) experience daily activity limitations due to upper limb motor impairments. While conventional physiotherapy remains the standard treatment, its repetitive nature may reduce motivation and engagement. Video game-based therapy (VGBT) offers an interactive approach to improving motor function and adherence. This review explores VGBT's benefits, challenges, and accessibility in enhancing upper limb function in children with hemiplegic CP.

Method: This scoping review followed PRISMA-ScR guidelines. Literature was sourced from PubMed, ProQuest, and Scopus. Study quality was assessed using the McMaster Critical Review Form.

Results: Thirteen articles met the inclusion criteria, with an average McMaster score of 13.5. VGBT, particularly exergames and virtual reality (VR), shows promise in improving hand function, coordination, and motor dexterity, alongside increased engagement and adherence of children with hemiplegic CP. Adaptive feedback and biofeedback-enhanced games enable personalized therapy. However, challenges include limited technology access, personalization, and long-term efficacy.

Conclusion: VGBT effectively enhances upper limb function and addresses limitations in conventional therapy. Overcoming technological and personalization barriers is crucial. Further research on adaptable, accessible, and personalized interventions is needed to ensure equitable rehabilitation outcomes for all children with hemiplegic CP.

Keywords: video game, children, upper motor, hemiplegic, cerebral palsy

ABSTRAK

Latar belakang: Anak dengan *cerebral palsy* (CP) hemiplegia mengalami keterbatasan aktivitas sehari-hari akibat gangguan motorik ekstremitas atas. Fisioterapi konvensional menjadi standar perawatan, tetapi sifatnya repetitif, sehingga menurunkan motivasi anak. Terapi berbasis *video game* (VGBT) menawarkan pendekatan interaktif untuk meningkatkan fungsi motorik dan kepatuhan. Tinjauan ini mengeksplorasi manfaat, tantangan, dan aksesibilitas VGBT dalam meningkatkan fungsi motorik ekstremitas atas pada anak dengan CP hemiplegia.

Metode: Tinjauan skoping ini mengikuti pedoman PRISMA *Extension for Scoping Reviews*. Literatur diperoleh dari *PubMed, ProQuest*, dan *Scopus*. Studi dinilai menggunakan *McMaster Critical Review Form*.

Hasil: Sebanyak 13 artikel yang memenuhi kriteria inklusi, dengan rata-rata skor *McMaster* adalah 13,5. VGBT, terutama *exergames* dan *virtual reality* (VR), terbukti meningkatkan fungsi tangan, koordinasi, dan ketangkasan motorik, serta meningkatkan keterlibatan dan kepatuhan terapi pada anak dengan CP hemiplegia. Permainan dengan umpan balik adaptif dan *biofeedback* memungkinkan terapi yang lebih personal dan sesuai dengan individu. Namun, tantangan seperti akses teknologi, kebutuhan personalisasi, dan efektivitas jangka panjang perlu diperhatikan.

Kesimpulan: VGBT efektif meningkatkan fungsi motorik ekstremitas atas dan mengatasi keterbatasan terapi konvensional. Mengatasi hambatan teknologi dan personalisasi penting untuk memaksimalkan manfaatnya. Penelitian lebih lanjut diperlukan untuk memastikan rehabilitasi yang efektif bagi anak dengan CP hemiplegia.

Kata kunci: *video game*, anak, motorik atas, hemiplegia, *cerebral palsy*

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INTRODUCTION

Cerebral palsy (CP) encompasses a range of complex and enduring neurodevelopmental disorders that impair movement and posture, resulting from non-progressive damage to the developing brain. This damage may occur prenatally, perinatally, or within the first two years of life, leading to significant limitations in activity and participation.[1–3] CP is the most common sensorimotor disorder in children, with an incidence of 1.5 to over 3 cases per 1,000 live births.[4,5] It also represents a major global health burden among non-communicable diseases, and rehabilitation for CP is aligned with the World Health Organization's Universal Health Coverage goals for 2030.[1]

Cerebral palsy (CP) is characterized by a mix of positive and negative motor symptoms, such as spasticity, weakness, compromised selective motor control, and sensory deficits.[6] These impairments significantly affect upper limb function, impacting activities of daily living (ADL), fine motor skills, and independence due to limitations in gross and fine motor tasks.[3,7]

Hemiplegic CP (also referred to as unilateral cerebral palsy [UCP] or hemiparetic cerebral palsy [HCP]) accounts for 10–30% of CP cases. It is characterized by unilateral motor impairment, predominantly affecting the upper extremity more than the lower limb, making it the second most common CP subtype after diplegia.[5,8] Children with hemiplegic CP frequently exhibit developmental disregard, a learned suppression of upper limb use that does not align with its functional capacity. This leads to delays in fine motor skill development[9] and impairments in hand function that remain a significant concern for both caregivers and affected children[10], impacting the ability to perform bimanual activities of daily living (ADL) and reducing overall quality of life.[1,11] Most cases are congenital, with early signs including difficulty using the affected hand before the age of one, with greater involvement of the arm than the leg, while speech development typically remains intact.[5] Upper extremity dysfunction in hemiplegic CP results from factors such as muscle imbalances, spasticity, and weakness.[12]

There is no definitive cure for CP; however, rehabilitation can improve motor function and quality of life.[3,13] Conventional therapy typically involves passive and active exercises, conducted at high intensity and repetitively by therapists, to stimulate damaged brain areas to enhance neural plasticity. However, conventional therapy can become monotonous for children, potentially leading to low adherence and engagement.[14]

There is a growing need for new methods and alternatives in the rehabilitation of children with cerebral palsy (CP) to encourage participation beyond traditional therapy settings.[1] The use of virtual reality (VR) and active video games for motor rehabilitation is becoming more popular as a way to improve neuromotor skills. Games that incorporate auditory and visual stimuli can enhance motivation and improve adherence to therapy.[11] Video games create a challenging, supportive, and safe environment, making them appealing for children with CP who may be resistant to conventional therapies.[15] Several gaming systems have been used in upper extremity rehabilitation for hemiparetic including commercial entertainment gaming systems such as Wii, Kinect, Leap Motion Sensor and robotic or sensor-equipped gloves for unilateral/hemiplegic CP[16]; they are inexpensive and readily available common and modern commercial games engaging to be played on computer mouse.[17]

Based on the references, virtual reality (VR) game-based rehabilitation has been shown to enhance upper extremity function, motivation, and engagement in children with cerebral palsy (CP).[3,13,18] However, effective participation in VR interventions requires cognitive abilities.[17] Given that hemiplegic CP primarily affects the upper extremities while often preserving cognitive function, children with this subtype are likely to gain the most benefit from VR-based rehabilitation. In contrast, quadriplegic CP is associated with severe motor impairments, often classified as Gross Motor Function Classification System (GMFCS) Level V, whereas most video game-based rehabilitation interventions are designed for children within GMFCS Levels I–II[18] Diplegic CP primarily affects lower extremities, making upper limb-focused interventions less relevant[5], suggesting that children with hemiparetic CP will gain greater advantages through video game rehabilitation compared to other CP subtypes.

These games require the integration of sensory and motor skills, making them a promising tool for neuromotor rehabilitation, particularly effective in enhancing upper limb abilities such as grip strength, fine manual dexterity, hand coordination, lifting capability, and finger range of motion.[19] Despite its potential, mainstream video games' therapeutic goals and long-term engagement remains a challenge.[6] The evidence from randomized controlled trials (RCTs) on video game-based therapy for upper limb rehabilitation in hemiplegic CP remains inconclusive. Therefore, this review aims to explore the role of video games in improving upper motor function in children with hemiplegic CP, discussing their potential benefits, challenges, and accessibility.

MATERIALS AND METHODS

Study design: this review was conducted according to Preferred Reporting Items for

Systematic Review and Meta-Analyses Extension for Scoping Reviews[20]

Search strategy: The literature was identified from electronic databases from PubMed, Proquest and Scopus by 3 investigators (SAH, F,A) The search terms are as follow

Search engine	Keyword
Pubmed	(((((video game) OR (computer game)) AND (cerebral palsy)) AND (children)) AND (upper motor)) AND (rehabilitation)))))
Scopus	(TITLE-ABS-KEY (children) AND TITLE-ABS-KEY (cerebral AND palsy) AND TITLE-ABS-KEY (upper AND motor) AND TITLE-ABS-KEY (rehabilitation) AND ALL (video AND game))
ProQuest	(cerebral palsy) AND children AND (video game) AND (upper motor) AND rehabilitation

Study selection: This scoping review included experimental design with intervention and comparison to conventional rehabilitation or pre-intervention measures.

The inclusion criteria for the analyzed articles were as follows:

1. Articles with participants of children (0-18 years old) with diagnosed hemiplegic cerebral palsy
2. Articles using the intervention of video games using innovative technology
3. Articles evaluating upper motor function
4. Articles published within the last 5 years (2019-2024)
5. Articles in English language

Differences in inclusion studies were discussed and addressed between SAH, F and A. The exclusion criteria for this review were as follows:

1. Articles that did not include participant evaluation
2. Articles lacking focus on intervention
3. Articles with insufficient information on the game played
4. Articles examining other than hemiplegic cerebral palsy

REVIEW ARTICLES

Searching process: Original articles that met inclusion and exclusion criteria were extracted using the search terms. A total of 978 articles were screened. First, through the title and abstract review, articles unavailable and duplicates were excluded according to exclusion criteria. The abstract and full texts were further scrutinized using exclusion and inclusion criteria. Any disagreement was discussed within SAH, F and A by full text review.

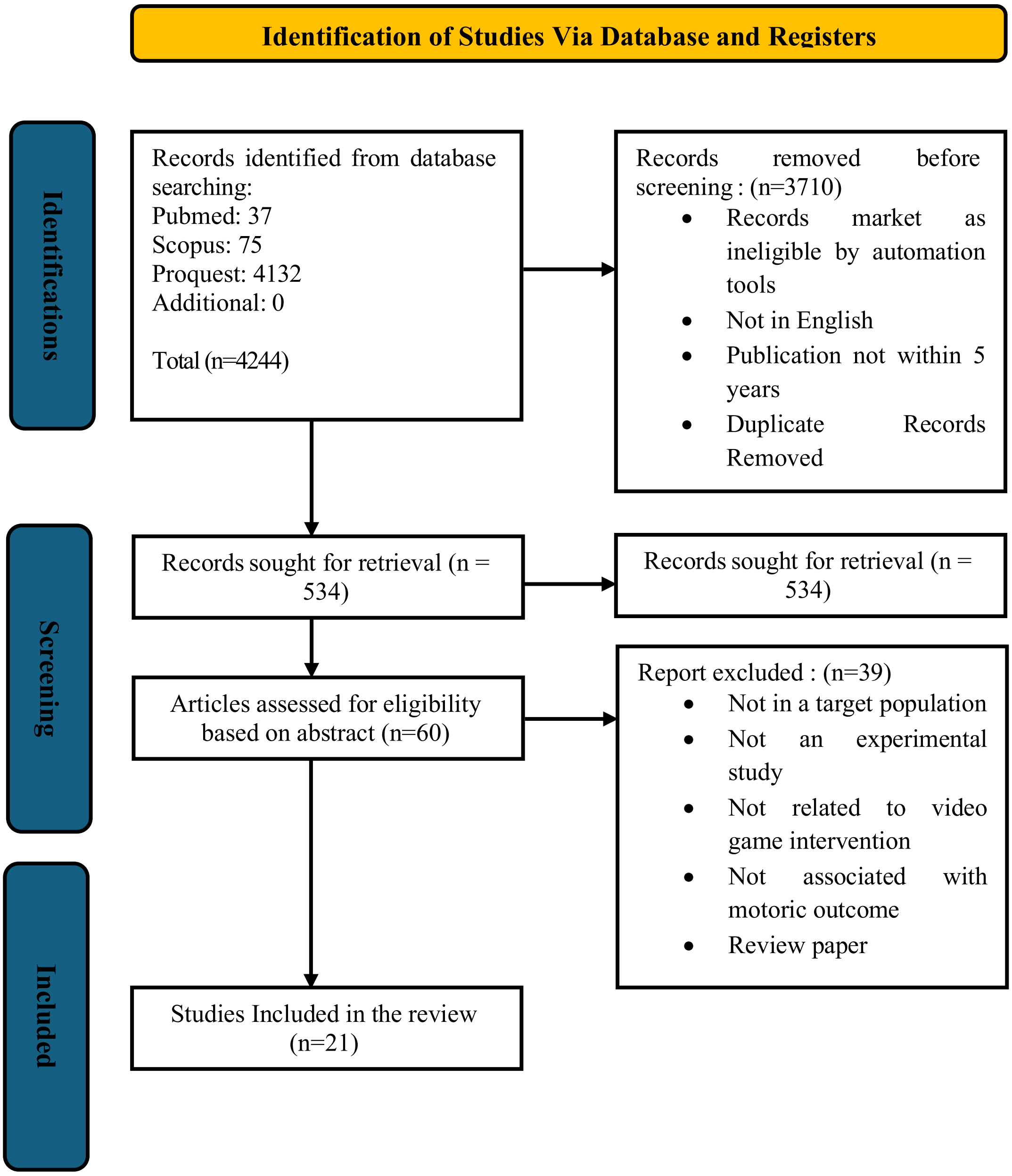
Data extraction and quality assessments:

The data collected included the study name, population, and intervention characteristics (author, year, country, study population, types of CP participants, intervention characteristics, and outcome measurements). To further examine all evidence related to video game interventions, the studies were appraised for their quality based on the MacMaster Critical Review Form for quantitative studies. This review is comprehensive and studies were assessed as to whether it fulfilled the requirements for each criterio.

The search was conducted on August 27, 2024. The search strategy produced 4244 records. Following the initial screening, 3,710 studies were excluded. Subsequently, 534 studies were assessed for eligibility, with 471 removed after title review. 60 articles were screened based on abstract review, resulting in the exclusion of 48 studies. The final list for review consisted of 13 studies.

RESULTS

Search results (flow diagram)



Author, year, country	Type of study	Study population	Intervention characteristics	Measurements	Outcome	McMaster critical review
Hosseini P et al, 2023, Iran[2]	Non randomized 1 group trial	5 hemiparetic CP children aged 4-8 years old	Car racing computer game (breaking random boxes appearing gives positive score) with specifically designed joysticks for a bimanual task with unity game engine compatible to Windows, Android and iOS. Intervention total of 15 sessions, each 30 minutes, 3 times a week	Pre and post-test with Fugl-Meyer assessment of upper extremities & corsi block tapping test	Mean FMA-UE score after intervention increases 51 vs 59.5 (P<0.008), significant improvement in upper extremity motor function, especially wrist joint, wrist stability at dorsiflexion and volar flexion. No improvement in wrist circumduction.	13/15
Srinivasan S et al, 2024, USA[21]	Pilot study	11 children with hemiplegia/UCP aged 4-10 years old	Hybrid training camp using commercial modified joystick operated ride on toys (WildThing and HuffyGreen) 5 days a week for 20-30 minutes each sessions for 3 weeks	QUEST pretest and posttest	Significant improvement in QUEST (p value 0.015-0.004) for grasp 63.3 vs 70, manipulation, release skill, and increased duration of moderate activity 79.3% vs 85.5%(p=0.025)	13/15
Shahane V et al, 2024, USA[22]	Single group before and after mixed method study	11 children with hemiplegia/UCP aged 4-10 years old	Hybrid training camp using commercial modified joystick operated ride on toys (WildThing and HuffyGreen) for 25-30 minutes every day within a 3-week intensive camp	ABILHAND Questionnaire pretest and posttest, EXIT questionnaire	Increases unprompted use of upper extremity (98.93 vs 99.06 percent, P<0.001), improvements in children's bimanual function, and spontaneously affected UE use during daily activities pretest vs posttest (- 0.29 vs 0.65, p<0.001)	13/15
Martins et al, 2019, Brazil[23]	A pilot study	10 children with spastic hemiparetic CP GFMCS I-II MACS I-II and 10 typically developing children aged 6-19 years old	2 software programs in a quiet room using (1) coincident timing task, pressing the space bar on the keyboard using a paretic upper limb, participants received immediate feedback on correctness (2) MoveHero software virtual task falling spheres on a 1.5m distance computer screen and webcam, react with upper limb by moving arms, 8 minutes (4 songs 2 minutes each). Modification of tasks was performed for adaptation	Pretest and posttest scores with real task, data provided in milliseconds of timing error	Non immersive virtual environment shows performance improvement between pretest and post test 5.01vs7.83 (P=0.014), only in the CP group, showing performance improvement in arm kinematics	13/15
H.M.Abd-Elfattah et al, 2024, Egypt[7]	Randomized control trial, 2 groups, double blind	30 children intervention (age 5 to 7 with unilateral CP MAS I-II and GMFCS I-II) and 30 children in control	GraphPad software on tablet, fine motor exercise for 30 minutes, continued with 30 minutes using a smart tablet iPad 3 playing games using the affected hand to control the game; bowling, scribbling, peg light, and rapid tap, each game for 5 minutes with 3 minutes break in between	Quality upper extremity skill function, pinch strength(dynamometer), finger dexterity (nine hole peg test)	Significant increase in all items of quality upper extremity skill function before vs after movement, 74.89 vs 82.27, grasp 71.27 vs 84.22(p<0.001), and pinch grip 0.88±0.34 vs 1.54±0.52, decrease in nine hole peg test time (p<0.001), giving mechanical benefit of hand function and neurological control	14/15
M. Daliri B.O et al, 2023, Iran[13]	Randomized clinical trial	Bilateral spastic or double hemiplegic CP 5-8 years old, MACS 1-3, GMFCS 1-3, MAS grade 2	Conventional therapy 4 weeks, continued by LMC rehabilitation for 12 weeks, repetition with leap motion + visual feedback (LMC software via USB) in 3 games for 20 minutes after 40 minutes of conventional therapy	Grip force, lateral pinch, palmar pinch, hand function QUEST test, hand dynamometer, pinch gauge	Higher grip strength (0.21 vs 2.31), lateral pinch (0.09 vs 1.25), palmar pinch (0.04 vs 0.88) strength increases (p<0.001), QUEST score was similar in the 2 groups but shows an increase in grasp score -4.39 vs 5.33 (p<0.01)	14/15
Chan-Viquez et al, 2023, Canada[9]	Mixed method multi case study	4 children, 7-17 years old with hemiplegic CP	Children were loaned a Bootle Blast videogame system at home for 12 weeks, using a Laptop with BB, a 3D camera, and toy instruments	Canadian occupational performance measure, assisting hand assessment, ROM, parent;- report CHEQ, interviews	Improved grip strength 160vs173.3, wrist extension ROM (60 vs 75 degrees), AHA, BBT on most children quantitatively, and increased use of affected UL qualitatively	13/15
Parmar S.T et al, 2021, India and Canada[16]	Mixed method exploratory randomized control trial single blind	6 children with CP GMFCS level I-III, MACS level I-III, MAS finger and wrist <2, MMSE >17	16-week intervention, 3 times per week each of 4 exercise sessions, computer game based telerehabilitation platform using readily available commercial game (Big Fish), with initial four 45 minutes therapy sessions	Peabody Developmental Motor Scale-2 grasping and visual- motor integration, CUE assessment`	PSDM-2 average grasp score improved by 12% (45.2% vs 50.1%), substantial improvement in performance measure of three CUE 30-55% success rate, 13-18% reduction in response time	13/15
Gozacan Karabulut et	Randomized control	30 children with unilateral CP	2 sessions per week for 8 consecutive weeks, 30 minutes	ABILHAND-kids, selective control of the	Improved ABILHAND- kids score 36.8 vs 39.2 (p<0.001),	14/15

al, 2024, Turkey[24]	trial, single blind	age 4-18 years old, GFMCS and MACS I, II, III	video-based game exercise (boxing, tennis, bowling, golf), television screen with Xbox Kinect 3600 1.5m away	upper extremity scale (SCUES), joint position sense test with clinometer, and entertainment rating	upper extremity functional abilities in intervention group (p=0.001), SMC and proprioception, Enjoyable in intervention than control 9.6 vs 6.3 (p<0.001)	
Saussez et al, 2023, Belgium[4]	Randomized control trial	40 children with unilateral CP in HABITLIE-camp 5-18 years old	Using the ReaTouch device by Axinesis SA, a virtual device designed with 45 inch reactive screen with an adjustable tiltable frame, 10-12 consecutive days, a total of 90h in which 37 h was spend with device, 2 sessions each 90-120min, playing regular games	Assisting Hand Assessment, Jebsen-Taylor test of Hand Function, Box and Block Test, Manual Form Perception Test, ABILHAND-kids, ABILOCO-Kids, ACTIVLIM-CP, PEDI, COPM	Significant improvement in ReaTouch in comparison to conventional therapy ABILHAND (2.4 vs 2.18), P<0.001	15/15
Kanitkar A et al, 2021, India[17]	Randomized control trial, single blind	63 children with CP age 4-10 years, GMFCS I-III, MACS I-III, MACS finger and wrist 1 to +1, MMSE >17	16-week computer game-based exercise program 3 times per week, each 45 minutes using inexpensive arcade-style low-cost computer games readily available online (bigfishgames.com) with wireless inertial based computer mouse	Peabody Developmental Motor Scale-2, Grasp and Visual- Motor Integration, computer game-based upper extremity	Significant improvement in success rate 58.1 pre vs 85 post, response time 13% faster, improved grasp 18.4%, and VMI test 12.6%, on both groups was higher in experimental group (p<0.01)	15/15
Gehringer et al, 2024, USA[25]	Case study	10 year old males with unilateral CP, left hand dominant	HABIT-VR games of shooting a robot with a rocket using a Meta Quest VR headset and controller in 3D space twice daily for 30 minutes over a 14 day period, total of 14 hours across 22 days	Box and Block Test, Nine-Hole Peg, Canadian Occupational Performance Measure, actigraphy	COPM post-intervention increases in performance and satisfaction (7.8 vs 9.4) (7.4 vs 9), box and block test (60.5 vs 65), nine peg hole (0.91 vs 0.92), and increase post assessment	13/15

Ethical approval was obtained for all included studies. The selected papers had an average score of 13.5 on the McMaster Critical Review Form.

DISCUSSION

Children with CP experience limitations in most daily life activities and restrictions in their ability to participate socially, hence the need for a multidisciplinary rehabilitation program.[23] Physiotherapy is crucial in managing children with cerebral palsy (CP), particularly in improving upper limb functionality.[12] For children diagnosed with hemiparetic CP, engaging both hands simultaneously in bimanual movement has proven to be one of the most beneficial rehabilitation strategies, focusing on enhancing muscle coordination through high-intensity, repetitive, and task-specific exercises.[2,13] Conventional therapeutic interventions include constraint-induced movement therapy (CIMT) and hand-arm bimanual intensive therapy (HABIT), both aimed at restoring hand and arm function[17] through repetition.[16]

Children with hemiplegia often struggle to achieve the optimal levels of practice necessary for neuroplasticity due to a lack of engaging interventions.[27,28] The repetitive nature of traditional therapy can also be perceived as monotonous, potentially leading to decreased adherence and engagement.[17,29] There is a growing need for innovative methods to encourage children with cerebral palsy to participate in rehabilitation outside traditional settings.[27] This calls for cost-effective solutions that not only enhance accessibility but also improve compliance with exercise regimes. Recent research suggests that incorporating video games into rehabilitation can significantly address these issues.[16]

This study confirms that video game interventions lead to improvements in upper motor functions and promote the use of the upper extremities, with higher adherence rates compared to conventional therapy. Our findings demonstrate improved upper motor skills[7], increased use of the affected limb[23,27], enhanced wrist joint dorsiflexion, volar flexion[2], and wrist extension[9]. These improvements enhanced wrist functions such as releasing, manipulation, grip strength, and pinch (lateral, palmar)[17]. Additionally, patients reported greater satisfaction[28] and enjoyment[19,25] compared to conventional therapy.

This study supports the utilization of video games for improving upper limb function, aligning with the findings of previous research by Alrashidi et al[12]. Similarly, Chang et al. reported that video games, when used as a complement to conventional occupational therapy, enhance upper extremity function.[32] These findings reinforce the growing recommendation of video games as complementary therapies to optimize rehabilitation outcomes.

The immersive nature of gaming encourages active participation in rehabilitation, fostering a sense of agency and enjoyment that is often absent in traditional therapies.[19] Video games require the integration of sensory and motor skills, making them a viable option for neuromotor rehabilitation and effective in enhancing various upper limb skills, such as grip strength, fine motor dexterity, hand coordination, lifting capability, and finger range of motion.[19] The results from this study align with the conclusions drawn from a scoping review by Ahn et al, supporting the application of game-based rehabilitation for CP.[30]
Active video games, also known as exergames, facilitate high-intensity practice through engaging and meaningful tasks-oriented games, complemented by relevant feedback, promoting a problem-solving mindset.[31] Video games incorporate auditory and visual stimuli, and significantly boost motivation and compliance.[19]

Over the past decade, the number of virtual innovations aimed at promoting motor skill integration in rehabilitation has risen substantially[4], proving to enhance brain plasticity through active engagement and feedback.[32] Virtual gaming provides immersive, real-time experiences allowing flexible adjustments in a safe and motivating environment.[32] Therapists can customize game settings and difficulty levels based on each child's abilities and therapeutic goals.[32]

Video game-based therapy (VGBT) can be categorized into two modalities: specifically designed games and low-cost commercial games such as LMC, Nintendo Wii[7,33] and Xbox Kinect.[7] While low-cost commercial consoles offer repetitive performance tasks and rich sensory stimulation and are easier to develop[29,33], they may lack the therapeutic relevance needed for targeted goals.[4,9,19] Specific personalized games are being developed, but they are not universally accessible.[4] Rehabilitation specific VR video game is reported to be more effective than commercial programs, however, the cost is high.[34]

Commercial games offer user-friendly interfaces, clear instructions, simple gameplay and short session lengths, which can enhance understanding and engagement. However, a single game may not appeal to a diverse age range and varying interests among participants.[6] Thus, a wider variety of game choices is necessary to maintain novelty and interest during rehabilitation sessions.[6] A study by Chan-Viquez et al mentioned that mini-games with 2 player modes and a reward system can give more encouragement.[9] Many gaming systems currently available feature a limited selection of games suitable for young children with motor impairments.[17]

Current personalization approaches utilize dynamic difficulty adaptation[32,35] techniques to identify optimal challenge levels that encourage effort without overwhelming users. Further research suggests a semi-automatic participatory design approach[32], utilizing pre-set parameters to inform decisions about patient progress and modify future rehabilitation sessions.[35] Recent studies by Tresser et al focus on the potential of personalized virtual gaming environments that adapt in real-time using intelligent systems, enabling therapists to fine-tune game parameters according to individual therapeutic needs.[32,35] A study by Seyma et al indicates that VR devices developed specifically for therapy offer more significant benefits in training upper limb functions in children with CP compared to commercially available VR systems(35). Despite the advancements in video game technology, personalization is still limited[35] and remains underexplored in the context of cerebral palsy rehabilitation.

Video gaming dosage is still an unresolved question[19], there is no consensus as to the effective therapeutic dose.[9] More intensive training—achieved through higher frequency and total hours within a shorter time frame—has shown significant positive effects on motor function improvements.[36] Preliminary evidence suggests that video game interventions can positively impact motor skills with single sessions lasting between 17 and 40 minutes, performed five times a week over 12 weeks, totaling around 1000 minutes of intervention.[15] Studies vary in the number of training weeks from 8 to 16, with different numbers of sessions in the week.[19]

Biofeedback-enhanced therapeutic video games are emerging as interactive technologies that integrate evidence-based biofeedback and coaching strategies to promote home-based hand and arm exercises[6], shown to improve outcomes, emphasizing the importance of incorporating real-time feedback into gaming systems. Monitoring of progress and intervention adjustment will enhance overall body function measures and participation.[6]

Despite its advantages to improve outcomes, video gaming with immersive virtual reality[27] also has potential drawbacks that warrant attention such as cyber-sickness and detachment from reality. To minimize discomfort, rehabilitation sessions should be appropriately timed and managed.[11] It is not recommended for children under 12 years old due to potential risks.[10] A systematic review by Alexandra Voinescu et al identified only minor negative outcomes, such as temporary dizziness and fatigue[37]. It is recommended to evaluate how long the gains in video games continue in future studies[24] to establish clinical protocols that maximize benefits, while retaining engaging characteristics.[19,38]

The application of video game-based rehabilitation for children with cerebral palsy remains limited in efficacy and accessibility. One significant barrier is the restrictive health insurance policies in certain countries, which can hinder access to essential rehabilitation programs.[2] Children lacking access to appropriate therapies may experience a pronounced progression of motor disabilities. Long-term adherence and motivation might still be a challenge, the use of devices longer than 90 minutes sometimes appears to be tiresome for children and also therapists.[4] It is recommended to evaluate how long the gains in video games continue in future studies.[24]

Another significant barrier is the availability of suitable technology; not all rehabilitation centers have access to the required equipment. Disparities in technology access can hinder the global reach of these interventions, especially in low-resource settings and economic constraints where traditional rehabilitation methods still prevail.[18] Collaboration among game developers, academic institutions, and clinicians is essential for developing both commercial and customized virtual gaming systems that meet clinical needs and optimize interventions for individuals with CP, regardless of geographic or socioeconomic status.[18]

Research on game design elements within healthcare contexts, particularly involving patients, is still limited.[23] There are no established guidelines for using video games to rehabilitate upper motor functions in children with CP. However, as technology continues to advance, video game interventions show promising potential for the future of rehabilitation.

Further research should focus on long-term outcomes because hand recovery is a lengthy and challenging process for improving dexterity skills in children.[13] Especially concerning children with vision and hearing impairments, or for other types of CP beyond hemiparetic CP and children scoring below a certain threshold on cognitive assessments. as no specific devices or games currently address their needs. It is crucial to ensure equal access to rehabilitation programs, especially in less developed countries or where national health insurance policies do not cover such interventions.[38] Addressing these disparities will be vital for promoting equitable rehabilitation opportunities for all children with CP.

LIMITATION

This review has several limitations. Firstly, the inclusion criteria restricted studies to those published in English, potentially omitting relevant research in other languages. Secondly, the quality of studies varied, which may affect the reliability of findings. Additionally, the diversity of video game technologies and rehabilitation approaches complicates direct comparisons among studies. Most publication were using short-term protocol; more research is needed using long-term protocol to have a better insight into the long term use of video game intervention and to discover side effects. Furthermore, the review highlights the limited availability of research addressing the needs of children with diverse impairments or those from low-resource settings. Future studies should aim to address these gaps and explore the long-term effects of video game interventions on functional outcomes in children with cerebral palsy.

CONCLUSION

The integration of video game-based therapies into rehabilitation programs for children with cerebral palsy demonstrated to be effective in improving upper limb function, engagement and therapy adherence in children with cerebral palsy. While exergames and commercial gaming platforms provide accessible options, personalized games are more effective for targeted rehabilitation. This review underscores the effectiveness of VGBT in improving upper limb functionality and highlights its potential to address some limitations associated with traditional rehabilitation methods. As research progresses, the focus must remain on developing adaptable, accessible in low resourced-setting, and personalized interventions to ensure all children can benefit from these advancements in rehabilitation.

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Informed consent statement: not applicable.

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Ethical issue: this article does not have approval from the ethics committee because this is a scoping review.

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